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Original article

Patient Reported Outcome Measures in Meniscal Tears and Arthroscopic Meniscectomy: The Value of Outcome Score Prediction

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Abstract

Background: There are several clinical outcome scores relating to meniscal injuries reported in the literature. However, the result of one scoring system is often different from that of the others even when assessing the same group of patients. This makes the comparison of results of studies who have used different outcome measures restrictive and difficult.

Hypothesis: Statistically derived formulae can be used to predict the outcome of one knee scoring system when the result of another is known in patients with meniscal tears before and after arthroscopic meniscectomy.

Patients and Methods: Thirty-four patients with meniscal tears were evaluated using nine clinical outcome scores. These included Tegner Activity Score, Lysholm Knee Score, Cincinnati Knee Score, International Knee Documentation Committee (IKDC) Objective

Knee Score, Tapper and Hoover Meniscal Grading Score, IKDC Subjective Knee Score, Knee Outcome Survey - Activities of Daily Living Scale, Short Form-12 Item Health Survey (SF-12) and Knee Injury and Osteoarthritis Outcome Score (KOOS). Twenty-nine patients underwent an arthroscopic meniscectomy and were reassessed 3 months post-operatively.

Results: There were considerable differences between the mean total of each of the nine outcome measures. Significant correlations and regressions were found between most of the outcome scores and were stronger following surgery. The strongest correlation was found between IKDC Subjective and SF-12 Physical Component Summary sub-score ($r=0.94$, $p<0.001$). The strongest regression formula was found between IKDC Subjective and KOOS ($R^2=0.93$, $p<0.001$).

Discussion: The outcome of one knee score can be predicted when the results of the other are known through formulae calculations produced from this study. This could facilitate the conduct of systematic reviews and meta-analysis in research pertaining to meniscal injuries by allowing the pooling of substantially more data.

Level of Evidence: II; low-powered prospective non-randomized trial.

Keywords: Meniscus; prediction; regression; correlation; patient reported outcome scores.

Introduction

Patient reported outcome measures (PROMs) are important in both clinical research and day-to-day clinical practice. They can be used to quantify injury severity and evaluate the effectiveness of medical interventions (i.e. surgery**[1-2]**). PROMs focus on the patients' experiences, preferences and values.

In broad terms, outcome measures can be categorised as being generic or disease-specific and clinician or patient-completed. Generic instruments (e.g. short-form-36 and short-form-12) generally measure health in populations with diverse characteristics. They are applicable across different disease processes and demographic sub-groups. They provide a general overview of health-related quality of life. Their main limitation is that they are less responsive to changes in health status and so are less likely to detect the effects of an intervention for a specific condition[3-4]. Disease-specific measures focus on complaints attributable to the disease or condition of interest. They relate more closely to a particular condition and so are more likely to be responsive to even small changes in health-related quality of life[3]. Clinician (or observer) completed instruments involve questions being answered by respondents about themselves by replying to an interviewers' question. Some clinician-completed outcome measures also require a clinical component to be assessed (i.e. radiological parameters or measurement of various physical signs) in addition to the patients' reported symptoms. Although the latter will provide a more thorough and comprehensive assessment, the inclusion of such data can reduce the ease of implementation and compliance of the user especially when the data is being gathered by several different investigators and so can potentially lead to incomplete data collection. Patient-completed (self-administered) instruments involve respondents reading and answering the questions by themselves without assistance. Previously they were considered unreliable and were dismissed by clinical investigators as being too subjective. Clinician-completed instruments were more favoured as they were thought to generate more objective data. More recently however it has been found that well designed self-reported questionnaires are good at determining health status and their value as outcome measures has become more appreciated among researchers.

In most circumstances, it is therefore considered more appropriate to use both clinician and patient-completed outcome measures and present the results as separate outcomes. The ideal instrument is quick and simple to use, reliable, specific to the question being investigated, cost-effective and applicable. There is no single outcome measure that is considered ideal and meets all these criteria. The three principal factors which substantiate the use of any clinical outcome measure are its validity, reliability and responsiveness.

Validity assess whether the instrument actually measures the intended outcome of interest[5]. Various forms of validity have been described. Face validity is a qualitative component that evaluates the extent to which the instrument appears to measure what it is intended to measure in that the respondents understand the questions and find the answers appropriate. Content validity reflects the extent to which the items of the instrument represent functions of relevance to the purpose or disease being assessed. Lack of floor or ceiling effects reflect good content validity**[6]**. Floor and ceiling effects can be defined as one-third of the subjects under study attaining the lowest or highest possible score, respectively. Criterion validity is a measure of agreement between the instrument and a previously validated measure or the accepted ‘gold standard’. When no gold standard exits, construct validity is used to measure the degree to which an instrument measures the theoretical construct it was designed to measure and essentially performs as expected[5-7]. Reliability refers to the test-retest stability of the instrument over time where repeat measurements on separate occasions are reproducible whether by the same interviewer (intra-observer reliability) or by a different interviewer (inter-observer reliability)[4]. Responsiveness can be defined as the instruments’ ability to detect clinically important change over time either due to the nature of the disease or following an intervention[5-7]. The use of these instruments in clinical research allows the patients’ perspective to be taken into consideration when investigating a disease process or evaluating the results of an intervention. Although traditionally end-points such as plain radiographs, measured ligament laxity and clinical findings have been used as the primary outcome measures, an increasing emphasis on the use of health-related quality of life instruments is emerging in the conduct of clinical trials. This is reflected by the dramatic increase in the number of validated clinical outcome measures reported in the literature today.

Comparing the results of studies that have investigated the same field but have used different outcome measures then becomes problematic. These restrictions are especially pronounced when researchers attempt to pool data from the published literature for the purpose of statistical analysis in the context of meta-analysis and systematic reviews.

The primary aim of this study was to assess the statistical correlation between nine commonly used clinical outcome scoring systems in patients with meniscal tears of the knee before and after arthroscopic meniscectomy surgery. The secondary aim of this study was to investigate if statistically derived formulae from regression analysis can be used to predict the outcome of one knee scoring system when the result of another is known. We hypothesized that the statistically derived formulae would be able to predict outcome scores with a high degree of accuracy.

Materials and methods

Full approval was received for the study from the Research Ethics Committee and the Research Governance Committee. All subjects signed informed consent forms to participate at the time of their attendance at the dedicated research clinic. This therapeutic study is a prospective longitudinal cohort study the data of which formed part of the first author's Doctorate thesis. Some data points in this study also served as data in the therapeutic arm of another case-control study submitted for publication.

Participants

There was a total of fifty subjects recruited to the study. Table I shows the demographics of all the patients. Age range of inclusion was 16 to 45 years of patients with isolated meniscal tears of the knee confirmed at the time of arthroscopy. Subjects were excluded if they had any concomitant ligament injury of the knee, significant articular cartilage lesions within the knee, history of major ankle or hip pathology, lumbar spine symptoms (including radiculopathy in either limb), neurological or vestibular disease, diabetes, regular use of opiate analgesics or implanted metal work that contra-indicated them undergoing an MRI scan.

The mean time from injury to clinic review was 63 weeks (SD = 41). The reasoning for the time delay to orthopaedic clinic attendance was multifactorial. This included a combination of delayed presentation by the patient, the time taken for the patient progressing from the General Practitioner through the intermediate musculoskeletal triage service (were a period of conservative treatment (i.e. physiotherapy for 3 months) was implemented) and finally the waiting times to see an Orthopaedic surgeon in the National Health Service in the United Kingdom. The diagnosis of an isolated meniscal tear in the presence of intact ligaments and cartilage was attained by clinical examination and MRI scan of the injured knee. These findings were confirmed at the time of knee arthroscopy for all the patients. Clinical history and examination confirmed a normal contra-lateral knee. Figure 1 shows the flow of patients through the study. Of the 34 patients with meniscal tears, 16 were found to have a medial meniscal tear, 17 had a lateral meniscal tear and one patient had concurrent medial and lateral meniscal tears. Thirty-two of these patients underwent an arthroscopic partial meniscectomy. Two patients were found to have partial meniscal tears. One had a superior surface partial tear of the posterior horn of the medial meniscus and the other had a similar tear but of the lateral meniscus. Neither of these two patients underwent meniscectomy. Eight patients were found to have isolated articular cartilage lesions (grade III / IV modified Outerbridge classification[8-12]) in their knee but without meniscal tears and so were excluded. The post-operative regimen for all patients who underwent a day case knee arthroscopy included full weight bearing with full range of movement as comfort allowed from the day of surgery which was supervised through outpatient physiotherapy and were allowed to gradually return to normal daily and recreational activities when pain and swelling subsided over the course of 3 to 6 weeks after their surgery. The mean time to follow-up was 13.4 weeks (SD = 3.8) post-operatively.

Clinical Outcome Scores

A total of nine clinical outcome measures were used in this study. Five were clinician-completed instruments and four were patient-completed instruments. These knee scores were chosen because they are the most commonly used in the literature with the exception of the Tapper and Hoover Grading Score which was included as it is the only outcome measure specifically developed to assess meniscal injuries. All of the clinical outcome measures have been validated for use in assessing patients with knee injuries. The clinician-completed knee scores were undertaken at the time of the subjects' attendance at the research clinic. The patient-completed knee scores were mailed to the subjects approximately 7 days prior to their attendance at the research clinic. Therefore, the participants completed these outcome measures in their own time and provided a completely uninfluenced evaluation and perception of their functional knee impairment. All subjects were assessed with these outcome measures at baseline (pre-operatively) and reassessed post-operatively (for the subjects who were followed-up after surgery).

Clinician-completed knee scores

The clinician-completed knee scores included:

- Tegner Activity Score[13]
- Lysholm Knee Score[13]
- Cincinnati Knee Score[14-16]
- International Knee Documentation Committee (IKDC) Examination Score[17-18]
- Tapper and Hoover Meniscal Grading Score[19] (T&H)

Patient-completed knee scores

The patient-completed knee scores included:

- International Knee Documentation Committee (IKDC) Subjective Knee Score[3-20]
- Knee Outcome Survey - Activities of Daily Living Scale[21] (KOS-ADLS)
- Short Form - 12 Item Health Survey[22] (SF-12)
- Knee Injury and Osteoarthritis Outcome Score[23-24] (KOOS)

Statistical Analysis

All continuous data variables displayed a normal distribution as verified by both plotted histograms and the Shapiro-Wilks test. The results were evaluated using the Pearson product moment correlation test and the linear and multiple linear regression tests to analyse the continuous variables. The results of both the IKDC Examination score and the T&H score were categorical ordinal variables and the appropriate non-parametric statistical test (Spearman rank-order correlation test) was used for their analysis. The level of statistical significance was set at $p < 0.05$. Statistical analysis was performed using SPSS for Windows version 25.0 (SPSS Inc., Chicago, Illinois).

Results

The mean and mode averages for each of the clinical outcome measures (continuous and categorical variables respectively) are displayed in Table II.

Correlation Analysis

Table III presents the results of the correlation analysis between each of the knee outcome scores (continuous variables) *pre*-operatively. In general, a significant correlation was found between most of the knee outcome scores with the strongest correlation being between the IKDC Subjective score and the KOOS - sport and recreation sub-score. The SF-12 MCS score was found to be the weakest comparator overall.

Table IV presents the results of the correlation analysis between each of the knee outcome scores (categorical ordinal variables with continuous variables) *pre*-operatively. The Tapper and Hoover Meniscal Grading score was found to have a significant correlation with all of the knee outcome scores, including the IKDC examination score. The IKDC examination score had a weaker correlation with all the knee outcome scores compared to the Tapper and Hoover Meniscal Grading score.

Table V presents the results of the correlation analysis between each of the knee outcome scores (continuous variables) *post*-operatively. Overall a significant correlation was found between most of the knee outcome scores with the strongest correlation being between the IKDC Subjective score and the SF-12 Physical Component Summary (PCS) sub-score. It is also evident that in general, the post-operative correlations are stronger in comparison to the pre-operative results.

Table VI presents the results of the correlation analysis between each of the knee outcome scores (categorical ordinal variables with continuous variables) *post*-operatively. The Tapper and Hoover Meniscal Grading score was found to have a significant correlation with all of the knee outcome scores and had a stronger correlation with each knee score compared to the IKDC examination score. There was also a significant correlation found between the IKDC examination score and the Tapper and Hoover Meniscal Grading score.

Regression Analysis

Figure 2 displays the results of the linear regression analysis between the knee outcome measures (continuous variables) *pre*-operatively which produce one overall outcome result. The predictive formulae revealed that the IKDC Subjective vs. KOS-ADLS scores yielded the strongest regression coefficient.

Table VII shows the results of the multiple linear regression analysis between the knee outcome measures (continuous variables) *pre*-operatively which produce two or more outcome results (i.e. SF-12 and KOOS scores). The predictive formulae revealed that the IKDC Subjective vs. KOOS scores yielded the strongest regression coefficient.

Figure 3 displays the results of the linear regression analysis between the knee outcome measures (continuous variables) *post*-operatively which produce one overall outcome result. The predictive formulae revealed that the IKDC Subjective vs. KOS-ADLS scores yielded the strongest regression coefficient. It is evident that in general, the post-operative regression analyses are stronger in comparison to the pre-operative results.

Table VIII shows the results of the multiple linear regression analysis between the knee outcome measures (continuous variables) *post*-operatively which produce two or more outcome results (i.e. SF-12 and KOOS scores). The predictive formulae revealed that the IKDC Subjective vs. SF-12 scores yielded the strongest regression coefficient. The post-operative regression analyses revealed stronger regression coefficients for the SF-12 (more so than the KOOS scores) in comparison to the pre-operative results.

Discussion

Overall, significant correlations were found between most of the clinical outcome scores. The post-operative correlations were found to be stronger than that of the pre-operative results. The most important finding of this study was that the statistical analysis yielded formulae which can be used to predict the outcome of one knee scoring scale when the result of another is known in patients with meniscal tears. The clinical relevance of this pertains to the ability to now be able to compare results of meniscus surgery with relative confidence despite the wide variation of validated outcome scores used in clinical practice.

Although significant correlations were found between most of the outcome measures used in this study, the correlation analyses conducted following arthroscopic meniscectomy was found to be stronger. This finding could be consequent to a more standardised comparison in terms of time from surgery to clinic review post-operatively in contrast to the pre-operative analysis where the time from injury to clinic assessment was more varied. The study group included patients with both relatively acute as well as chronic meniscal tears which may account for a slightly greater degree of diversity in terms of reported functional impairment symptoms pre-operatively. The IKDC subjective knee score was found to be the strongest correlate variable while the Mental Component Summary (MCS) sub-score of the SF-12 was found to be one of the weakest in this respect before and after surgery. The latter result may be due to a comparison being made between a generic instrument and disease-specific outcome measures. An interesting finding was that the Tapper and Hoover Meniscal Grading System demonstrated stronger correlations with all the other knee scores than the more comprehensive IKDC examination knee score. The formulae produced following linear and multiple linear regression analyses allow the outcome of one instrument to be calculated based on the results of another knee score. The IKDC subjective knee score was consistently found to be the strongest regression variable before and after surgery. The outcome data of different knee scoring systems in studies relating to meniscal injuries can therefore be pooled more readily in order to facilitate the statistical calculations involved in the conduct of meta-analyses. It was noted that post-operative regression analyses results were stronger than those of the pre-operative findings. None of the formulae revealed a particularly weak regression coefficient (R^2<0.3) in the statistical analyses. There is no single universally agreed outcome score that is routinely used to assess patients with meniscal tears. The formulae produced in this study can therefore allow for a more direct comparison between the clinical outcome results of studies investigating different interventions in patients with meniscal injuries. However, calculating outcome scores using these mathematical formulae will not necessarily replicate every element of fine detail within each item (question) of every instrument. Nonetheless, they do provide an accurate approximation as evidenced by the highly significant regression coefficients accompanying each formula.

The recommended clinician-completed outcome measure for use in clinical practice based on the results from this study is the Tapper and Hoover Meniscal Grading System because of its ease of use, responsiveness following partial meniscectomy and it was found to be one of the strongest clinician-completed correlate variables when compared to the other outcome measures. The recommended patient-completed outcome measure is the IKDC subjective knee score as it was found to be the strongest overall correlate variable among all of the knee scores used. This study has highlighted the problem associated with the multiplicity of available knee outcome scores and consideration may be given by the governing national and international knee societies of the practicality and plausibility of developing a single and universally accepted clinical outcome score to mitigate the existing variability in this regard.

Conclusion

Overall, a statistically significant correlation was found between most of the knee outcome scores with the IKDC Subjective score being the strongest correlate variable and is the recommended patient-completed outcome measure. It was also evident that the post-operative correlations were stronger in comparison to the pre-operative results. The Tapper and Hoover Meniscal Grading System was found to have a strong correlation with the other knee outcome scores and is the recommended clinician-completed outcome measure. The resultant formulae produced in this study can be used to predict the outcome scores of one knee scoring system when the results of the other are known. This will be of great value to researchers completing systematic reviews and meta-analysis by allowing the pooling of substantially more data relating to meniscal injuries of the knee.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee (East Norfolk and Waveney Research Governance Committee, United Kingdom (ID 116/07/07)) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest All authors declare that they have no conflict of interest.

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Authors' contribution:

OA:

1. Made substantial contributions to conception and design of the study and acquisition of data. He also performed the analysis and interpretation of data.
2. Has been involved in drafting the manuscript and revising it critically for important intellectual content.
3. Has given final approval of the version to be published.
4. Agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

LS:

1. Made substantial contributions to conception and design of the study. He also made substantial contributions to the analysis and interpretation of data.
2. Has been involved in drafting the manuscript and revising it critically for important intellectual content.
3. Has given final approval of the version to be published.
4. Agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

SD:

1. Made substantial contributions to conception and design of the study. He also made substantial contributions to the interpretation of data.
2. Has been involved in drafting the manuscript and revising it critically for important intellectual

content.

3. Has given final approval of the version to be published.

4. Agrees to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Figure Legends

Fig. 1 Flow of subjects through the study.

Fig. 2 Scatterplots and linear regression analysis of ***pre***-operative knee outcome scores (n=34).

(A) Lysholm vs. Cincinnati; (B) Lysholm vs. IKDC Subjective; (C) Lysholm vs. KOS-ADLS;

(D) Cincinnati vs. IKDC Subjective; (E) Cincinnati vs. KOS-ADLS;

(F) IKDC Subjective vs. KOS-ADLS; (G) Lysholm vs. Tegner; (H) Cincinnati vs. Tegner;

(I) IKDC Subjective vs. Tegner; (J) KOS-ADLS vs. Tegner.

R^2 = regression coefficient; σ_E = root mean squared error.

Fig. 3 Scatterplots and linear regression analysis of ***post-***operative knee outcome scores (n=29).

(A) Lysholm vs. Cincinnati; (B) Lysholm vs. IKDC Subjective; (C) Lysholm vs. KOS-ADLS;

(D) Cincinnati vs. IKDC Subjective; (E) Cincinnati vs. KOS-ADLS;

(F) IKDC Subjective vs. KOS-ADLS. (G) Lysholm vs. Tegner; (H) Cincinnati vs. Tegner;

(I) IKDC Subjective vs. Tegner; (J) KOS-ADLS vs. Tegner.

R^2 = regression coefficient; σ_E = root mean squared error.

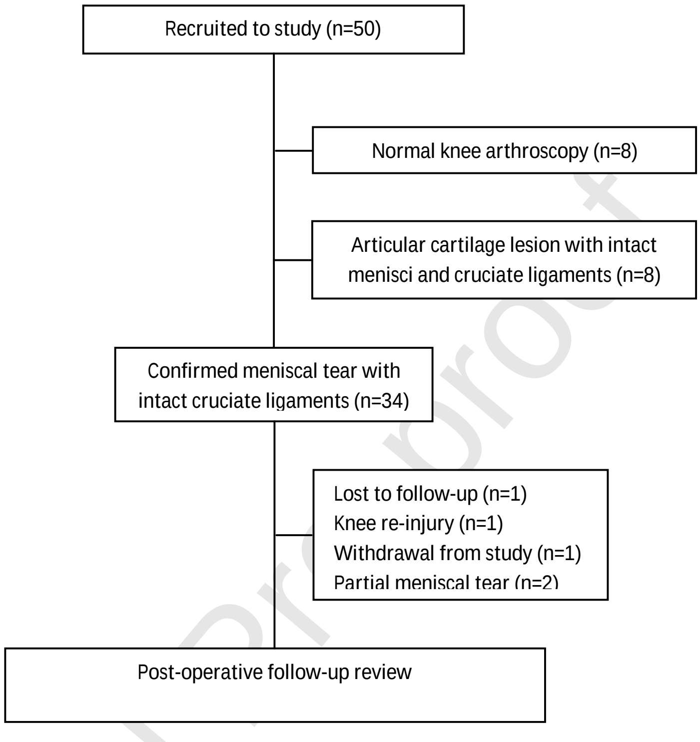
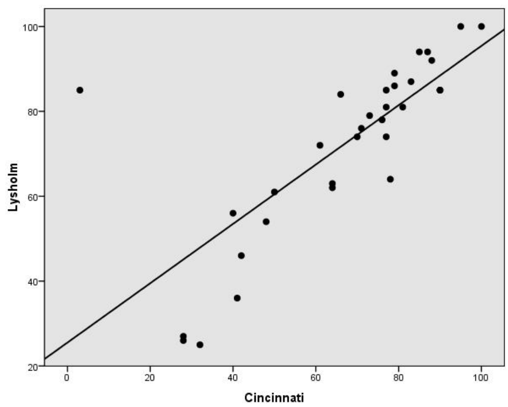
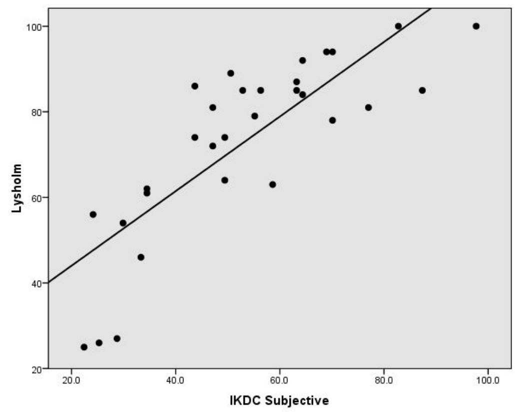


Figure 1.



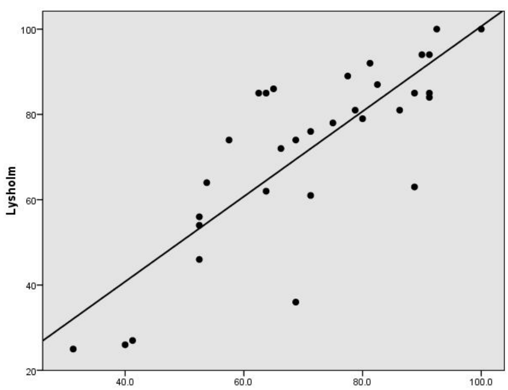
(A)

(B)

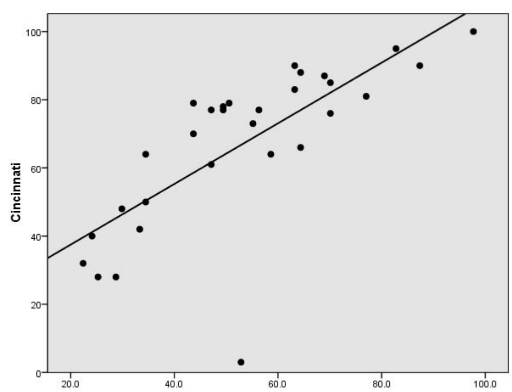


Lysholm = 25.5 + (0.70 x Cincinnati) R^2= 0.58, p<0.001, σ_E = 14.1

Lysholm = 26.6 + (0.87 x IKDC Subjective) R^2= 0.66, p<0.001, σ_E = 12.4

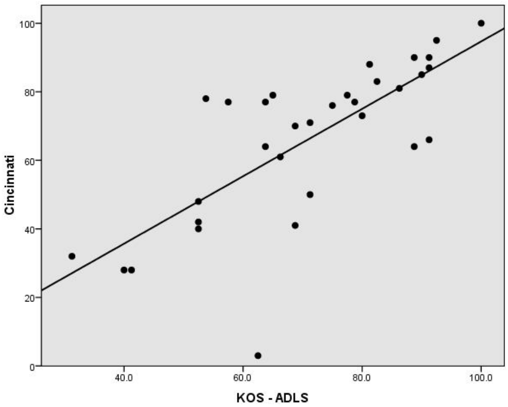


(D)



(C)

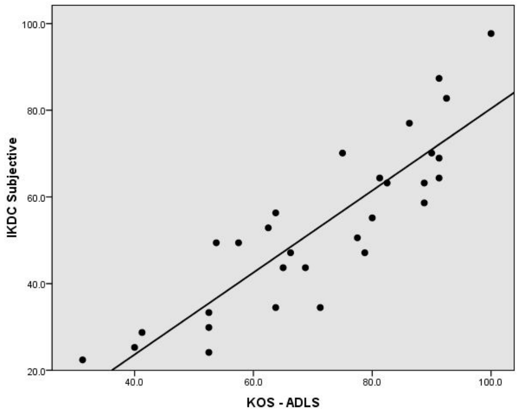
Lysholm = 0.9 + (1.0 x KOS-ADLS) R^2= 0.67, p<0.001, σ_E = 12.5



(E)

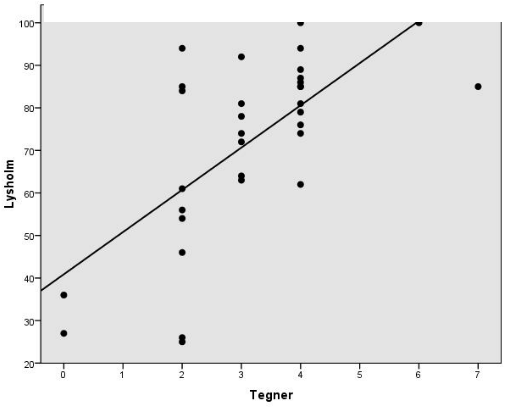
Cincinnati = (0.98 x KOS-ADLS) – 3.6 R^2= 0.55, p<0.001, σ_E = 15.7

(F)



IKDC Subjective = (0.95 x KOS-ADLS) – 14.2 R^2= 0.76, p<0.001, σ_E = 9.7

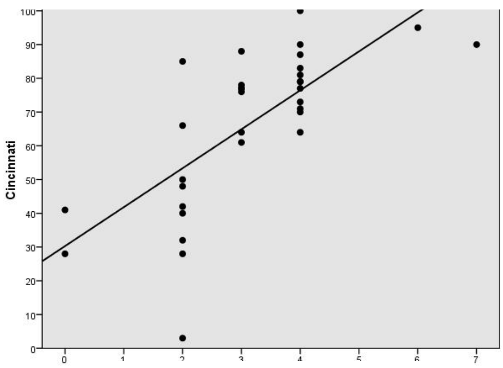
Figure 2.



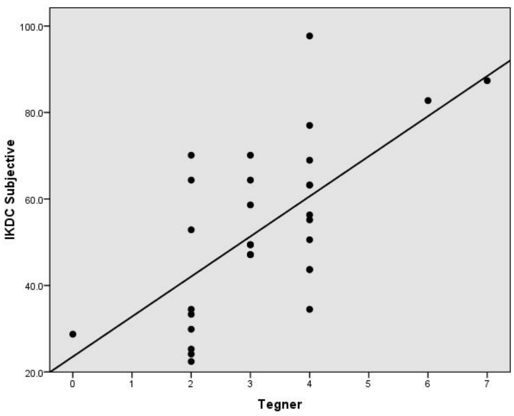
(G)

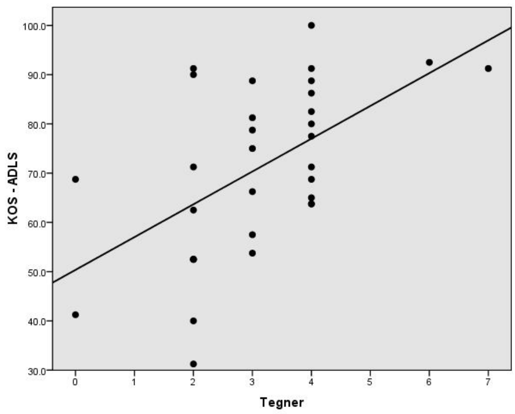
0.45, p<0.001, σ_E = 16.1

(H)



Cincinnati = 30.3 + (11.54 x Tegner)
R^2= 0.51, p<0.001, σ_E = 16.4



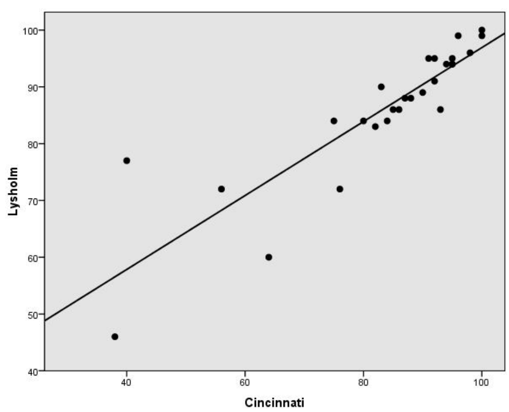


(I) (J)

IKDC Subjective = 23.5 + (9.27 x Tegner)
R^2= 0.41, p<0.001, σ_E = 15.2

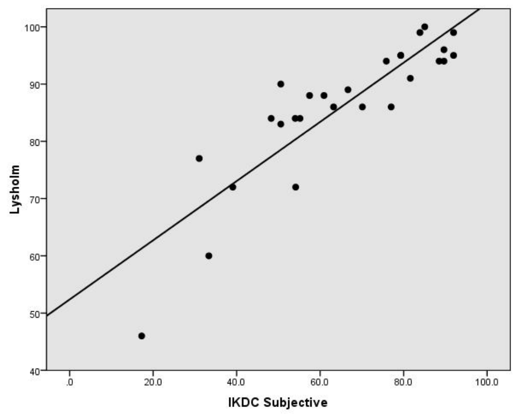
KOS-ADLS = 50.4 + (6.65 x Tegner)
R^2= 0.30, p=0.001, σ_E = 14.8

Figure 2. continued…



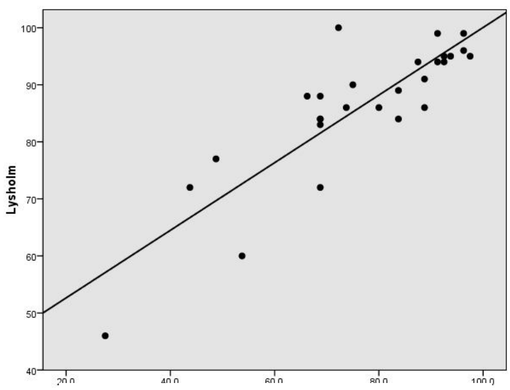
(A)

Lysholm = 31.8 + (0.65 x Cincinnati) R^2= 0.77, p<0.001, σ_E = 6.0



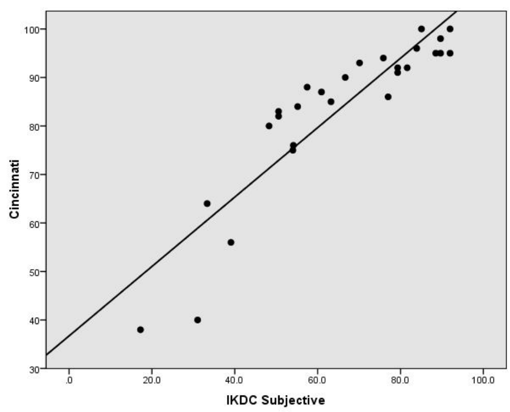
(B)

Lysholm = 52.4 + (0.52 x IKDC Subjective) R^2= 0.77, p<0.001, σ_E = 6.0



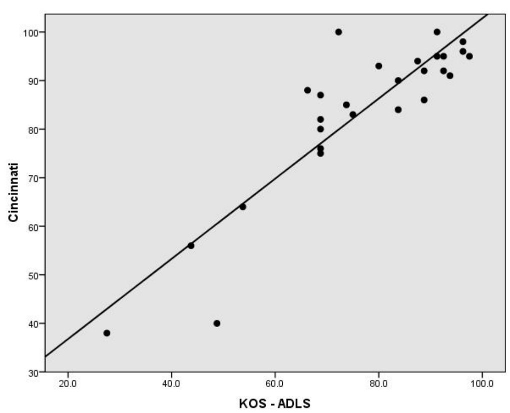
(C)

Lysholm = 40.8 + (0.59 x KOS-ADLS) R^2= 0.74, p<0.001, σ_E = 6.4



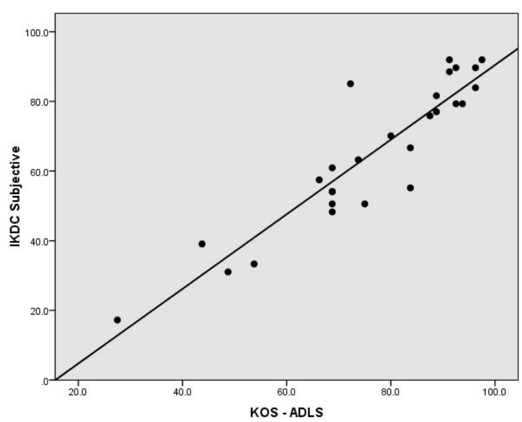
(D)

Cincinnati = 36.7 + (0.72 x IKDC Subjective) R^2= 0.81, p<0.001, σ_E = 7.2



(E)

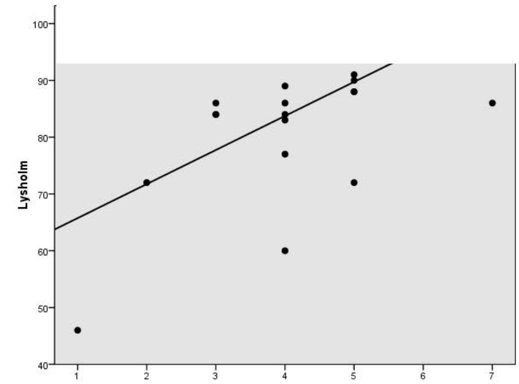
Cincinnati = 20.3 + (0.83 x KOS-ADLS) R^2= 0.79, p<0.001, σ_E = 7.6



(F)

IKDC Subjective = (1.07 x KOS-ADLS) – 16.7 R^2= 0.84, p<0.001, σ_E = 8.4

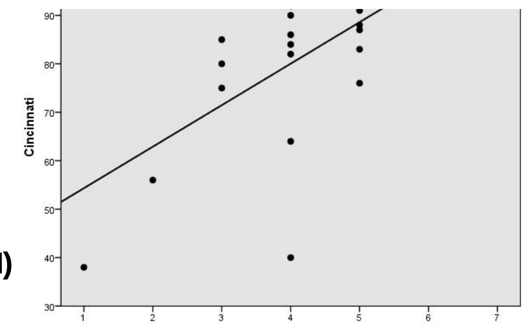
Figure 3.



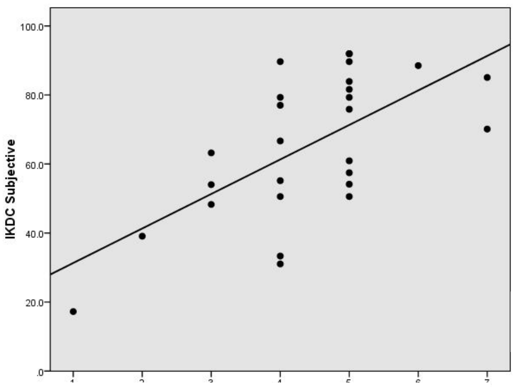
(G)

Lysholm = 59.8 + (6.0 x Tegner) R^2= 0.41, p<0.001, σ_E = 9.6

(H)



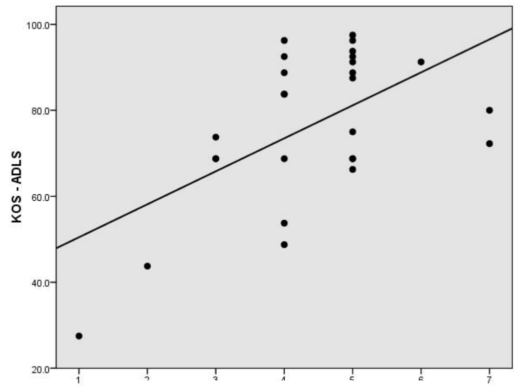
Cincinnati = 45.8 + (8.57 x Tegner) R^2= 0.46, p<0.001, σ_E = 12.3



(I)

IKDC Subjective = 21.3 + (10.0 x Tegner) R^2= 0.40, p<0.001, σ_E = 16.4

(J)



KOS-ADLS = 42.8 + (7.67 x Tegner) R^2= 0.32, p=0.002, σ_E = 14.9

Figure 3. continued…

Table I. Demographics of subjects.

	Meniscus patients

	(n = 50)
Mean Age (yrs) (SD)	34 (9)
Male : Female	37:13
Injured Knee (Right : Left)	29:21
Mean Height (m) (SD)	1.74 (0.1)
Mean Weight (kg) (SD)	83.9 (18.6)
Mean BMI (kg/m^2) (SD)	27.6 (4.9)

BMI: Body Mass Index

SD: Standard Deviation

Table II. Results of knee outcome scores

	Pre-Operative (n=34)	Post-Operative (n=29)
	Mean (SD)	Mean (SD)
Tegner	3.1 (1.2)	4.4 (1.3)
Lysholm	72.6 (21.7)	86.2 (12.2)
Cincinnati	66.7 (23.9)	83.5 (16.4)
IKDC Sub.	53.2 (19.3)	65.0 (21.0)
KOS-ADLS	70.9 (18.5)	76.6 (17.8)
SF-12 PCS	41.6 (10.9)	45.3 (9.1)
SF-12 MCS	51.7 (11.4)	52.2 (11.8)
KOOS		
Symptoms	65.6 (16.7)	73.7 (19.5)
Pain	65.6 (17.6)	74.2 (22.2)
ADL	75.0 (20.7)	83.8 (18.5)
Sp. & Rec.	47.9 (29.4)	59.1 (30.4)
QOL	37.5 (22.0)	51.6 (25.6)

	Mode	Mode
IKDC Exam.	Nearly Normal	Nearly Normal
T&H	Fair	Good

SD: Standard Deviation

ADL: Activities of Daily Living

Sp. & Rec: Sport and Recreation

QOL: Quality of Life

Table III. Correlations between ***pre***-operative knee outcome scores (n=34).

Results of Pearson product moment correlation analysis.

	Tegner	Lysholm	Cincinnati	IKDC Sub.	KOS ADLS	SF-12 PCS	SF-12 MCS	KOOS Symp.	KOOS Pain	KOOS ADL	KOOS Sp. &Rec.	KOOS QOL
	r	r	r	r	r	r	r	r	r	r	r	r
	p	p	p	p	p	p	p	p	p	p	p	p
Tegner	--	0.67	0.72	0.64	0.55	0.57	0.16	0.66	0.61	0.54	0.58	0.45
	--	<0.001*	<0.001*	<0.001*	0.001*	0.001*	0.389	<0.001*	<0.001*	0.002*	<0.001*	0.010*
Lysholm	0.67	--	0.76	0.81	0.82	0.59	0.45	0.77	0.66	0.70	0.82	0.57
	<0.001*	--	<0.001*	<0.001*	<0.001*	0.001*	0.011*	<0.001*	<0.001*	<0.001*	<0.001*	0.001*
Cincinnati	0.72	0.76	--	0.74	0.74	0.68	0.46	0.62	0.68	0.71	0.68	0.61
	<0.001*	<0.001*	--	<0.001*	<0.001*	<0.001*	0.009*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*

IKDC Sub.	0.64	0.81	0.74	--	0.87	0.82	0.36	0.74	0.78	0.82	0.93	0.84
	<0.001*	0.001*	<0.001*	--	<0.001*	<0.001*	0.051	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
KOS-ADLS	0.55	0.82	0.74	0.87	--	0.68	0.50	0.78	0.82	0.86	0.86	0.74
	0.001*	<0.001*	<0.001*	<0.001*	--	<0.001*	0.004*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
SF-12 PCS	0.57	0.59	0.68	0.82	0.68	--	0.01	0.64	0.62	0.68	0.77	0.68
	0.001*	0.001*	<0.001*	<0.001*	<0.001*	--	0.955	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
SF-12 MCS	0.16	0.45	0.46	0.36	0.50	0.01	--	0.29	0.44	0.45	0.37	0.36
	0.389	0.011*	0.009*	0.051	0.004*	0.955	--	0.106	0.012*	0.009*	0.035*	0.046*
KOOS												
Symptoms	0.66	0.77	0.62	0.74	0.78	0.64	0.29	--	0.77	0.73	0.73	0.57
	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.106	--	<0.001*	<0.001*	<0.001*	0.001*
Pain	0.61	0.66	0.68	0.78	0.82	0.62	0.44	0.77	--	0.91	0.75	0.59
	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.012*	<0.001*	--	<0.001*	<0.001*	<0.001*
ADL	0.54	0.70	0.71	0.82	0.86	0.68	0.45	0.73	0.91	--	0.77	0.65
	0.002*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.009*	<0.001*	<0.001*	--	<0.001*	<0.001*
Sp. & Rec.	0.58	0.82	0.68	0.93	0.86	0.77	0.37	0.73	0.75	0.77	--	0.75
	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.035*	<0.001*	<0.001*	<0.001*	--	<0.001*
QOL	0.45	0.57	0.61	0.84	0.74	0.68	0.36	0.57	0.59	0.65	0.75	--
	0.010*	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.046*	0.001*	<0.001*	<0.001*	<0.001*	--

*Statistically significant at <0.05 level.

r: Correlation coefficient

p: P-value

ADL: Activities of Daily Living

Sp. & Rec: Sport and Recreation

QOL: Quality of Life

Table IV. Correlations between ***pre***-operative knee outcome scores (n=34).

Results of Spearman rank correlation analysis.

	Tegner	Lysholm	Cincinnati	IKDC Sub.	KOS ADLS	SF-12 PCS	SF-12 MCS	KOOS Symp.	KOOS Pain	KOOS ADL	KOOS Sp. &Rec.	KOOS QOL	IKDC Exam.
	r_s p	r_s p	r_s p	r_s p	r_s p	r_s p	r_s p	r_s p	r_s p	r_s p	r_s p	r_s p	r_s p
IKDC Exam.	-0.56 0.001*	-0.49 0.006*	-0.51 0.003*	-0.52 0.003*	-0.39 0.030*	-0.38 0.038*	-0.03 0.859	-0.49 0.005*	-0.40 0.027*	-0.43 0.017*	-0.49 0.006*	-0.43 0.016*	-- --
Tapper & Hoover	-0.60 <0.001*	-0.84 <0.001*	-0.86 <0.001*	-0.83 <0.001*	-0.83 <0.001*	-0.62 <0.001*	-0.41 0.023*	-0.72 <0.001*	-0.71 <0.001*	-0.78 <0.001*	-0.79 <0.001*	-0.73 0.001*	0.50 0.005*

*Statistically significant at <0.05 level.

r_s: Correlation coefficient

p: P-value

ADL: Activities of Daily Living

Sp. & Rec: Sport and Recreation

QOL: Quality of Life

Table V. Correlations between ***post***-operative knee outcome scores (n=29).

Results of Pearson product moment correlation analysis.

	Tegner	Lysholm	Cincinnati	IKDC Sub.	KOS ADLS	SF-12 PCS	SF-12 MCS	KOOS Symp.	KOOS Pain	KOOS ADL	KOOS Sp. &Rec.	KOOS QOL
	r p	r p	r p	r p	r p	r p	r p	r p	r p	r p	r p	r p
Tegner	--	0.64	0.68	0.63	0.57	0.62	0.40	0.60	0.46	0.50	0.58	0.52
	--	<0.001*	<0.001*	<0.001*	0.002*	0.001*	0.040*	0.001*	0.016*	0.007*	0.001*	0.006*
Lysholm	0.64	--	0.88	0.88	0.86	0.86	0.52	0.84	0.83	0.83	0.81	0.81
	<0.001*	--	<0.001*	<0.001*	<0.001*	<0.001*	0.005*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
Cincinnati	0.68	0.88	--	0.90	0.89	0.88	0.42	0.92	0.75	0.78	0.86	0.84
	<0.001*	<0.001*	--	<0.001*	<0.001*	<0.001*	0.030*	<0.001*	<0.001*	<0.001*	0.004*	<0.001*
IKDC Sub.	0.63	0.88	0.90	--	0.92	0.94	0.45	0.93	0.83	0.83	0.89	0.86
	<0.001*	<0.001*	<0.001*	--	<0.001*	<0.001*	0.018*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
KOS-ADLS	0.57	0.86	0.89	0.92	--	0.85	0.48	0.91	0.79	0.84	0.88	0.86
	0.002*	<0.001*	<0.001*	<0.001*	--	<0.001*	0.012*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
SF-12 PCS	0.62	0.86	0.88	0.94	0.85	--	0.33	0.86	0.77	0.80	0.82	0.83
	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	--	0.090	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*
SF-12 MCS	0.40	0.52	0.42	0.45	0.48	0.33	--	0.51	0.40	0.53	0.58	0.54
	0.040*	0.005*	0.030*	0.018*	0.012*	0.090	--	0.006*	0.037*	0.004*	0.001*	0.003*
KOOS												

Symptoms	0.60	0.84	0.92	0.93	0.91	0.86	0.51	--	0.80	0.84	0.88	0.88
	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.006*	--	<0.001*	<0.001*	<0.001*	<0.001*
Pain	0.46	0.83	0.75	0.83	0.79	0.77	0.40	0.80	--	0.94	0.85	0.82
	0.016*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.037*	<0.001*	--	<0.001*	<0.001*	<0.001*
ADL	0.50	0.83	0.78	0.83	0.84	0.80	0.53	0.84	0.94	--	0.91	0.82
	0.007*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.004*	<0.001*	<0.001*	--	<0.001*	<0.001*
Sp. & Rec.	0.58	0.81	0.86	0.89	0.88	0.82	0.58	0.88	0.85	0.91	--	0.86
	0.001*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.001*	<0.001*	<0.001*	<0.001*	--	<0.001*
QOL	0.52	0.81	0.84	0.86	0.86	0.83	0.54	0.88	0.82	0.82	0.86	--
	0.006*	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.003*	<0.001*	<0.001*	<0.001*	<0.001*	--

*Statistically significant at <0.05 level.

r: Correlation coefficient

p: P-value

ADL: Activities of Daily Living

Sp. & Rec: Sport and Recreation

QOL: Quality of Life

Table VI. Correlations between ***post***-operative knee outcome scores (n=29).

Results of Spearman rank correlation analysis.

	Tegner	Lysholm	Cincinnati	IKDC Sub.	KOS ADLS	SF-12 PCS	SF-12 MCS	KOOS Symp.	KOOS Pain	KOOS ADL	KOOS Sp.&Rec.	KOOS QOL	IKDC Exam.
	r_s	r_s	r_s	r_s	r_s	r_s	r_s	r_s	r_s	r_s	r_s	r_s	r_s
	p	p	p	p	p	p	p	p	p	p	p	p	p
IKDC	-0.32	-0.41	-0.53	-0.53	-0.48	-0.56	0.24	-0.52	-0.40	-0.40	-0.45	-0.54	--

Exam.	0.107	0.034*	0.004*	0.004*	0.011*	0.003*	0.227	0.005*	0.042*	0.038*	0.020*	0.003*	--
Tapper & Hoover	-0.59 0.001*	-0.91 <0.001*	-0.90 <0.001*	-0.91 <0.001*	-0.87 <0.001*	-0.81 <0.001*	-0.23 0.250	-0.90 <0.001*	-0.87 <0.001*	-0.85 <0.001*	-0.84 <0.001*	-0.74 <0.001*	0.41 0.035*

*Statistically significant at <0.05 level.

r_s: Correlation coefficient

p: P-value

ADL: Activities of Daily Living

Sp. & Rec: Sport and Recreation

QOL: Quality of Life

Table VII. Multiple linear regression analysis of ***pre***-operative knee outcome scores (n=34).

Equation (R^2, p, σ_E)
KOOS
Tegner = (0.04 x Symp.) + (0.03 x Pain) **-** (0.02 x ADL) + (0.01 x Sp. & Rec.) + (0.003 x QOL) – 0.2
(R^2 = 0.48, p =0.003, σ_E = 1.1)
Lysholm = 22.1 + (0.56 x Symp.) **-** (0.39 x Pain) + (0.32 x ADL) + (0.47 x Sp. & Rec.) **-** (0.14 x QOL)
(R^2 = 0.76, p <0.001, σ_E = 11.4)
Cincinnati = 10.4 + (0.18 x Symp.) + (0.08 x Pain) + (0.36 x ADL) + (0.14 x Sp. & Rec.) + (0.19 x QOL)
(R^2 = 0.57, p <0.001, σ_E = 16.5)
IKDC Subjective = 13.2 **-** (0.11 x Symp.) + (0.08 x Pain) + (0.19 x ADL) + (0.39 x Sp. & Rec.) + (0.24 x QOL)

($R^2 = 0.93$, $p < 0.001$, $\sigma_E = 5.6$)

KOS-ADLS = 21.4 + (0.19 x Symp.) + (0.01 x Pain) + (0.32 x ADL) + (0.20 x Sp. & Rec.) + (0.13 x QOL)

($R^2 = 0.86$, $p < 0.001$, $\sigma_E = 7.0$)

SF-12

Tegner = (0.08 x PCS) + (0.02 x MCS) – 1.2

($R^2 = 0.35$, $p = 0.002$, $\sigma_E = 1.2$)

Lysholm = (1.21 x PCS) + (0.88 x MCS) – 23.4

($R^2 = 0.56$, $p < 0.001$, $\sigma_E = 14.9$)

Cincinnati = (1.51 x PCS) + (0.98 x MCS) – 45.9

($R^2 = 0.68$, $p < 0.001$, $\sigma_E = 13.8$)

IKDC Subjective = (1.50 x PCS) + (0.63 x MCS) - 40.9

($R^2 = 0.81$, $p < 0.001$, $\sigma_E = 8.8$)

KOS-ADLS = (1.15 x PCS) + (0.80 x MCS) – 17.3

($R^2 = 0.73$, $p < 0.001$, $\sigma_E = 9.6$)

R^2: Regression coefficient

σ_E: Root mean squared error

ADL: Activities of Daily Living

Sp. & Rec: Sport and Recreation

QOL: Quality of Life

Table VIII. Multiple linear regression analysis of ***post-***operative knee outcome scores (n=29).

Equation (R^2, p, σ_E)

KOOS

Tegner = 2.3 + (0.03 x Symp.) - (0.01 x Pain) - (0.01 x ADL) + (0.02 x Sp. & Rec.) - (0.01 x QOL)

(R^2 = 0.38, p =0.055, σ_E = 1.1)

Lysholm = 47.3 + (0.24 x Symp.) + (0.18 x Pain) + (0.06 x ADL) - (0.01 x Sp. & Rec.) + (0.06 x QOL)

(R^2 = 0.77, p <0.001, σ_E = 6.5)

Cincinnati = 38.7 + (0.59 x Symp.) - (0.03 x Pain) - (0.10 x ADL) + (0.15 x Sp. & Rec.) + (0.07 x QOL)

(R^2 = 0.86, p <0.001, σ_E = 6.9)

IKDC Subjective = 7.3 + (0.67 x Symp.) + (0.25 x Pain) - (0.26 x ADL) + (0.19 x Sp. & Rec.) + (0.02 x QOL)

(R^2 = 0.89, p <0.001, σ_E = 7.6)

KOS-ADLS = 22.5 + (0.45 x Symp.) - (0.10 x Pain) + (0.18 x ADL) + (0.13 x Sp. & Rec.) + (0.12 x QOL)

(R^2 = 0.86, p <0.001, σ_E = 7.4)

SF-12

Tegner = (0.08 x PCS) + (0.03 x MCS) – 0.5

(R^2 = 0.42, p =0.001, σ_E = 1.0)

Lysholm = 24.0 + (1.04 x PCS) + (0.29 x MCS)

(R^2 = 0.80, p <0.001, σ_E = 5.7)

Cincinnati = 3.7 + (1.52 x PCS) + (0.21 x MCS)

(R^2 = 0.79, p <0.001, σ_E = 7.8)

IKDC Subjective = (2.06 x PCS) + (0.29 x MCS) - 42.6

(R^2 = 0.92, p <0.001, σ_E = 6.3)

KOS-ADLS = (1.54 x PCS) + (0.34 x MCS) – 10.9

(R^2 = 0.78, p <0.001, σ_E = 8.8)

R^2: Regression coefficient

σ_E: Root mean squared error

ADL: Activities of Daily Living

Sp. & Rec: Sport and Recreation

QOL: Quality of Life