THE ROLE OF BODY MASS INDEX (BMI) ON TOTAL KNEE REPLACEMENT REHABILITATION

A Report of a Senior Study

by

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Fall, 2010

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ABSTRACT

In the last 20 years, the demand for total knee replacements has risen and is expected to continue rising. This increase in demand can be attributed to the increased diagnosis of osteoarthritis, increased rate of recovery after surgery, and better surgical techniques utilized by surgeons. The objective of this study was to determine the influence of body mass index (BMI) on the time for total knee replacement rehabilitation in an outpatient setting. Information including gender, height, weight, age, and range of motion (ROM) at evaluation and discharge was obtained for 26 patients from two physical therapy clinics. ROM was a measure of success in this study with a successful total knee replacement rehabilitation achieving 0-110˚ ± 5 in flexion and extension. Age, gender and BMI were analyzed to determine their role in total knee replacement rehabilitation time. Age was found to have an inverse relationship, with the elderly patients gaining full range of motion quicker than the younger patients ($p=0.046$), but there was no apparent relationship between gender and rehabilitation time ($p=0.530$). BMI did play a role in rehabilitation time, with higher BMI's requiring more time for total rehabilitation ($p= 0.044$). As BMI is one of the few characteristics that is modifiable prior to surgery, this influence of BMI on total knee replacement rehabilitation time is significant. A more successful rehabilitation could occur if surgeons informed patients that a reduction in weight would greatly improve their chances for rehabilitation success.

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ACKNOWLEDGEMENTS

I would sincerely like to thank Blount Memorial Total Rehabilitation at Springbrook and Total Rehabilitation-Cherokee for providing the data for this study. Specifically I would like to thank James Robbins (Springbrook), Justin Robbins (Springbrook), Joe Black (Cherokee), Crystal Robinson (Cherokee) and the rehabilitation teams at Blount Memorial Total Rehabilitation at Springbrook and Total Rehabilitation-Cherokee for their help and guidance in this project. This thesis would not have been possible without them.

I would also like to thank my thesis advisor Dr. Drew Crain, who has provided much intellect, insight and encouragement to me throughout this process.

INTRODUCTION

The demand for total knee replacements has increased in the last 20 years and is expected to continue rising. A study in Wisconsin showed that the rate of total knee replacements nearly doubled in the last decade, with the number of total knee replacements increasing from 162 to 294 per 100,000 (Mehrotra et al, 2005). This increase was most prevalent in individuals over 55 years of age. Joint replacement surgeries help alleviate pain, improve the function of the joint, and increase the mobility of the individual. These surgeries have also become more cost-effective and are shown to increase the overall quality of life for the individual (Healy et al, 2001). After knee replacement, there are improvements in duration of exercise, ability to lift a heavier load, and many individuals lead a much more active lifestyle.

Osteoarthritis

There are multiple causes for the increased demand for total knee replacements, including increased diagnosis of osteoarthritis, increased rate of recovery after surgery, and better surgical techniques. The majority of all joint replacements are performed because of osteoarthritis, with estimates between eighty-five and ninety-five percent of all people requiring a total knee replacement being diagnosed with osteoarthritis (Hunter and Felson, 2006). Osteoarthritis is a condition of the entire joint consisting of the articular cartilage, subchondral bone, menisci, ligaments, periarticular muscle, capsule, and synovium (Hunter and Felson, 2006). This condition often causes pain, stiffness, and inflammation of the joint.

Osteoarthritis is the most commonly treated medical condition for individuals older than 65 and is most prevalent in individuals who are advanced in age, female, have a higher BMI, or have a history of previous injury. As individuals age, the cartilage begins to degrade from extended use. The cartilage is also undergoing morphological changes that are due to the decrease of mitotic activity, and the inability to repair and maintain tissue (Ding et al, 2007). This leads to grinding of the bone and can progress to severe osteoarthritis with the amount of cartilage continually decreasing as the individual ages (Ding et al. 2007). Osteoarthritis is also influenced by weakening of the quadriceps muscle which leads to overall instability of the knee. (Rudolph et al, 2007).

The incidence of osteoarthritis for women and men are equal until the age of 50. However, at the onset of menopause women have more cases of osteoarthritis than men due to the altered hormone activity associated with menopause (Wluka et al, 2000). Prior to menopause, estrogen receptors present in the articular chondrocytes upregulate proteoglycan synthesis. So, as the levels of estrogen plummet during menopause the volume of articular cartilage is decreased (Abramson and Attur, 2009).This is supported by radiographic evidence showing that men have a larger cartilage volume than women than post-menopausal women (Ding et al, 2007). Hormone replacement decreases this degradation, so post menopausal women on hormone replacement therapy have a higher cartilage volume than women that are not on hormone replacement (Ding et al, 2007).

Increased body mass index is another risk factor for osteoarthritis. Body mass index is calculated using height and weight. Table 2 in Appendix A shows the body mass index table. Overweight individuals with a BMI greater than 27 kg/m^2 are more likely to show symptoms of knee osteoarthritis (Reijman et al, 2007). This relationship is due to the excess amount of weight that the joint is sustaining (Liu et al. 2007). The risk of severe osteoarthritis is almost doubled with an increase of 5 kg/m^2 (Jarvholm et al, 2005). Also, factors such as IL-6 and C-reactive protein are derived from adipocytes and are pro-catabolytes for chondrocytes, causing cartilage degradation (Abramson and Attur, 2009).

Recent studies have shown a significant correlation between history of injury to a joint and the occurrence of osteoarthritis. When trauma is inflicted on a joint, it can lead to tearing of cartilage, stretching of ligaments, injury of bone, rupture of the synovial membrane, and damage to the surrounding muscles. The aforementioned injuries can lead to compromised integrity of the joint and osteoarthritis (Gelber et al. 2000). Repair of anterior cruciate ligament and meniscal tears often lead to osteoarthritis several years after surgery. This is common in 60-90% of patients 10-15 years after surgery (Roos et al, 1995). The correlation between previous injury and osteoarthritis can be further seen in table 1.

Table 1: Previous Injury and the risk of developing osteoarthritis.

Injury	**Notes**	**Reference**
Meniscal Tear	Long term effects of a total meniscectomy show a higher rate of severe osteoarthritis than those patients who have had a	Englund et at. (2001)

	partial meniscetomy.	
ACL injury	More than 50% of 20-40 year old female soccer players, players who had obtained ACL injury 12 years prior to the study were diagnosed with radiographic osteoarthritis.	Lohmander et al. (2004)
ACL injury	In 60-90% of injuries to the collateral ligaments and menisci lead to osteoarthritis 10-15 years after the injury was sustained.	Roos et al. (1995)
Joint Trauma	81% of individuals that sustained joint trauma at an earlier age were diagnosed with radiographic osteoarthritis.	Gelber et al. (2000)
Cartilage degradation due to long term use	Many athletes are diagnosed with osteoarthritis because of severe cartilage degradation due to long term daily use.	Manninen et al. (2001)

Surgical Procedure

Total knee arthroplasty is the replacement of both articular surfaces of the knee with a metallic prosthesis to increase efficiency of the knee and decrease pain (Townley and Hill, 1974). Need for a total knee replacement is based on age, general heath, and pathology of the affected knee (Townley and Hill, 1974). This procedure begins with an incision greater than 10 cm along the length of the patella. Patellar eversion is required to access the ends of the tibia and femur (Bonutti, 2004). The articular surfaces of these bones are exposed by dislocating the joint, and the bone ends are removed with an oscillating bone saw. The prosthesis is cemented into the knee and fitted with a polyethylene spacer to keep correct tension in the remaining ligaments and tendons (Townley and Hill, 1974). The splitting of the quadriceps muscle and the eversion of the patella increase rehabilitation time. In some total knee replacements, patellar resurfacing is performed. This is done by removing articular cartilage and subchondral bone from the patella and cementing a polyethylene domed component to the back of the patella (Feller et al. 1996). The incision length at the end of the procedure is 7-8 inches (J. Robbins pers. Com, 2010).

Figure 1 shows the typical total knee replacement prosthesis and the prosthesis inserted in the tibia and femur.

Figure 1: Typical total knee replacement prosthesis alone and inserted in a tibia and femur (Kienzle et al., 1995).

An alternative replacement procedure gaining popularity is the minimally invasive total knee replacement. The first benefit of this procedure is decreased incision length, as the final incision length of this procedure is typically 6-11cm (Bonutti, 2004;

see Figure 2). Many of the soft tissues are spared in this procedure, mainly the quadriceps muscle which is split during a typical total knee replacement. Another benefit is the *in situ* removal of bone ends which removes the need for joint dislocation. Success has been documented with a 97% approval rating. Interest is growing and expected to continue because of the increased rate of rehabilitation and the decrease in postoperative pain (Bonutti, 2004). Many surgeons are beginning to use a combination of the two procedures, where the incision length is greater than the minimally invasive but the quadriceps muscles is not split and the patella is not everted. This allows the surgeon to have full visual access of the knee without the harmful effects of the invasive total knee arthroplasty (Morgan pers. com 2010)

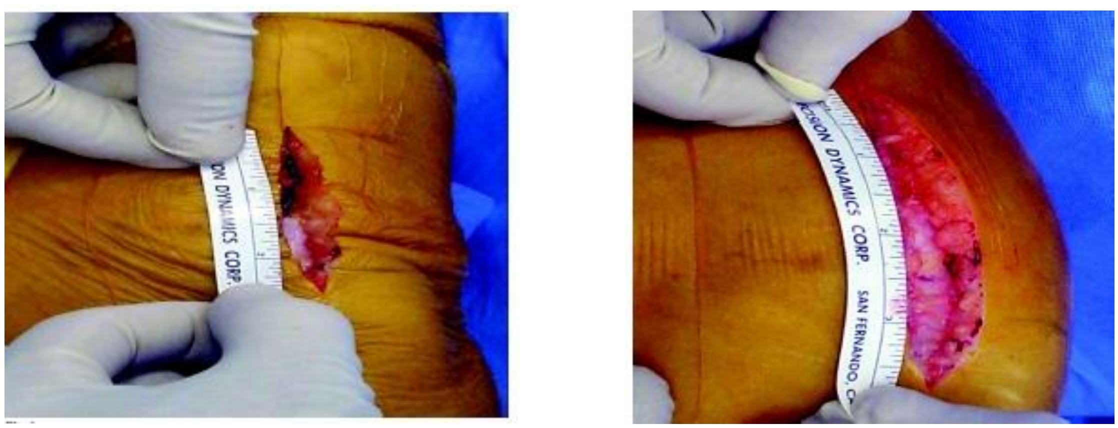


Figure 2: Incision for the minimally invasive total knee replacement in both extension and flexion (Bonutti et al., 2004).

The main type of prosthesis for a total knee replacement is the bicondylar unconstrained replacement with a polyethylene spacer to keep correct tension in ligaments and tendons (Gidwani and Fairbank, 2004). This prosthesis is used to keep the anatomical structure of the knee (Insall et al, 1976). When resurfacing of the patella is included in the surgery, a polyethylene patellar button is added to aid in patellar movement (Gidwani and Fairbank, 2004).

After the surgery is performed, a rehabilitation regimen begins. This usually follows the progression of continuous passive range of motion, inpatient care, and discharge followed by either aqua therapy or home health, and concluded with rigorous outpatient care. Not all post-operative procedures follow this progression, and many are very different due to the specialized needs and condition of the patient.

Rehabilitation

Several indices are commonly used to evaluate rehabilitation success, including a range of motion with full extension and flexion of 120˚. The process to obtain these endpoints typically begins the first few days after surgery, and there is a twelve week window where major steps in rehabilitation can be made. The first focus during this period of time is gaining full range of motion (ROM), the second goal is strengthening the muscles that surround the joint.

Typically after the total knee replacement is performed, the patient is placed on a continuous passive motion machine. This machine is motorized, and allows the knee to be moved passively through an entire arc of motion (Lenssen et al, 2008). This motion is beneficial for the short term, but it is not chronically beneficial in gaining range of motion (Lenssen et al, 2008).

Aquatic therapy is sometimes used for patients after a total knee replacement. Aquatic therapy can provide many advantages that land based therapy cannot offer. The patient is more buoyant in the water and this buoyancy increases the deeper the patient is submerged (Hinman et al, 2007). The resistance of the workout can be increased by increasing the current of the water; this allows for different levels of aquatic workout to strengthen the muscles around the knee before transitioning to land based therapy (Hinman et al, 2007).

Swelling must be reduced in order for the knee to increase its ROM, and this can be accomplished through the use of anti-inflammatory drugs, ice, and elevation. Once the swelling is controlled, the physical therapist can fully concentrate of gaining ROM. Amounts of flexion needed for daily life vary on the activities performed. Studies have demonstrated that a range of 67˚-93˚ is needed in order to have a normal gait, climb and descend stairs, and rise from a chair (Chiu et al, 2002). Knees without injury typically have a range of motion from 0-140˚. Patients who have undergone total knee replacement are not required to regain all of the motion; however, they are encouraged to gain a range of 0-120˚.

There are many different ways that range of motion can be restored. One common element used in numerous physical therapy protocols is the use of a stationary bicycle (McLeod and Blackburn, 1980). There can be many different alterations to the bicycle as therapy progresses. These include changing seat heights, petal positions, and resistance. One of the main advantages of the bicycle is that it allows improvements to be made in range of motion while the muscle strength is gained in the quadriceps muscle (McLeod and Blackburn, 1980). One revolution of the bicycle takes approximately 100˚ of flexion, and the degrees of extension can be varied by changing the seat height (McLeod and Blackburn, 1980).

In some cases, range of motion is difficult to regain after the total knee replacement, and surgeons may consider manipulation if 90˚ of flexion is not achieved within 10-14 days of the surgery (Panni et al, 2009). Closed manipulation is best if used in the first three months following the operation (Valle et al, 2007). Manipulation is very painful and is considered to be a last resort if the patient is not achieving the desired results by the rehabilitation performed by the physical therapist. This procedure is performed under local anesthesia to decrease pain and relax the muscles for maximum flexion (Panni et al, 2009). Surgeons push the knee to maximum flexion and gently apply force to the knee to destroy the connections that have been made to the suprapatellar pouch (Panni et al, 2009). This procedure is repeated several times to make sure all the connections are destroyed. After the manipulation the patient is placed on a continuous passive range of motion machine that is set to the maximum flexion and extension achieved during the procedure (Panni et al, 2008). Manipulation increases the maximum flexion of the knee an average of 35˚ (Panni et al, 2008).

After adequate ROM has been restored, the main focus of the physical therapist is to build strength. Quadriceps femoris weakness is a typical problem with a total knee replacement due to the splitting of the muscle during surgery. In many cases strengthening exercises performed at the physical therapy clinic three times a week and assigned daily exercises are enough to strengthen the muscle. In other cases the exercises are not enough to regain all the muscle strength required. In cases such as this neuromuscular electrical stimulation (NMES) can be used (Lewek et al, 2001). With the use of NMES patients can regain greater strength in a shorter period of time in the quadriceps femoris muscle than with strengthening exercises alone (Lewek et al, 2001).

There are many different strengthening exercises that are prescribed by physical therapists. Appendix B illustrates a pamphlet given to the patient to visualize exercises to be performed at home (Saunders Exercises Xpress). Exercises are not limited to the sixteen listed, however these are the most common. The main goal of these home exercises is to reinforce the exercises performed during the physical therapy session. These exercises focus on increasing blood flow to the leg after surgery, strengthening of the muscles that surround and support the knee, and maintaining flexion through stretching.

Factors that influence rehabilitation success

Outpatient physical therapy is usually performed two to three times per week for a one hour session. The frequency of physical therapy sessions differ for each patient based on physical and financial constraints. Outcomes for outpatient physical therapy vary depending on the work ethic of the patient and how much out-of-clinic time is spent stretching and strengthening the knee.

BMI is an important factor that could influence the overall success of physical therapy after a total knee replacement. Patients that are severely obese typically have more revision surgeries for mechanical reasons, and this is a factor that usually delays rehabilitation time (Vincent and Vincent, 2008). In inpatient care, body mass index does not appear to prevent gains of functionality of the patient; however, the degree of these gains is dependent on BMI (Vincent and Vincent, 2008). Functional independence is found to be higher in patients of a normal weight <25kg/m and the severely obese group with a mean BMI of 45.9 kg/m had the lowest score of functional independence (Vincent and Vincent, 2008). It is also predicted that obese patients have a 2.8 greater chance of using walking aid after therapy than non-obese patients (Naylor et al, 2008). An increased BMI leads to excessive pressure placed on the newly replaced knee, and could influence the rate and success of the rehabilitation.

Research Question

Typically after the surgical procedure, physical therapy is required in the forms of inpatient therapy, home therapy, aquatic therapy, and outpatient therapy. Several factors influence rehabilitation success after surgery, one of which could be BMI. The purpose of this study is to gather more information about the role of BMI on outpatient rehabilitation. More research is needed on this topic because if body weight is shown to influence rehabilitation success, then it could be factored into the rehabilitation plan or even modified prior to or during the rehabilitation period to influence rehabilitation success. The present study will focus on the progression of the patient through various checkpoints, and the success of rehabilitation will be measured by the range of motion and the presence or absence of a walking aid. These measures are important because ROM and the ability of the joint to bear weight are important indicators of the functionality of the joint.

MATERIALS AND METHODS

Data Collection

<u>Participants</u>

Data was collected from patients that underwent outpatient physical therapy for total knee replacement at either Blount Memorial Outpatient Rehabilitation at Springbrook (220 Associates Blvd. Alcoa, TN 37701) or Total Rehabilitation-Cherokee (1412 Sevierville Rd. Maryville, TN 37804). Patient selection occurred from April 2010-October 2010. For each patient, age, gender, height, weight, walking aid information, and range of motion at both evaluation and discharge were noted by the physical therapist. As dictated by the institutional review board (see Appendix C), the data received from the therapy clinics did not have any identification on them and remained anonymous throughout the study. Information was gathered on a total of 47 patients. Total Rehabilitation-Cherokee provided information on 36 patients, and Blount Memorial Outpatient Rehabilitation at Springbrook provided information on 11 patients. Only patients arriving at the outpatient facility within 2 weeks of surgery were included in this study. Data from patients were placed in an excel chart, and individuals with unsuccessful total knee rehabilitations were removed. Successful total knee rehabilitation was characterized by obtaining 0-110˚± 5 in range of motion. Also, one patient was removed from the overweight group as a statistical outlier, according to the Grubb's outlier test (z=2.46). This created the final sample size of 26.

Data Recording

<u>Range of Motion Measurement</u>

The physical therapist measured range of motion with a goniometer (Fig 3). The patient was placed in the supine position with the stationary arm of the goniometer placed on the greater trochanter of the femur; the axis placed on the lateral epicondyle, and the movable arm is placed in alignment with the lateral malleolus of the ankle (Kosmahl, E.M. 1999). Flexion occurs at the hip, and the knee and the angle is measure at the knee. The range of motion was assessed at evaluation and discharge. Successful rehabilitation was defined as having full extension (0˚) and flexion of 110 ± 5˚.

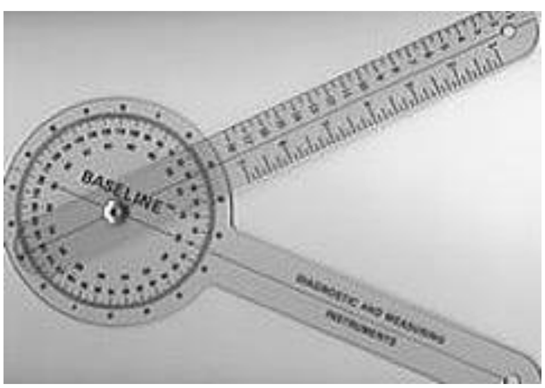


Figure 3: Goniometer used to measure range of motion (ROM) of the knee. (Picture provided by www.thehumansolution.com).

<u>Use of walking aid</u>

The other factor that assesses the functionality of the joint after total knee replacement rehabilitation is the ability of the joint to bear weight. Because of this the second criteria that determines successful rehabilitation is the absence of walking aid. Date of walking aid abandonment was recorded for each patient. The type of walking aid was also recorded throughout the rehabilitation. In order to quantify this information, numerical values were designated for each type of walking aid based on the degree of assistance. These numerical values range from 4 (maximum assistance) to 0 (no assistance). Table 2 presents the values placed on walking aids.

Table 2: Numerical values placed on walking aids.

Walking Aid	Assistance Value
Wheelchair	4
Rolling walker	3
Quad cane	2
Straight cane	1
No aid	0

Statistical Analysis

In Microsoft Excel, data were grouped into different BMI categories: normal, overweight, obese, and very obese. A Grubb's outlier test was performed to determine the outliers of the sample. A one-way ANOVA was used to determine significant differences among normal, overweight, obese, and very obese BMI categories, whereas 2-tailed t-tests assuming equal variance were performed on the following categories to determine if there was significant variation between the groups: age and rehabilitation time, BMI and rehabilitation time, gender and rehabilitation time, and gender and BMI. Simple linear regression analysis was performed to determine the relationship between

BMI and rehabilitation time, and age and rehabilitation time. To look at the relationship of BMI, and age on walking aid usage, the change in walking aid values were obtained (value at evaluation – value at discharge). Simple linear regression analysis was performed to determine the relationship between the change in walking aid values and BMI and age. For all statistical tests, $p<0.05$ was designated as the demarcation for significance.

RESULTS

A moderate correlation (r^2=0.159) and a statistically significant relationship (p=0.044) was shown between BMI and rehabilitation time. Patients with lower body mass indices achieved successful rehabilitations over shorter periods of time (Fig 3). A significant inverse relationship was found between rehabilitation time and age (p=0.044), with older patients having shorter rehabilitation time (Fig 4). The data also showed that individuals with a BMI $\leq$ 29 have a shorter rehabilitation time than individuals with a BMI > 30 (Fig 5).

There was no difference in rehabilitation time among normal, overweight, obese, and very obese groups as the very obese and normal group had 4 and 5 individuals respectively (p=0.07); however, this is likely due to inadequate sample size (Fig 6). There was no statistical difference between BMI of males and females in this study (p=0.26), and therefore a comparison of gender on rehabilitation time was performed (Fig 7). No statistical difference in rehabilitation time between men and women was found (p=0.53, Fig 8).

Table 3 presents results for use of walking aid pre- and post-rehabilitation. Walking aid use was significantly reduced after rehabilitation (p=1.89E-05). Because of the nearly 100% walking aid abandonment neither gender, age nor BMI appeared to have an influence on the final use of a walking aid. However, the change in levels of walking aids from evaluation to discharge did vary with age, with the younger population having a larger change in walking aid usage from evaluation to discharge (p=0.006). There was no relationship between change in walking aid usage and BMI (p=0.82).

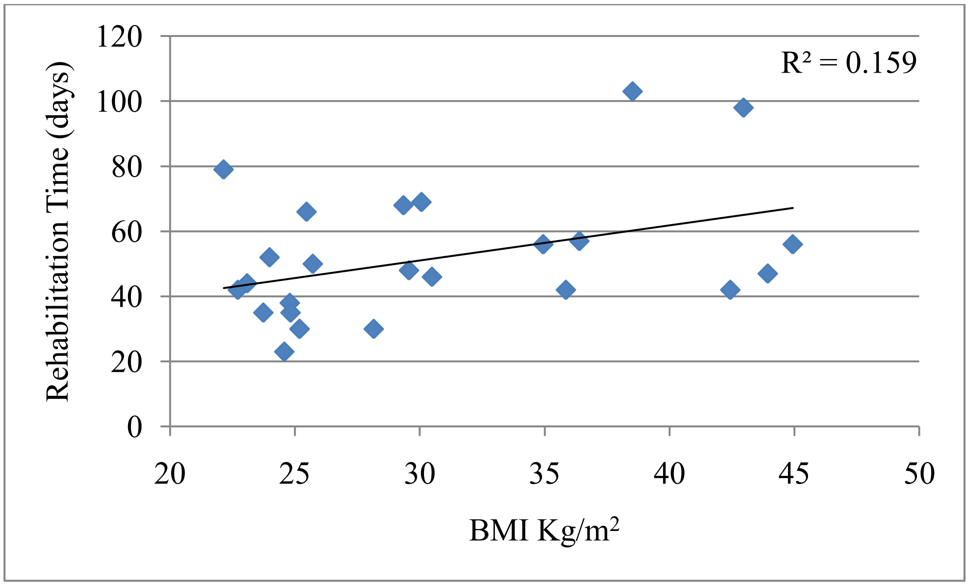


Figure 4: Correlation between BMI and rehabilitation time. The data was found to be significant. (p= 0.043577)

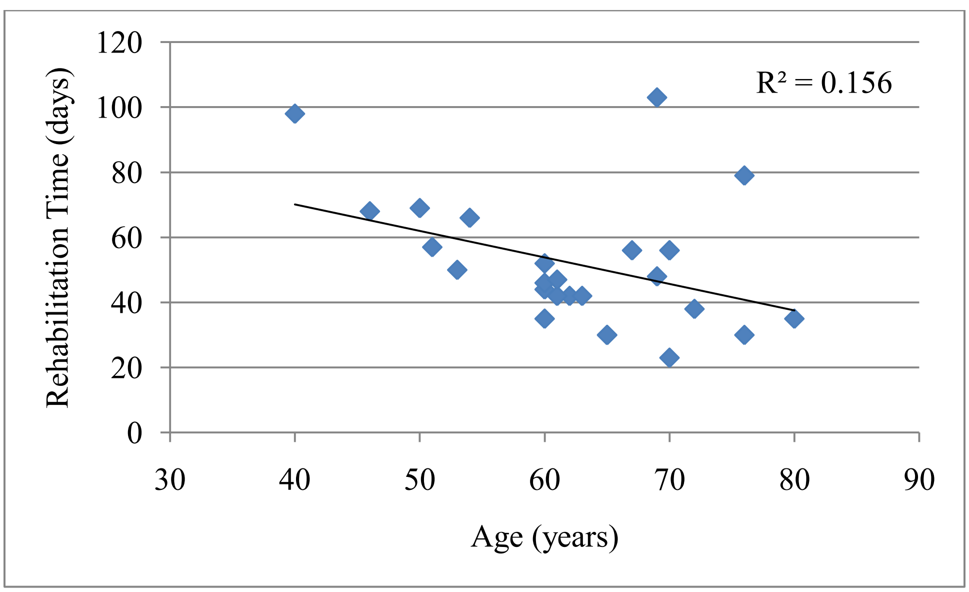


Figure 5: Correlation between age and rehabilitation time. The data was found to be significant. (p= 0.045869)

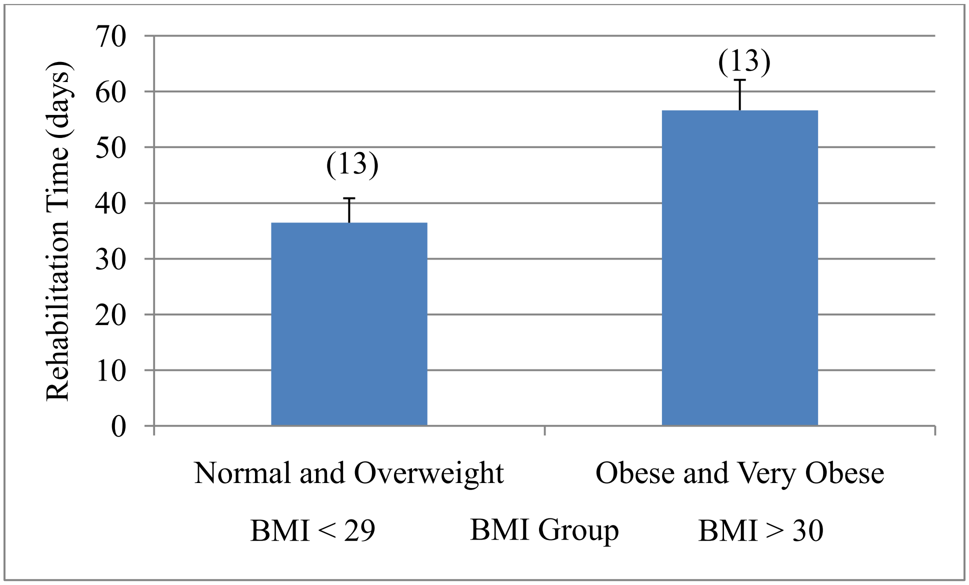


Figure 6: Average rehabilitation times for two different BMI categories. Parentheses denote sample size. The difference between the groups was significant. (p= 0.016865)

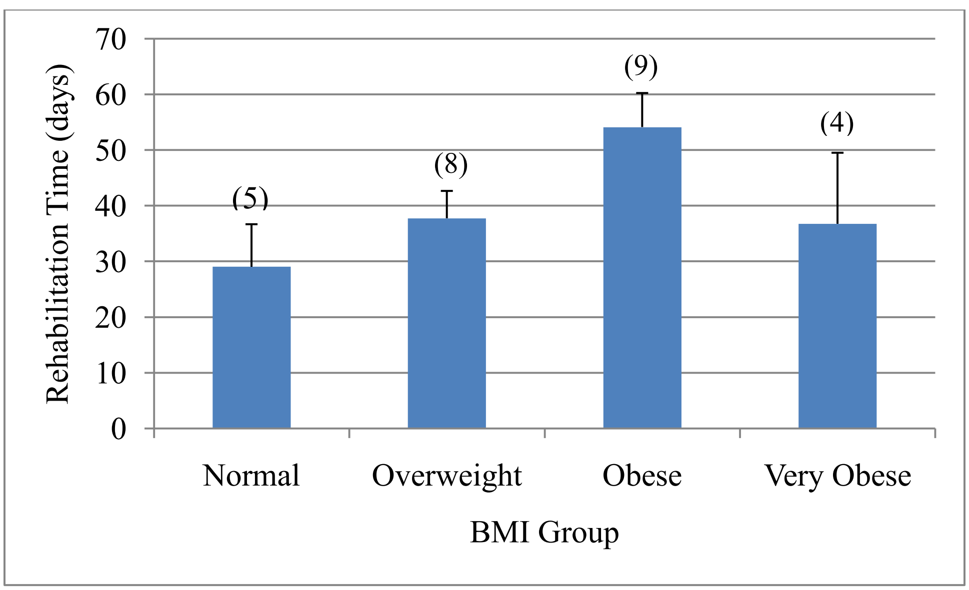


Figure 7: Average rehabilitation times for four different BMI categories. Parentheses denote sample size. There was no significant difference between the groups. (p= 0.073454)

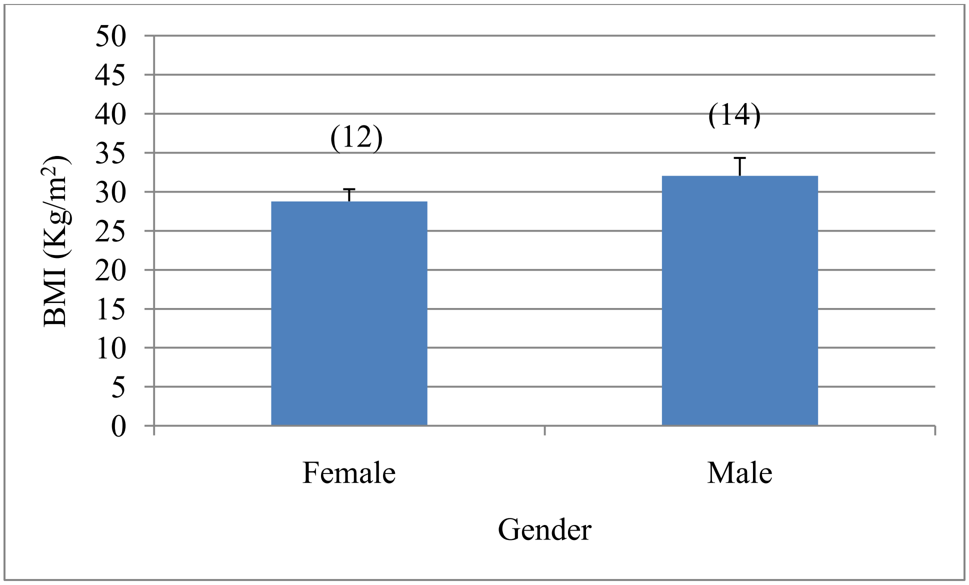


Figure 8: Average BMI for males and females. Parentheses denote sample size. There was no significant difference between the groups (p= 0.263359).

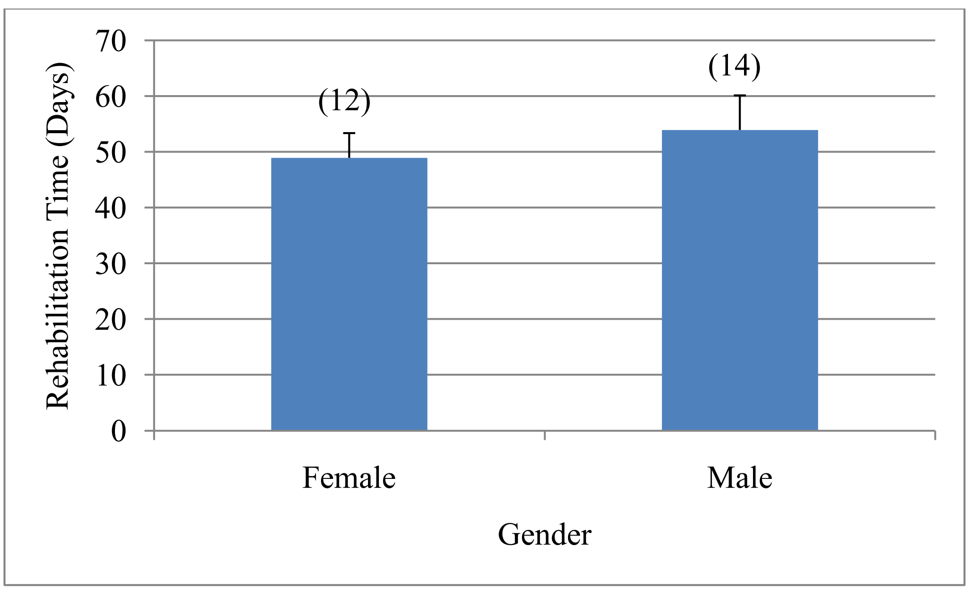


Figure 9: Average rehabilitation time for males and females. Parentheses denote sample size. A There was no significant difference between the groups (p= 0.530278).

Table 3: Relationship between BMI, Gender, and Age with pre and post surgery walking aid use. (Refer to table 2 for a description of designated values)

BMI (Kg/m^2)	Gender	Age	Pre-Rehabilitation	Post-Rehabilitation
42.96	M	40	3	0
29.35	M	46	3	0
30.07	M	50	3	0
36.39	F	51	3	1
25.72	F	53	3	0
25.47	F	54	0	0
30.49	M	60	0	0
23.09	M	60	1	0
23.74	M	60	3	0
23.99	M	60	0	0
43.93	M	61	3	0
35.85	F	61	0	0
22.72	F	62	3	0
42.43	M	63	3	0
25.19	M	65	3	0
25.19	M	65	0	0
44.93	M	67	3	0
38.52	M	69	0	0
29.57	F	69	3	0
34.94	F	70	0	0
34.94	F	70	0	0
24.58	F	70	0	0
24.80	F	72	0	0

Table 3 (cont.)

BMI (Kg/m^2)	Gender	Age	Pre-Rehabilitation	Post-Rehabilitation
28.16	F	76	0	0
22.15	F	76	3	0
24.83	M	80	0	0

DISCUSSION

The results from this study show that body mass index (BMI) significantly influences the time it takes to rehabilitate from a total knee replacement, with individuals with lower BMI's rehabilitating faster than those with higher BMI's. There was also a significant relationship between rehabilitation time and age, with patients more advanced in age having a shorter rehabilitation time. There was no difference between the genders in rehabilitation time, nor was there a difference in BMI's between males and females. These data provide physical therapists and physicians important information that can be used to advise patients before total knee replacement surgery.

Effect of BMI on Rehabilitation Success

While several other studies suggest that BMI influences rehabilitation success, there is no consensus among studies as to this relationship. Table 4 presents a comparison of the studies, their endpoints, and methods. From the articles reviewed, BMI has been shown to have an effect on the morbidly obese specifically including post-operative complications, loosening of the prosthesis, and decrease in gains of functionality. The impact of BMI on total knee replacement rehabilitation is seen in studies that focus on quantitative measures like range of motion versus qualitative measures such as quality of life. Qualitative studies do not show a difference in patients that are obese versus patients with normal BMI's (see Table 4). The current study showed that there was a significant relationship between BMI and rehabilitation time with BMI's greater than 30 kg/m^2 requiring a longer time for a successful rehabilitation.

Table 4: Previous studies on the role of BMI on total knee replacement rehabilitation.

Obesity-influenced rehabilitation	Conclusion	**Methods and Measurement Used**	**Reference**
Yes	A BMI > 30 increases rehabilitation time.	ROM and walking aid use	Clark and Crain (present study)
Yes	The average knee function was statistically lower in the morbidly obese group compared to other groups.	KSS scoring systems (measures ability to walk, climb stairs, pain, ROM, stability)	Armin, A.K et al. (2006)
Yes	Morbidly obese patients are more likely to have complications post operatively. These complications include: problems with wound healing, infection, and MCL avulsion.	Likelihood of post operative complications.	Winarsky et al (1998)
Yes	Patients with higher BMI's are more likely to have poor flexion and range of motion after total knee replacement	Range of Motion	Chiu, K.Y. et al. (2002)
Yes	Lower scores were seen in functionality of the joint, and obese individuals were less likely to be happy with the total knee replacement.	Pain and function, complications, and time to revision	Santaguida, P. et al (2008)
Yes	Obese patients are more likely to have loosening of the prosthesis	HRQoL (health related quality of life)	Escobar A. et al. (2007)

Table 4 (cont)

Obesity-influenced rehabilitation	Conclusion	**Methods and Measurement Used**	**Reference**
No	There is no difference between the obese and non obese group.	KSS scoring system	Armin, A.K. et al. (2006)
No	BMI does not have an effect on rehabilitation outcomes.	Assessment of Functional Independent Measure (overall quality of life)	Vincent, H.K, Vincent, K.R. (2008)
No	There is no statistically significant difference between the clinical outcomes. However, there was a trend toward loosening of the prosthesis in the more obese patients.	Radiographic loosening of the prosthesis, and clinical implications of this loosening.	Foran, J.R.H, et al. (2004)
No	There was not a statistically significant correlation between body mass index and quality of life.	Quality of life as represented by pain and function.	Fitzgerald, J.D. et al. (2004)

Effect of Age on Rehabilitation Success

Age had an effect on rehabilitation success with the more elderly patients achieving full range of motion in less time than the younger patients. Other studies have researched the role that age plays in rehabilitation of total knees, and found that age does not act as a barrier for total knee replacement rehabilitation (Escobar et al., 2007). However, Santaguida et al. (2008) found that elderly patients were more likely to achieve poorer overall functionality of the joint. Jones et al. (2001) found that age does not play a factor in quality of total knee replacement rehabilitation, and that all total knee rehabilitations showed a decrease in pain and stiffness and an increase in function. In a later study Jones showed that overall pain is not significantly worse in older individuals, but there is an increase risk of complications and mortality (Jones et al. 2001). Although some studies suggest that elderly patients will not have as favorable of an outcome as younger patients, several studies support the results of the present study, suggesting that age does not act as a barrier for total knee replacement rehabilitation success.

Effect of Gender on Rehabilitation Success

Data in this study did not show a relationship between gender and rehabilitation time, however other studies have found differences between rehabilitation success of men and women. Women tended to have more pain before surgery, but post-operatively women showed greater gains in functionality (Escobar et al. 2007). Other studies suggest that men make more gains in functionality and benefit more overall from total knee replacements. However, data from the same study showed that men were more likely to require revisions than women (Santaguida et al., 2008). Schurman et al. (1985) showed that even though there were no differences in functional status of total knee replacements, men average 13.4 degrees more flexion than females at evaluation. Since there is no consensus among studies, more research needs to be conducted to determine the role of gender in total knee replacement rehabilitation.

Walking Aid Use

Walking aid use has been used as a determinant of successful total knee replacement rehabilitation. Naylor et al. (2008) found that obese patients were 50% more likely to use walking aids after discharge compared to the non-obese group. Data from the current study showed that younger people had higher change in walking aid values from evaluation and discharge, but there was no significant relationship between changes in walking aid usage regarding neither BMI nor gender.

Recommendations and Conclusions

Based on the results of this study, specific recommendations can be made to surgeons or physicians recommending total knee replacement surgery. Because BMI does have a role on rehabilitation time for total knee replacements, doctors should discuss weight loss with the patients presenting this data. This could greatly improve the individual's chances for successful total knee replacement rehabilitation. Recommendations to physical therapists include the maintenance of rehabilitation plans that are specific to the individual, as observed at Blount Memorial Total Rehabilitation at Springbrook and Total Rehabilitation-Cherokee.

Based on this study, the recommendations that I would make for further research would be to look at the effects of subtle differences in surgical techniques on rehabilitation time. The preferences of the surgeon could play an important role in the rate of total knee replacement rehabilitation, and this factor should be further examined.

This research is particularly relevant due to the increased demand of total knee replacements in the last twenty years. The factors that significantly affected the rehabilitation time for total knee replacement rehabilitation were age and BMI. Age was found to have an inverse relationship with the elderly patients gaining full range of motion quicker than the younger patients. This shows that age does not act as a barrier for successful total knee replacement rehabilitation. However, there was no significant relationship between gender and rehabilitation time. BMI did play a role in rehabilitation time, with higher BMI's requiring more time for total rehabilitation. As BMI is one of the few characteristics that is modifiable prior to surgery, this influence of BMI on total knee replacement is significant. A more successful rehabilitation could occur if surgeons informed patients that a reduction in weight would greatly improve their chances for rehabilitation success.

APPENDIX A

The index table showing ranges of body mass index.

Body Mass Index Table

	Normal						Overweight					Obese										Extreme Obesity														
BMI	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Height (inches)	Body Weight (pounds)																																			
58	91	96	100	105	110	115	119	124	129	134	138	143	148	153	158	162	167	172	177	181	186	191	196	201	205	210	215	220	224	229	234	239	244	248	253	258
59	94	99	104	109	114	119	124	128	133	138	143	148	153	158	163	168	173	178	183	188	193	198	203	208	212	217	222	227	232	237	242	247	252	257	262	267
60	97	102	107	112	118	123	128	133	138	143	148	153	158	163	168	174	179	184	189	194	199	204	209	215	220	225	230	235	240	245	250	255	261	266	271	276
61	100	106	111	116	122	127	132	137	143	148	153	158	164	169	174	180	185	190	195	201	206	211	217	222	227	232	238	243	248	254	259	264	269	275	280	285
62	104	109	115	120	126	131	136	142	147	153	158	164	169	175	180	186	191	196	202	207	213	218	224	229	235	240	246	251	256	262	267	273	278	284	289	295
63	107	113	118	124	130	135	141	146	152	158	163	169	175	180	186	191	197	203	208	214	220	225	231	237	242	248	254	259	265	270	278	282	287	293	299	304
64	110	116	122	128	134	140	145	151	157	163	169	174	180	186	192	197	204	209	215	221	227	232	238	244	250	256	262	267	273	279	285	291	296	302	308	314
65	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300	306	312	318	324
66	118	124	130	136	142	148	155	161	167	173	179	186	192	198	204	210	216	223	229	235	241	247	253	260	266	272	278	284	291	297	303	309	315	322	328	334
67	121	127	134	140	146	153	159	166	172	178	185	191	198	204	211	217	223	230	236	242	249	255	261	268	274	280	287	293	299	306	312	319	325	331	338	344
68	125	131	138	144	151	158	164	171	177	184	190	197	203	210	216	223	230	236	243	249	256	262	269	276	282	289	295	302	308	315	322	328	335	341	348	354
69	128	135	142	149	155	162	169	176	182	189	196	203	209	216	223	230	236	243	250	257	263	270	277	284	291	297	304	311	318	324	331	338	345	351	358	365
70	132	139	146	153	160	167	174	181	188	195	202	209	216	222	229	236	243	250	257	264	271	278	285	292	299	306	313	320	327	334	341	348	355	362	369	376
71	136	143	150	157	165	172	179	186	193	200	208	215	222	229	236	243	250	257	265	272	279	286	293	301	308	315	322	329	338	343	351	358	365	372	379	386
72	140	147	154	162	169	177	184	191	199	206	213	221	228	235	242	250	258	265	272	279	287	294	302	309	316	324	331	338	346	353	361	368	375	383	390	397
73	144	151	159	166	174	182	189	197	204	212	219	227	235	242	250	257	265	272	280	288	295	302	310	318	325	333	340	348	355	363	371	378	386	393	401	408
74	148	155	163	171	179	186	194	202	210	218	225	233	241	249	256	264	272	280	287	295	303	311	319	326	334	342	350	358	365	373	381	389	396	404	412	420
75	152	160	168	176	184	192	200	208	216	224	232	240	248	256	264	272	279	287	295	303	311	319	327	335	343	351	359	367	375	383	391	399	407	415	423	431
76	156	164	172	180	189	197	205	213	221	230	238	246	254	263	271	279	287	295	304	312	320	328	336	344	353	361	369	377	385	394	402	410	418	426	435	443

Source: Adapted from *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report.*

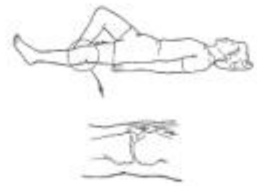
National Heart, Lung and Blood Institute BMI chart

Appendix B: Typical exercises for total knee replacement rehabilitation.

Exercise 1 of 16

DORSI/PLANTAR FLEXION - ACTIVE

1. Bend ankle up toward your body as far as possible
2. Hold _____ seconds
3. Now point toe away from your body
4. Hold _____ seconds
5. _____ repetitions, _____ times per day



Exercise 2 of 16

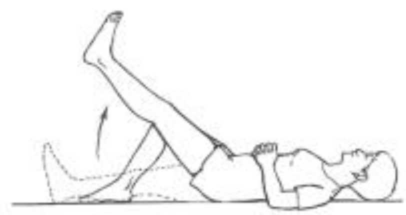
QUAD SETS/EXTENSION

1. Sit or lie on your back with _____ leg straight
2. Press the back of your _____ knee downward
3. This will tighten the muscle on top of your thigh and move your kneecap as shown
4. Hold _____ seconds
5. _____ repetitions, _____ times per day

Exercise 3 of 16

SHORT ARC QUAD/EXTENSION

1. Lie on your back with _____ inch roll under _____ knee
2. Raise heel off floor until knee is straight
3. Hold _____ seconds and slowly lower
4. _____ repetitions, _____ times per day



Exercise 4 of 16

STRAIGHT LEG RAISE

1. Lie on back with _____ knee straight and the other knee bent as shown
2. Keep the leg completely straight, then raise it _____ inches
3. Hold _____ seconds and slowly lower
4. _____ repetitions, _____ times per day

Exercise 5 of 16

KNEE EXTENSION/HAMSTRING

1. Sit with leg propped as shown
2. Relax, letting the leg straighten
3. Lean forward, keeping the back straight
4. Hold _____ seconds
5. _____ repetitions, _____ times per day

Exercise 6 of 16

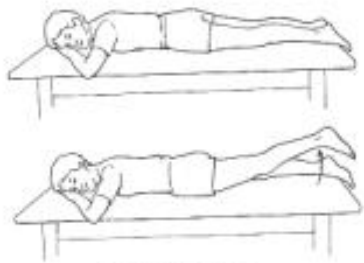
DORSIFLEXION

1. Sit on floor with towel or strap around _____ foot as shown
2. Pull top of foot toward your body so that you feel a stretch
3. Hold _____ seconds, repeat _____ times

Exercise 7 of 16

QUADRICEPS/EXTENSION

1. Sit on edge of table or bed
2. Straighten knee fully
3. Hold _____ seconds and slowly lower
4. _____ repetitions, _____ times per day



Exercise 8 of 16

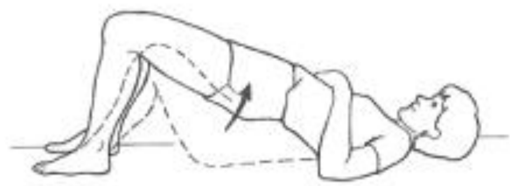
HIP EXTENSION

1. Lie on belly
2. Raise _____ leg off floor as shown
3. Hold _____ seconds, slowly relax
4. _____ repetitions, _____ times per day

Exercise 9 of 16

HIP ABDUCTION

1. Lie on side with _____ leg on top
2. Bend lower leg slightly
3. Raise top leg straight up, without letting it come forward
4. Hold _____ seconds, slowly relax
5. _____ repetitions, _____ times per day



Exercise 10 of 16

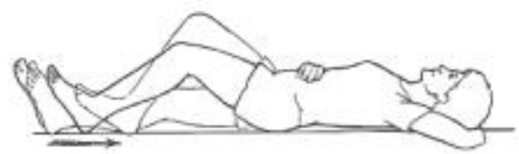
HIP EXTENSION

1. Lie on back with both legs bent as shown
2. Tighten buttocks and raise them off floor as high as you can
3. Hold _____ seconds, slowly relax
4. _____ repetitions, _____ times per day

Exercise 11 of 16

HIP ADDUCTION

1. Sit with ball between knees as shown
2. Squeeze thighs together tightly
3. Hold _____ seconds, slowly relax
4. _____ repetitions, _____ times per day



Exercise 12 of 16

KNEE FLEXION

1. Lie on bed or table as shown
2. Slide your _____ heel up toward your buttocks bending your knee until you feel a stretch
3. Hold _____ seconds
4. _____ repetitions, _____ times per day

*–

Exercise 13 of 16

DORSIFLEXION

1. Position your body against a wall as shown with _____ foot behind
2. Point toes directly toward wall and hold heel down
3. Lean into wall as shown so that you feel a stretch
4. Hold _____ seconds, repeat _____ times□

Exercise 14 of 16

PLANTAR FLEXION - TOE RAISES

1. Stand with feet 12 inches apart
2. Raise up slowly onto your toes as high as you can
3. Hold _____ seconds
4. _____ repetitions, _____ times per day

Exercise 15 of 16

HAMSTRING/FLEXION

1. Stand holding onto solid object as shown
2. Slowly bend _____ knee
3. Hold _____ seconds and slowly lower
4. _____ repetitions, _____ times per day

Exercise 16 of 16

QUADRICEPS - STEP UPS

1. Place enough books on floor to total _____ inches tall
2. Hold onto solid object for support
3. Step up onto books with _____ foot
4. Slowly lower
5. _____ repetitions, _____ times per day

Appendix C:

Maryville COLLEGE

Division of Behavioral Sciences

Principal Researcher: Shelley Clark
Faculty Supervisor: Dr. Drew Crain
Division: Natural Sciences
Title: "The Role Of Bmi On Total Knee Replacement Rehabilitation"
Protocol# 220410-01
Approval Status: Approved

April 26, 2010

Dear Shelley:

The Maryville College Institutional Review Board (IRB) has carefully considered your proposal referenced above. The proposed procedures afford reasonable protection to the human participants involved and therefore you are granted approval for the study.

Your approval is effective April 26, 2010 and will expire one year from this date. Thereafter, continued approval is contingent upon submission of a progress report that must be reviewed and approved prior to the expiration date.

Approval is contingent upon your agreement to obtain informed consent from your participants, to abide by the protocol summarized in the approved IRB application, and to keep appropriate records concerning your participants.

You are required to submit to the Maryville College IRB for review any changes in procedures involving human participants prior to the implementation of such changes.

If you have any questions concerning this approval or regulations governing human participant activities, please contact Dr. Chad Schrock, Chair of the Maryville College IRB at 865.981.8268, e-mail at chad.schrock@maryvillecollege.edu.

Sincerely,

Dr. Chad Schrock
Chair, Maryville College Institutional Review Board

502 E. Lamar Alexander Parkway, Maryville, Tennessee 37804-5907
Voice 865.981.8000 | Fax 865.981.8010 | maryvillecollege.edu

MARYVILLE COLLEGE
Human Participants Research Proposal Form

Principal researcher(s): Shelley Clark

Faculty sponsor (if applicable): Dr. Crain

Division: Biology

Mailing address of the principal researcher: Box #2187 502 E. Lamar Alexander Parkways Maryville TN 37804

Title of proposed research: The Role of BMI on Total Knee Replacement Rehabilitation

Proposed starting date: April 16, 2010

Ending date: December 3, 2010

Purpose and objectives of proposed research: To determine the correlation between BMI and rehabilitation time for total knee replacements.

Participants: Medical charts from 150 participants who have undergone physical therapy for total knee replacement.

Methods and procedures: I will obtain a maximum of 150 charts from Springbrook Outpatient Rehabilitation (Alcoa, TN) and Appalachian Physical Therapy (Johnson City, TN). From these charts, I will document the age, gender, cause for surgery, benchmark dates, and the date full range of motion was achieved for each patient. As height and weight are not on the physical therapy charts, I will contact the referring physician to get these data for BMI calculation. Once all the information is recorded, I will examine the correlation between BMI and length of rehabilitation for a total knee replacement. (Attached is a data collection spreadsheet to show the categories for data collection.)

The names of the participants will be needed until the heights and weights are obtained from the referring physician. Once these data are collected, the names of the participants will no longer be needed and they will be deleted from the spreadsheet. At no time will any information about patients be released.

Principal Researcher Shelley Clark Signature **Faculty Supervisor** Signature

Committee Approval Signature **Date** 05-22-10

Total Knee Replacement Rehabilition Spreadsheet
Shelley Clark, Maryville College

Age	Sex	Height	Weight	BMI	cause of Injury	ROM day after surgery	ROM day 14-16	ROM day 28-30	ROM day 42-44	ROM day 56-58

CITI Collaborative Institutional Training Initiative

IRB Training English Curriculum Completion Report
Printed on 3/22/2010

Learner: Shelley Clark (username: shelleyclark)
Institution: IRB Training
Contact Information 4001 Marable Lane
Johnson City, TN 37601 United States
Department: Biology
Phone: (423)-676-5922
Email: shelley.clark@my.maryvillecollege.edu

IRB Training English:

Stage 1. Stage 1 Passed on 03/17/10 (Ref # 4228530)

Required Modules	Date Completed	Score
Module 1: History and Ethical Principles	03/17/10	4/4 (100%)
Module 2: Basic Institutional Review Board (IRB) Regulations and Review Process	03/17/10	5/5 (100%)
Module 3: Informed Consent	03/17/10	3/3 (100%)
Module 4 - International Research	03/17/10	no quiz

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator

Return

Maryville COLLEGE

Division of Natural Sciences

Blount Memorial Hospital

Outpatient Rehabilitation Center at Springbrook

220 Associates Blvd.

Alcoa, Tenn. 37701

Dear Blount Memorial Administrative Member,

My name is Shelley Clark and I am a junior biology major at Maryville College. I am beginning my research to write my senior thesis. I am interested in physical therapy, so I am writing my thesis on a topic that allows me to make connections to that particular field. My main goal of research is to determine the correlation between body mass index and rate of total knee replacement rehabilitation. To collect the data, I need to acquire 75 charts from your facility.

The data gathered from these charts will be sex, age, and notes made by the physical therapist on range of motion during different weeks of rehabilitation. I will need to know the names of the patients so that I can contact the referring physician for height and weight to calculate BMI. To maintain confidentiality, the names of the participants will be destroyed after the height and weight information are obtained.

From this research I hope to gain more insight on the role of body mass on total knee replacement rehabilitation, and your help in this study would be greatly appreciated.

Sincerely,

Shelley Clark

502 E. Lamar Alexander Parkway, Maryville, Tennessee 37804-5907
Voice 865.981.8000 | Fax 865.981.8010 | www.maryvillecollege.edu

Shelley Clark has approval to retrieve the following information about patients who have undergone total knee replacement: name, sex, age, notes by the physical therapist on range of motion, height, and weight. It is understood that Ms. Clark will remove the names of individual patients after all data is obtained, and that at no time will the identity of individuals be made available to anyone besides Ms. Clark.

Name ____________________________

Title ____________________________

Institution ________________________

Date ____________________________

Shelley Clark has approval to retrieve the following information about patients who have undergone total knee replacement: name, sex, age, notes by the physical therapist on range of motion, height, and weight. It is understood that Ms. Clark will remove the names of individual patients after all data is obtained, and that at no time will the identity of individuals be made available to anyone besides Ms. Clark.

Name ____________________________

Title ____________________________

Institution ________________________

Date ____________________________

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