Comparative Study of Body Mass Index Effects on Physical Therapy Results after Total Knee Arthroplasty During Hospitalization

MOHAMMAD F. ALI, Ph.D.*; MAGDY MUSTAFA, Ph.D.** and EHAB K. ZAYED, Ph.D.***

The Departments of Orthopedics & Traumatology*, Internal Medicine** and Surgery***, Faculty of Physical Therapy, October 6 University, Egypt

Abstract

Background: Rates of total knee arthroplasty (TKA) are increasing each year and considered as an effective management for obese patients with degenerated knee joints.

Objectives: To determine the effect of the degree of body mass index on inpatients results of physical therapy program after total knee arthroplasty during hospitalization period.

Participants: Forty patients with knee osteoarthritis were involved in this study after total knee arthroplasty and they were randomly distributed into two experimental groups. The first group was consisted of 20 patients (16 females, 4 males) with BMI ranged from 25 to 29.9kg/m$^2$ (overweight degree). The second group was consisted of 20 obese patients (15 females and 5 males) with BMI ranged from 35 to 40Kg/m$^2$ (moderate obesity degree).

Methods: All patients after surgery were treated by the same standard plan of physical therapy including continuous passive motion, active assisted and active free range of motion exercises, isometric and isotonic strengthening exercises, gait training and transfer training.

Main Outcomes Measures: Both groups were evaluated pre-operatively and after the 6th day of hospitalization period post-operatively by knee function test score [Hospital for Special Surgery (HSS) score], pain, and range of motion of knee flexion.

Results: The overweight group showed that there is significant increase in physical therapy outcomes than the moderate obese group ($p>0.05$). Both groups significantly improved in all parameters after 6 days of hospitalization.

Conclusions: The decreased BMI is more effective for physical therapy outcomes during the hospitalization period than the increased BMI after total knee arthroplasty. By these findings the patients who will undergo TKA should follow weight reduction program to decrease their BMI before the surgery.

Key Words: Body mass index – Physical therapy – Total knee Arthroplasty.

Introduction

OSTEOARTHRITIS (OA) is a common condition of multifactorial origin. Most current classification systems use a combination of pain and radiographic criteria (which include both joint space narrowing and osteophytosis). Joint space narrowing largely reflects cartilage loss, whereas osteophytosis reflects marginal bony joint expansion. It is uncertain which of these is the initial step [1].

It is well established that Body Mass Index (BMI) is most strongly linked to knee OA in both symptoms and radiographic changes. Radiographic knee OA is increased nearly 4-folds in obese women, and there is a dose response relationship between body weight and knee OA. However, the underlying mechanism remains obscure [2].

Being overweight is associated with increases in the amount of force across a weight-bearing joint and cartilage turnover biomarkers [3].

In addition, adipose tissue may produce changes in hormones and growth factors. These biomechanical, biochemical, and metabolic changes may lead to loss of articular cartilage and sclerosis of subchondral bone; however, there is limited direct evidence to support this [4].

This is, in part, because of the limitations of conventional radiographic measurement, which provides only an approximation of articular cartilage with measurement of joint space narrowing and poor characterization of other tissue. In contrast, magnetic resonance imaging (MRI) can visualize joint structure directly and is recognized as a valid, accurate, and reproducible tool to measure articular cartilage defects, volume, thickness, and subchondral bone size [5].
Total knee arthroplasty (TKA) is a commonly performed surgical procedure designed to alleviate knee pain and improve function in individuals with knee osteoarthritis (OA) or rheumatoid arthritis. As (TKA) reliably reduces pain and improves self-reported function in patients with end-stage OA, the recovery of strength and function to normal lev-els is expected, which predisposes patients to future better function [6].

More than 687 000 total knee arthroplasties (TKAs) are performed each year in the United States, secondary to the pain and physical limitations caused by knee osteoarthritis (OA) [7]. Over the next 2 decades, the number of TKAs performed yearly is ex-pected to grow dramatically to reach 3.48 million [8].

In obese patients, after TKA, quadriceps strength drops to 60% of preoperative levels, even when traditional postoperative rehabilitation is initiated within 48 hours after surgery [9].

This quadriceps weakness per-sists years after surgery, based on comparisons with age-matched controls [4]. Similarly, functional performance declines precipitously by up to 88% in the first month after TKA [1] and reduced function persists, with reports of 18% slower walking speed and 51% slower stair-climbing speed compared to age-matched controls at 12 months after TKA [10].

Muscle weakness affects functional performance in older adults. Loss of muscle mass and overall strength with aging (sarcopenia) has been well documented [11].

Despite the high incidence of knee replacement and the availability of postoperative rehabilitative approaches, the resultant muscle impairments are not well defined and are an understudied area of postoperative care. Of particular interest to rehabili-tation professionals is the acute profound post-operative deficit in quadriceps muscle strength that fails to completely resolve even years after surgery. Hamstring strength deficits have also been reported after TKA surgery however, the focus on the quadriceps is due to the association of the quadriceps to normal functional activities such as walking and stair climbing [12].

Therefore, quadriceps weakness will be the focus for the postoperative total knee replacement. While the reason for quadriceps weakness is not well understood in this patient population, it has been suggested that a combination of muscle atro-phy and neuromuscular activation deficits contribute to residual strength impairments. Failure to adequately address the chronic muscle impairments is potentially limiting the long-term functional gains that may be possible following TKA [13].

Total knee arthroplasty (TKA) is a very common procedure, principally implemented for the treatment of knee osteoarthritis (OA) [14,15].

The prevalence of TKA in the US is predicted to continue rising with numbers approaching half a million surgeries annually by the year 2030. Advancements in the durability of the endopros-theses have made it possible for younger patients with severe disease to undergo TKA [16]. The National Hospital Discharge Survey 1996-99 re-port ed that individuals between 45 and 64 years old represent the fastest growing age group to undergo TKA [8]. An increasing incidence in TKA and a rise in utilization by a relatively younger patient population have prompted considerable interest in determining factors that influence post-operative outcome [15].

Determination of functional capacity can be performed through the use of self-assessment questionnaires or through performance based functional tests. Recent evidence has shown that preoperative self-report questionnaire scores consistently predict postoperative questionnaire scores [17,18]. While those patients who score lower on a questionnaire prior to surgery make the most improvements following TKA, they ultimately do not reach the same functional level as those with higher scores prior to surgery [19]. Results of functional assessment in individuals with knee OA showed only modest correlations between the questionnaires and performance [20,21]. The majority of patients who undergo TKA attain good to excellent ratings on self-assessment questionnaires [22]. Questionnaire scores improve considerably in almost all patients, yet performance based functional tests do not show as much improvement [23].

Material and Methods

This study was conducted on forty patients with knee osteoarthritis after total knee arthroplasty at October 6 University Hospital from 2012 – 2013. They were randomly divided into two equal groups in number. The first group (overweight group) was twenty patients (sixteen females and four males) with BMI ranged from 25 to 29.9kg/m². The second group (moderate obesity) was twenty patients (fifteen females and five males) with BMI ranged from 35 to 39.9Kg/m². All patients were carefully assessed by orthopaedic surgeon and received the same and necessary physiotherapeutic regimen, dieting, medical and nursing care.
Inclusion criteria: Patients aged from 56 to 66 years. All the patients have knee OA. The body mass index ranged from 25-29.9 kg/m$^2$ (in the first group) and between 35 and –39.9 kg/m$^2$ (in the second group).

Exclusion criteria: Patients with rheumatoid arthritis, septic arthritis, gout, paresis or any neurological affection, metastatic bone disease or previous fracture of the lower limbs, any BMI rather than the mentioned two groups ranges and smokers were excluded from this study.

Measurement:

Instruments:
Weight was measured to the nearest 0.1 kg (with shoes, socks, bulky clothing removed) using a single pair of electronic scales (Seca Delta Model 707, Seca, Germany) that were calibrated using a known weight at the beginning of each clinic. Height was measured to the nearest 0.1 cm (with shoes and socks removed) using a stadiometer. BMI was calculated. Overweight was defined as a BMI (25-29.9 kg/m$^2$), whereas obesity was defined as a BMI >30 kg/m$^2$.

Objective measures of physical function included measurement of muscle strength by muscle testing and active and passive knee flexion range were measured by universal goniometer and recording degree on CPM machine [24]. CPM machine is J.A.C.E. Universal with model K100-2. It has override and hand controller switches within patient reach. Serial number 407-K 3709 with Max speed 120 beats per hour.

The score of hospital for special surgery (HSS) functional grade is divided into the following categories:

Lack of pain = 35 points (20 point pain at rest and 15 point at any motion of knee joint); functional tests (24 points) divided as the following where (0 point = Not tested up to 6 points = Independent) for the 4 tested activities. Functional activities of patients were evaluated preoperatively [25] and at day 6 postoperatively. Active range of knee flexion was measured with a universal goniometer. The four functionally related activities assessed were ability to: Move into a sitting position from supine lying; stand from sitting; ambulate 15 feet; and climb up and down three steps [17].

The total functional score represented the sum of the level of assistance values for all four functionally related activities (Appendix 1) [18]. The post-operative course of each patient was reviewed for two preoperative complications that are believed to be related to obesity: Wound complications and thromboembolic disease. Wound complications included necrosis of the skin, heamatoma and wound drainage.

Evaluation:

All patients signed a written informed consent and were subjected to all of the following evaluation protocols:

1- Detailed medical history and physical examinations including vital signs.
2- Anthropometric measurements: Weight, height, BMI, waist, and waist hip ratio.
3- Laboratory investigations: Fasting blood glucose, and C-reactive protein (CRP). Baseline blood samples, obtained after over-night fasting for at least 12 hours, were taken and analyzed.
4- All anthropometric measurements and laboratory investigations were repeated at the end of the study at day 6 postoperatively before discharge using the Hospital for Special Surgery (HSS) knee score criteria, which is based on certain functional points concerning post operative knee arthroplasty.

All patients of both groups received standard post-operative treatment, including continuous passive motion, active-assistive and active range of motion exercises, isometric and isotonic strengthening exercises, gait training and transfer training every day during the hospitalization period [7].

Statistical analysis:

Statistical analysis were performed using Statistical Package for the Social Sciences for Windows (Version 15.0, SPSS Inc.). Mann-Whitney U-test was used to evaluate group differences (age, weight, and height, BMI, HSS scale and range of motion). Within-group differences in pre- and post-operative values were examined for statistical significance Using Wilcoxon signed rank test for HSS scale. The total functional scores were for the following tasks (supine-to-sit, sit-to-stand, ambulate 15 feet, and climb up and down three stair steps). A probability of $p<0.05$ was considered to be significant.

Results

Mann-Whitney U-test was used to evaluate group differences (age, weight, and height, BMI).

Mann-Whitney U-test was used to evaluate differences between group (1 & 2) preoperatively in HSS Scale.
Within-group differences in pre- and postoperative values were examined for statistical significance using Wilcoxon signed rank test in HSS scale.

Within-group differences in pre- and postoperative values were examined for statistical significance using Wilcoxon signed rank test in HSS scale.

Mann-Whitney U-test was used to evaluate the postoperative differences between group 1 & 2 in knee flexion ROM, pain scores during activity and pain scores at rest.

There were no significant differences between the 2 groups for age or height. However, the overweight group (group 1) had lower weight and BMI ($p=0.001$) than the moderate obese group (group 2) as shown in (Table 1 and Fig. 1). There were no significant differences between both groups in functional activities Supine-to-sit, Sit-to-stand, Ambulate 15 feet, Climb up and down three steps, and Total functional score of HSS scale in preoperative period as shown in (Table 2 and Fig. 2). There is a significant difference between preoperative and postoperative functional activities and in total functional score of HSS scale of in group 1 as shown in (Table 3 and Fig. 3). There is no significant difference of knee flexion ROM between group 1 & group 2 postoperatively (Table 5 and Fig. 4). But, it shows a significant increase in pain relief scores during activity and at rest in group 1 than group 2 at day 6 postoperative as shown in (Table 5 and Fig 5). The confidence level was at 95% ($p>0.05$).

### Table (1): Baseline characteristics of study patients.

<table>
<thead>
<tr>
<th>Group Patients</th>
<th>Group 1 Mean ± (SD)</th>
<th>Group 2 Mean ± (SD)</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>69.1±8.3</td>
<td>68.2±6.8</td>
<td>0.417</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>76.1±7.5</td>
<td>105.7±6.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.3±8.3</td>
<td>166.2±7.1</td>
<td>0.064</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27.9±2.0</td>
<td>38.4±1.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>N</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

SD : Standard deviation.
BMI : Body mass index.

### Table (2): Difference between group (1 & 2) preoperatively.

<table>
<thead>
<tr>
<th>Preoperative HSS scale</th>
<th>Median &amp; interquartile range Group 1 (n=20)</th>
<th>Median &amp; interquartile range Group 2 (n=20)</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supine-to-sit</td>
<td>3 (2 to 6)</td>
<td>5 (2 to 6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sit-to-stand</td>
<td>3 (2 to 6)</td>
<td>5 (2 to 6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ambulate 15 feet</td>
<td>3 (2 to 6)</td>
<td>2 (0 to 6)</td>
<td>0.029</td>
</tr>
<tr>
<td>Climb up and down three steps</td>
<td>2 (1 to 6)</td>
<td>2 (0 to 6)</td>
<td>0.109</td>
</tr>
<tr>
<td>Total functional score</td>
<td>11 (7 to 24)</td>
<td>10 (8 to 16)</td>
<td>0.224</td>
</tr>
</tbody>
</table>

### Table (3): Pre-operative and Post-operative differences within group 1.

<table>
<thead>
<tr>
<th>HSS scale</th>
<th>Median &amp; interquartile range (Pre-operative)</th>
<th>Median &amp; interquartile range (Post-operative)</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supine-to-sit</td>
<td>3 (2 to 6)</td>
<td>5 (2 to 6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sit-to-stand</td>
<td>3 (2 to 6)</td>
<td>5 (2 to 6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ambulate 15 feet</td>
<td>3 (2 to 6)</td>
<td>5 (2 to 6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Climb up and down three steps</td>
<td>2 (1 to 6)</td>
<td>4 (0 to 6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Total functional score</td>
<td>11 (7 to 24)</td>
<td>19 (8 to 24)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

### Table (4): Pre-operative and Post-operative differences within group 2.

<table>
<thead>
<tr>
<th>HSS scale</th>
<th>Median &amp; interquartile range (Pre-operative)</th>
<th>Median &amp; interquartile range (Post-operative)</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supine-to-sit</td>
<td>3 (2 to 6)</td>
<td>5 (2 to 6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sit-to-stand</td>
<td>3 (2 to 6)</td>
<td>4 (2 to 6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Ambulate 15 feet</td>
<td>2 (2 to 6)</td>
<td>3 (2 to 6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Climb up and down three steps</td>
<td>2 (1 to 6)</td>
<td>3 (0 to 6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Total functional score</td>
<td>10 (7 to 24)</td>
<td>15 (8 to 24)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

### Table (5): Difference between group (1 & 2) post operatively.

<table>
<thead>
<tr>
<th>HSS scale</th>
<th>Post-operative outcomes</th>
<th>Group 1 (n=20) Mean±(SD)</th>
<th>Group 2 (n=20) Mean±(SD)</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee flexion ROM</td>
<td>74±3.2</td>
<td>69±3.3</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Pain scores During activity</td>
<td>15±1.5</td>
<td>9±1.2</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Pain scores at rest</td>
<td>17±1.3</td>
<td>13±1.1</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

HSS: Hospital for special surgery. * Grades: No pain, 15 points. Mild pain, 10 points. Moderate pain, 5 points. Severe pain, 0 points.
Fig. (1): Baseline characteristics of group 1 & group 2.

Fig. (2): Functional scores in HSS scale in group 1 & group 2.

Fig. (3): Total functional scores of HSS scale in group 1 & group 2.

Fig. (4): Knee flexion ROM in group 1 & group 2.

Fig. (5): Post-operative pain during activity and at rest in group 1 & group 2.

**Discussion**

The relationship between body mass index and physical therapy for total knee arthroplasty (TKA) results is of increasing importance. As many patients for TKA had osteoarthritis due to gained weight and high BMI, leading to increased pressure over some areas of the articular cartilage [22].

In addition to difficulties with anesthesia, baseline pulmonary dysfunction, and hypercoagulability, the large tissue mass at the incision site have been hypothesized to contribute to higher complication rates in elevated body mass index patients group [16,25,26].

The relationship between initial function and functional outcome following TKA also has impli-
cations for identifying those patients who might or might not require further inpatient rehabilitation [17].

The results of this study are contradicted with, long-term outcome studies which have shown that obese TKA patients do as well as their nonobese counterparts in terms of patient satisfaction, quality of life and wear of the implanted components. Also, long duration of rehabilitation after TKA can ameliorate the effectiveness of physical therapy results and improve the function [22,26-28].

Two previous studies have investigated the effects of obesity on inpatient rehabilitation outcomes in total hip arthroplasty patients. Jibodh et al., [25] reported that obesity did not delay early functional recovery from surgery in total hip arthroplasty patients. They indicated that planning of inpatient rehabilitation programmes should not be based on obesity status. Conversely, De Pablo et al., [29] showed that obesity is an independent predictor of discharge to an inpatient rehabilitation facility after primary total hip arthroplasty. They suggested that obesity may impair functional ability, and obese patients undergoing total hip arthroplasty may need more professional assistance for recovery after surgery.

The present study found that obesity had significant contribution to the physical therapy outcomes of inpatient rehabilitation following TKA. Survey data indicated that supine-to-sit, sit-to-stand, ambulation, and stair climbing were the criteria used for discharging TKA patients from physical therapy during hospitalization. The HSS scale is valid and reliable [30].

As such, they were used in this study to determine physical function and to shed some light about the effectiveness of low BMI on the success of physical therapy rehabilitation. The present study found higher significant differences of low BMI group than high BMI group in post-operative functional recovery levels. However, the functional scores showed that both over weight and moderate obese patients require assistance with the basic tasks of standard transfers, ambulation and stair climbing after TKA. Knee flexion range of motion is often used as the primary outcome measure, evaluating short-term effectiveness (measured at discharge) [19].

In addition, discharge from hospital is dependent on the mobility of patients following TKA [31]. Range of knee flexion at discharge was similar in both groups of patients (there was no significant difference), with both groups achieving the recommended 65-70° of active flexion before discharge. In some studies, this range of motion varied from 61 to 80° after TKA [9,14,19].

The patients in present the flexion range of motion had been decreased the post-operatively than preoperatively.

In the present study, these values had been reached by the time of discharge but knee flexion range of motion had been decreased postoperatively than preoperatively. The findings of the present study were in consistent with the findings of Beaufre et al., [33] and Lorentzen et al., [32] They found that obesity status can affect improvements in knee flexion range of motion during the rehabilitation process. Flexion knee range can be affected and diminished in early phase of physical therapy after knee surgery. In increased BMI the bulk of soft tissue behind knee region can show this decreased knee flexion range especially with the presence of pain after anterior approach of knee surgery [32,33].

Functional movements, knee flexion, and pain during activity and rest which were used to determine the level of results of early physical therapy after TKA were easier to be performed after surgery in patients with low BMI than the other group. So, the first group could collect additional points during evaluation process and higher improvement significantly than the second group at discharge [25].

Reducing pain in the first group more than the second group postoperatively at discharge was attributed to high pressure between the original bones, femur and tibia, and connected prosthesis when weight bearing was loaded, also due to stress on the newly operated ligaments and capsules around knee joint. The results assured also, that both groups had a significant improvement in pain relief at discharge than preoperative. Pain in osteoarthritic knee (preoperative) is caused by developed osteophytes and from degenerated joint capsule and ligaments [32,33].

Conclusions:

The results of this study revealed that decreased BMI is more effective for physical therapy outcomes during the hospitalization period in basic functional activities and pain relief than the increased BMI after total knee arthroplasty. By these findings the patients who will undergo TKA should follow weight reduction program to decrease their BMI before the surgery to get high results of physical therapy rehabilitation.
Acknowledgment:

The authors are thankful to Dr. Ahmed Fawzy Ghonaim, Lecturer of Mathematics, Math Department Helwan University.

References


Appendix I

<table>
<thead>
<tr>
<th>Functional grade definition</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 : Not tested.</td>
<td>A patient who is not tested for reasons of safety, determined by the therapist’s judgment.</td>
</tr>
<tr>
<td>1 : Failed maximal assistance</td>
<td>An activity that is attempted but is not completed, even with maximal assistance</td>
</tr>
<tr>
<td>2 : Maximal assistance</td>
<td>The therapist provides a total of three or more points of contact or help with the patient.</td>
</tr>
<tr>
<td>3 : Moderate assistance</td>
<td>The therapist provides two points of contact or help with the patient</td>
</tr>
<tr>
<td>4 : Minimal assistance</td>
<td>The therapist provides one point of contact or help with the patient</td>
</tr>
<tr>
<td>5 : Stand by assistance</td>
<td>The therapist would not feel comfortable leaving the patient; the therapist, however, provides no physical assistance.</td>
</tr>
<tr>
<td>6 : Independent</td>
<td>The therapist could leave the room and the patient could safely perform the activity being assessed.</td>
</tr>
</tbody>
</table>