# DOES FUNCTIONAL IMPROVEMENT FOLLOWING TKA CORRELATE TO INCREASED SPORTS ACTIVITY?

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## ABSTRACT

**Improved TKA designs and surgical techniques have allowed surgeons to not only treat the pain associated with osteoarthritis but also to restore function. The present study analyzed whether the increase in physical activity of patients following surgery is associated with their level of functional and objective improvement. An activity questionnaire was utilized to collect pre- and post-operative information from 355 patients (417 knees). Corresponding functional and objective assessments were collected using the Knee Society rating system. Overall, a mean 48 point (range, -44 to 97 points) improvement in Knee Society function score showed moderate correlation to a 2.5 point (range, -40 to 57 points) increase in weighted activity score (R = 0.362). There was less of a correlation between the mean objective score increase of 49 points (-32 to 84 points) and change in activity level (R = 0.194). There were 29% of the patients who showed no change in activity level. These results suggest that change in activity level is more closely associated with improved function than changes in objective measures. With more than 52% of TKA patients reporting increased activity scores, further studies are needed to assess longer-term effects of activity levels on the durability of these prostheses.**

## INTRODUCTION

Total knee arthroplasty (TKA) has been shown to provide excellent short- and long-term outcomes in individuals who are largely sedentary.[1-4] Recently, there has been more attention to patients achieving more functional outcomes and participating in various sporting activities after total knee arthroplasty. This is still an ill-defined area with some orthopaedic surgeons recommending only sedentary activities and other surgeons allowing certain low impact sports.[5-7] Typically, higher impact sports have not been recommended after TKA. However, it is generally accepted that some level of exercise is beneficial and ideally, the return of function and relief of pain provided by TKA will lead to increased exercise and an overall healthier lifestyle. It remains unclear whether improved functional and objective outcomes correlate with an increase in activity level.

Part of the difficulty of analyzing the effects of differing activity levels on knee replacement outcomes is that there is no validated method to analyze these activity levels. The Knee Society functional score describes basic activities such as use of a cane and walking up and down steps.[8] There have been a few recent studies that have described functional results of patients with total knee arthroplasty. For example, Noble et al. reported on the functional results of 257 knee patients.[9] They found that 48% of the patients did not report a functional limitation while participating in activities. In another recent report, 72 high activity knee replacement patients were compared to sedentary TKA patients and found similar clinical and radiographic outcomes at a mean follow-up of 7 years.[10] The authors analyzed patients with an activity scale which was made up of two components; patient activities and impact of activity levels based on Knee Society and American Association of Hip and Knee Surgeons (AAKHS) recommendations. This activity score lacked any information on the duration of sports participation. There are a few other activity scores that have been utilized, but most are qualitative and have not been validated. For example, the UCLA score is a 10-point scoring system based on a general question about activity participation. It has been recommended

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**TABLE 1**
**Impact scores for each activity listed on the sports activity questionnaire**

| Impact Score = 1 | Impact Score = 2 | Impact Score = 3 |
|---|---|---|
| Aerobics | Ice Skating | Baseball/Softball |
| Badminton | Roller/Inline Skating | Basketball |
| Bicycling (road) | Skiing (cross country) | Football |
| Bicycling (stationary) | Skiing (downhill) | Gymnastics |
| Bowling | Tennis (singles) | Handball |
| Croquet | Weight lifting/machines | Hockey |
| Dancing | | Jogging |
| Farming | | Lacrosse |
| Fencing | | Martial Arts |
| Gardening | | Racquetball |
| Golf | | Rock Climbing |
| Hiking | | Soccer |
| Horseback Riding | | Squash |
| Horseshoes | | Volleyball |
| Rowing/Canoeing | | |
| Shooting/Hunting | | |
| Shuffleboard | | |
| Speed Walking | | |
| Swimming | | |
| Tennis (doubles) | | |

that this score can be adjusted based on a visual analog scale and the surgeons assessment of the frequency and intensity of activity.[11]

This study evaluated changes in activity levels following TKA by asking a number of questions: 1) Can a weighted activity score (adding temporal and duration components, and other new recommendations) be easily utilized for TKA patients?; 2) Does functional improvement correlate to an increase in this weighted activity score?; 3) Does objective improvement predict changes in weighted activity score?; 4) What are the activity levels of patients relative to functional and/or objective outcome?; and 5) Do various clinical or demographic factors influence the weighted activity score and objective functional outcomes?

## MATERIALS AND METHODS

A group of 417 total knee arthroplasties were assessed for clinical and radiographic follow-up at three institutions between August 1, 2006 and August 1, 2007. The primary purpose of this study was to analyze the weighted activity score for these patients and correlate these to objective and functional outcomes. The activity survey was utilized a cross-sectional assessment of patients who were returning for follow-up for a minimum of 12 months following TKA. All patients who enrolled in this study had Institutional Review Board approval from each center.

There were 162 men and 255 women who had a mean age of 69 years (range, 35 to 95 years). The group consisted of only patients with primary osteoarthritis and excluded any patients with osteonecrosis or post-traumatic arthritis, rheumatoid arthritis or other diagnoses. Patients had a mean body mass index of 31 (range, 17 to 51). Patients were followed for a mean of 36 months (range, 12 to 116 months).

Patients were evaluated with a new weighted activity questionnaire which can be found in Appendix I. A previously reported questionnaire included a listing of activities, frequencies of the activity participation per week, month, and years, and a series of patient-related questions that had to do with activity level, competitiveness, and satisfaction.[10] The activities were then given scores of 1 to 3 points based on a previous Knee Society survey. Activity scores were calculated using frequency times weighted points. The new weighted activity score utilizes all of these questions with some small modifications, but added further information concerning time of involvement per day. In addition, changes were made for the stratification of the sports on the 3-point scale to reflect recent recommendations based on impact level.[12] Table 1 provides the weighted score for each of the sports. Sports listed by the patient on their survey in the "Other" category were assigned a weighted score based on the surgeon assessment of impact level and

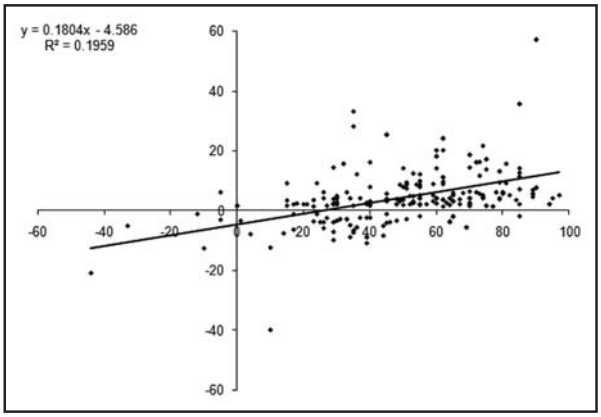


**Figure 1. There was a moderate, positive correlation between the increase in Knee Society functional score and the increase in weighted activity score. This figure shows the change in functional score on the x-axis and change in activity score on the y-axis, excluding those patients who had relatively no change in activity level.**

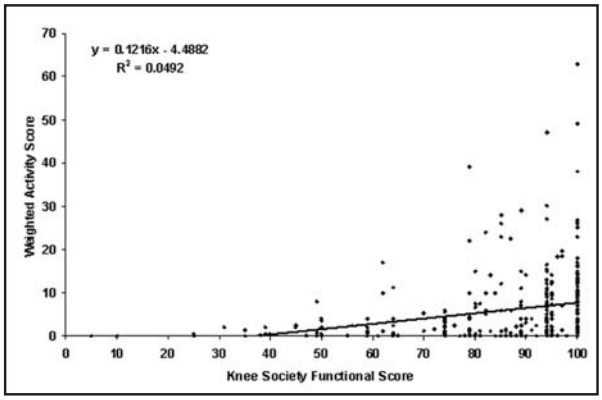


**Figure 2. Patients who had higher functional scores were consistently more active than their counterparts who had lower scores.**

whether they recommend the activity for their patients. Patients were administered pre- and post-operative activity questionnaires and the change in weighted activity score was determined for each patient.

All the knees were evaluated using the Knee Society objective and functional scores.[8] As previously noted, the activity questionnaire was also used to collect data concerning patient satisfaction using a Likert 10-point scale.[13] Various demographic variables were collected for all of the patients which included age, gender, body mass index, Charnley class,[14] as well as American Society of Anesthesiologists (ASA) classification.

All of the data for weighted activity scores, as well as demographic data and Knee Society objective and functional scores and satisfaction indices, were collected using a Microsoft Access Database (Microsoft Corporation, Seattle, Washington). Data was exported to SPSS version 13.0 software (SPSS Incorporated, Chicago, Illinois) for statistical analysis. An initial power analysis indicated our sample size was sufficient to answer our primary research questions at a power of 80% (alpha = 0.05) for an effect size of 0.2 for the correlation coefficients assessed. All correlations were assessed by Spearman's rank coefficient. Linear regression analysis was used to analyze the correlation of change in functional and objective outcomes and the corresponding change in weighted activity score. Based on initial survey results suggesting a large proportion of patients reporting no change in activity level, we re-assessed the linear correlations after excluding patients who had less than plus or minus one point change in their activity scores. In addition to evaluating the change in scores, we also compared the final outcomes based on post-operative Knee Society objective and function scores with the final weighted scores. In order to assess which demographic factors may have affected the weighted activity score as well as the functional and objective outcomes, we conducted a stepwise regression analysis including age, gender, BMI, Charnley class, and ASA classification as potential predictors of change in activity and final activity scores. Additionally, the data was stratified by each of these variables and a Chi-square analysis was used to compare the proportions of patients who had a decrease in activity level, no change, or an increase in activity level.

## RESULTS

Overall, the Knee Society function score increased by a mean of 48 points (range, -44 to 97 points) from pre-operative assessment to final follow-up. The mean pre- and post-operative function scores were 40 points (range, 0 to 86 points) and 88 points (range, 5 to 100 points), respectively. The corresponding increase in weighted activity score was 2.5 points (range, -40 to 57 points) with a mean activity score of 6.2 points (range, 0 to 63 points) at final follow-up. Linear regression analysis showed that the increase in weighted activity level had a direct positive correlation with the increase in functional improvement ($R = 0.362$, $p < 0.001$). The linear model of the best fit relationship for the change in weighted activity level as a function of the increase in Knee Society function score showed that every 10 point increase in function score was predictive of a 1.2 point increase in weighted activity score. When excluding the large number of patients who showed no or limited change (between plus or minus one point) in their weighted activity score, the correlation coefficient improved to 0.443 (Figure 1). This subset of patients had a mean increase in weighted activity score of 4.6 points (range, -40 to 57 points)

The increase in weighted activity level also had a positive correlation with the 49 point (range, -32 to 84 points)

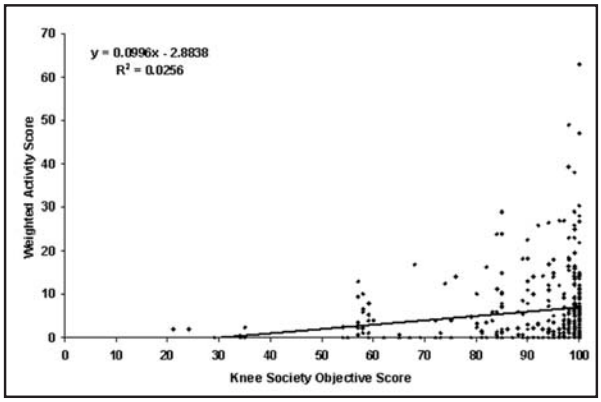


**Figure 3. This graph shows a linear model for comparing the Knee Society score and a weighted activity score that assesses frequency, duration, and impact of sports participation.**

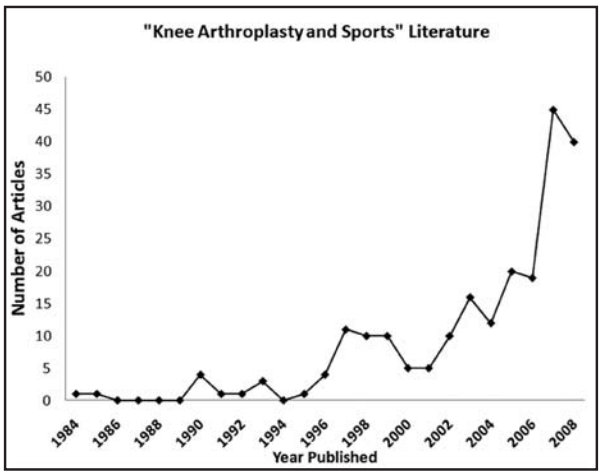


**Figure 4. This graph shows the increasing number of studies related to sports activity following total knee arthroplasty, especially in the past five years.**

increase in Knee Society objective scores. Although the R value was statistically significant for this relationship ($p < 0.001$), the correlation of 0.194 was less than that of the correlation between the functional score and the weighted activity level.

The assessments of the correlation between the Knee Society functional and objective outcomes to the final weighted activity scores are provided in Figures 2 and 3.

The stepwise linear regression analysis indicated that Charnley class, age, and gender were the best predictors of change in activity level following surgery (see Table 2). BMI and ASA classification were shown to not be significant predictors in this multi-variate analysis. A large number of patients (29%) did not change their activity level. Table 3 provides a stratification by demographic factors and the number of patients who decreased, had no change, or increased their sports activity following TKA.

**TABLE 2**
**Demographic Predictors of Increased Activity Level Following TKA**

| Data | Coefficient | Std. Error | P-Value |
|---|---|---|---|
| Constant | 10.917 | 2.57 | |
| Charnley Class | -1.497 | 0.449 | <0.001 |
| Age | -0.0884 | 0.037 | 0.018 |
| Gender | 1.552 | 0.758 | 0.041 |

## DISCUSSION

There has been a tremendous interest in activity levels and return to sports and higher functioning total knee replacements (Figure 4). This is reflected in the nearly tripling of publications concerning "total knee arthroplasty and sports" when comparing the number of publications in the most recent five year period (2004 to 2008, n = 136) with the preceding five years period (1999 to 2003, n = 46). In fact, the studies from the 2004 to 2008 period represent over 60% of the published sports related TKA reports to date. This interest served as one of the justifications for this study which attempted to understand how to grade the activity levels of TKA patients and how well improvement in functional and objective outcomes predicted increases in activity level following surgery.

The limitations of the present study include that a small percentage of patients (less than 1%) who came in for follow-up chose not to participate in this study. However, it is likely that this small number of patients would not have changed the results significantly. Another limitation was that the follow-up for most of the patients in this study was short term. Patients with follow-up as short as one year were included because our primary question was not related to implant survival, but rather was assessing whether there was a correlation between improvement in functional and objective outcomes and increases in activity level. A separate statistical analysis showed that time following surgery was not significantly correlated with sports activity for our cohort; however, it remains unclear whether the correlations in this study would be valid for patients at longer follow-up.

In a few recent studies, it has been shown that a large percentage of TKA patients return to sporting activities. Bradbury et al.[15] studied 160 TKA patients and found that 75% returned to sports activity with 20% participating in high impact sports such as tennis. Bock et al.[16] studied 167 TKA patients and found 80.4% returning to sports activity with some of them to high activity sports such as cycling (18%). In another study by Bauman et al.,[17]

**TABLE 3**
**Change in Weighted Activity Score Stratified by Demographic Variables**

| Group/Stratification | Points Change (range) | Decrease (%) | No Change (%) | Increase (%) | P-value* |
|---|---|---|---|---|---|
| Gender | | | | | |
| Men | 3.6 (-21 to 57) | 34 (0.21) | 40 (0.25) | 88 (0.54) | 0.295 |
| Women | 1.9 (-40 to 25) | 44 (0.17) | 80 (0.31) | 131 (0.51) | |
| < 60 years old | 4.9 (-12.5 to 57) | 14 (0.17) | 12 (0.14) | 59 (0.69) | <0.001 |
| > 60 years old | 1.9 (-40 to 35.5) | 64 (0.19) | 108 (0.33) | 160 (0.48) | |
| BMI Classification | | | | | |
| Obese | 2.6 (-40 to 57) | 40 (0.19) | 63 (0.3) | 109 (0.51) | 0.888 |
| Non-obese | 2.4 (-21 to 20) | 38 (0.19) | 57 (0.28) | 110 (0.54) | |
| ASA Classification | | | | | |
| 1 | 4.0 (-4 to 25) | 4 (0.36) | 0 (0) | 7 (0.64) | 0.004 |
| 2 | 3.1 (-40 to 57) | 31 (0.14) | 60 (0.27) | 130 (0.59) | |
| 3 | 1.8 (-12.5 to 35.5) | 41 (0.23) | 60 (0.33) | 81 (0.45) | |
| 4 | -2.9 (-8.5 to 0.8) | 2 (0.67) | 0 (0) | 1 (0.33) | |
| Charnley Class | | | | | |
| A | 3.8 (-21 to 33) | 29 (0.18) | 22 (0.14) | 107 (0.68) | <0.001 |
| B | 3.7 (-40 to 57) | 14 (0.12) | 34 (0.28) | 72 (0.6) | |
| C | 0.2 (-12.5 to 12.3) | 35 (0.25) | 64 (0.46) | 40 (0.29) | |
| Overall | 2.5 (-40 to 57) | 78 (0.19) | 120 (0.29) | 219 (0.53) | |

*P-value is Chi-square analysis of group stratifications and the numbers of decrease, no change, and increase.

a cross-sectional survey using the UCLA activity score was used to assess the level of 184 TKA patients who had a mean age of 69 years (range, 41 to 88 years). The survey was only given to patients who had a minimum of one year follow-up. Patients showed sustained, moderate activity levels with a median UCLA score of 6 points (range, 3 to 8 points). As patients increasingly are interested in participating in sports activity following surgery, it is important to have tools to evaluate their activity and its correlation with outcomes.

It was previously shown by Konig et al. that there was a need for separate functional and objective ratings following TKA.[18] They reported that between two and five years following surgery functional scores declined, whereas objective scores plateaued. They showed that pain had a significant but low correlation with walking distance ($p = 0.027$, $r = 0.13$). Although age ($p < 0.00001$), BMI ($p = 0.0025$), and pre-operative patient category ($p < 0.005$) were significant predictors for functional scores in a multiple-regression, none of these correlated with the knee score. The present study showed similar results with relatively poor correlation between change in activity and change in objective measures compared to a higher correlation between change in activity and functional score.

Although there was a moderate correlation between change in activity and change in function score, it should be noted that there was a large variation in the final activity scores for patients who had similar function scores. This suggests the need for an additional outcome measurement that is a function of activity level. The need for an activity component for a rating system is further indicated by the increasing demand of patients to participate in sports. Validation of any scoring system can be a very complex one, and it is hoped that this work may serve as a step towards the validation of both of these scoring systems.

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