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Development and Evaluation of an Activity Rating Scale for Disorders of the Knee

Robert G. Marx,*† MD, Timothy J. Stump,‡§ MS, PT, Edward C. Jones,* MD, Thomas L. Wickiewicz,* MD, and Russell F. Warren,* MD

*From the *Sports Medicine and Shoulder Service and ‡Department of Rehabilitation, Hospital for Special Surgery, New York, and §Pro Fit Orthopaedic and Sports Physical Therapy, New York, New York*

ABSTRACT

Reports of clinical studies of patients with knee disorders should routinely include their activity levels to enable comparison of treatment groups and to allow generalizability. The goal of this study was to develop and evaluate a new rating scale to measure activity levels of patients. We assessed reliability by administering the scale to 40 subjects on 2 separate occasions, 1 week apart. Validity was evaluated by comparing the activity rating on the new scale with that from other instruments that use activity level scales (concurrent construct validity) and also by correlating the score on the new scale with age (divergent validity). Patients easily understood the scale and were able to complete it in 1 minute. The reliability was high (intraclass correlation coefficient, 0.97). The scale also correlated well with existing activity rating scales: Spearman correlation coefficient for Cincinnati score, 0.67; for Tegner scale, 0.66; for Daniel scale, 0.52. The activity score was significantly inversely correlated with age ($P = 0.002$), indicating divergent validity. This instrument will facilitate generalizability of results and allow more accurate comparisons among patient groups in outcomes research in sports medicine.

The number of outcome rating scales to measure patient function has recently increased. Questionnaires have been used with increasing frequency to better measure issues that are important to patients.[9,20,21,24,42] For example, the Lysholm knee rating scale has been used to evaluate patients after ACL reconstruction.[24] This instrument asks these patients about issues that are specifically relevant to them, such as giving way, pain, locking of the knee, and ability to run.[24] Among patients who are very active or who participate in high-demand activities, the level of symptoms and disability of the patient must be evaluated in the context of their activity level.[13,28,40] Most studies reporting on outcomes in athletes with disorders of the knee do not directly report the level of activity of the patients studied.[2,7,11,22,26,29,34–36,38]

A prognostic factor is a patient variable or characteristic that is associated with a good or bad outcome. For example, lack of full range of motion before reconstruction for an acute ACL rupture is a negative prognostic factor, as this has been associated with arthrofibrosis.[27] Similarly, in a study of two treatments for chronic lung disease, the number of smokers receiving each treatment would be considered extremely important because it is known that smoking has an important effect on lung disease.[15] Activity levels of patients are important prognostic factors in the sports medicine population because patients who are very active have different expectations and demands than patients who are relatively sedentary.[5,31]

There are large variations among patients in terms of the frequency and intensity of sports participation. Therefore, a rating of activity is critical for studies comparing two treatments to ensure that the patient groups are equivalent with respect to this characteristic.[3] For example, if an investigator compared the semitendinosus and gracilis tendon graft with the bone-patellar tendon-bone graft for ACL reconstruction, it would be important for the activity levels of the two groups to be similar. If the patients receiving the semitendinosus and gracilis tendon grafts were relatively sedentary, whereas the patients receiving the bone-patellar tendon-bone grafts were extremely active, the investigator would then effectively be comparing apples and oranges.

Although the age and sex of the patients studied are generally reported, these variables do not relate directly to the patients' activity levels. It is important to know

† Address correspondence and reprint requests to Robert G. Marx, MD, Sports Medicine and Shoulder Service, Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021.
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whether the patients studied in the evaluation of a treatment (such as a technique for knee ligament reconstruction) are placing high loads across their knee or if they are relatively sedentary. A recent study of autologous chondrocyte transplantation[10] received criticism in the form of an editorial in a leading orthopaedic journal[33] for not describing the activity levels of the patients, which limited generalizability.

The purpose of this study was to develop a rating scale for patients' activity levels. The goal was to construct a scale that is self-administered, able to be completed in approximately 1 minute (to facilitate use with other instruments), and that is not based on specific sports (to allow for comparisons of patients who participate in different sports).

MATERIALS AND METHODS

To locate activity rating scales that would be useful for knee-related outcome research, we performed a formal literature search using Medline (1966 to 1999). We used the following search strategy: activity (key word) *and* sports/sports medicine (key word) *and* scale (key word, "exploded") *or* questionnaire (key word). We also polled experts in the field of sports medicine and used the references of relevant articles to search for activity rating scales. We evaluated all relevant scales systematically with respect to the purpose, the methods used for development, and the reliability and validity.

To construct the new activity level rating scale we performed item generation, item reduction, and subsequently tested the instrument for reliability and validity.[18,19] The instrument was intended to be discriminative, that is, to differentiate among patients at a point in time. Changes in activity level (what the patient is doing) may or may not reflect changes in health status (how the patient is doing). This instrument was not intended to measure the outcome of medical or surgical interventions, which would be better accomplished by a joint-specific or condition-specific instrument.[24]

Methods for Item Generation

To identify all potentially relevant items, we consulted with orthopaedic surgeons who specialize in sports medicine, as well as physical therapists and athletic trainers who specialize in sports medicine. We also surveyed 20 patients with disorders of the knee for items they considered relevant.

Methods for Item Reduction

A total of approximately four items or questions was desired to facilitate completion in a 1-minute period, because completing information forms, knee-specific scales, and generic health status measures can be extremely onerous and time consuming for patients. We asked 50 patients[18] with knee complaints who were physically active (Tegner score of at least 4) to rate the importance of each function identified in item generation and the difficulty they had with each on a scale from 1 to 10. We chose to study patients with a variety of disorders of the knee to improve generalizability. The importance and severity scores for each activity were added,[25] and we selected the items with the highest mean importance-severity scores. Therefore, we included the items that patients considered the most important and most difficult to physically perform. It is crucial to have items that are both important to patients and difficult for them so that the scale will be clinically relevant for the sports medicine population. If an item is very important but not difficult for the patient, or the converse, that item is not as useful as one that is both important and physically difficult. The goal was to reduce the number of items to approximately four to avoid responder burden, as the instrument is intended for use with both disease-specific and generic health status measures.

Clinical sensibility, which involves the opinion of clinicians with expertise in the domain under study,[17] was employed to ensure that the instrument was relevant to practitioners as well. Therefore, the final selection of the items was based both on the patient data and the opinion of the clinicians.[17]

Methods for Reliability Testing

For test-retest reliability a sample size of 40 volunteers was required.[16] We retested the subjects after a 1-week interval.[8,14] The subjects were professionals in fields other than health care, 18 to 50 years of age, who were healthy and not involved in the study design or execution. Patients were not shown their previous responses. The intraclass correlation coefficient was used to measure reliability.[3]

Methods for Validity Testing

Criterion validity could not be assessed because there is no accepted standard for the concept of activity level. Face and content validity were assured by the expert input of the physicians, physical therapists, and trainers consulted in the development of the scale. Construct validity was evaluated by comparing the score on the new instrument with those of other activity rating scales (Tegner,[40] Cincinnati,[28] and Daniel[13]). We anticipated positive correlations with these scales that also purport to measure activity levels of patients. For divergent validity, the new scale was correlated with patient age, and an inverse correlation was anticipated, with older patients expected to have lower activity scores. A cross-sectional analysis was performed to correlate age with activity level. Older patients were expected to have lower activity scores. The Spearman correlation coefficient was used for all correlations because the scales are considered ordinal data.

RESULTS

Literature Review

Many scales that quantify physical activity have been devised for epidemiologic studies.[1,4,12,23,32,43] These

scales generally evaluate the amount of time the subjects spend participating in physical activity, without defining the specific level of activity in detail. These instruments are not useful for sports medicine studies as they lack specificity.

We identified five activity level rating scales that are potentially applicable to outcome studies in sports medicine, but there are inherent problems with each of these available instruments. Straub and Hunter[39] published an activity rating scale along with a study of acute ACL repair. Five categories of sports were listed based on the stress level that each sport was perceived to place on the ACL repair. There was no mention of patient input in the description of the development of this scale. Further, the difference between some of the activities listed is not intuitively obvious. For example, the authors differentiate between light and hard dance by scoring them as one and three of five, respectively. The authors also rated basketball as five, whereas racquetball was rated as three. These differences in activity rating appear to be somewhat arbitrary since quick stops and starts and aggressive pivoting characterize both sports.

Seto et al.[37] used a rating of patient activity for their follow-up study of patients with ACL reconstruction. They defined three levels of activity, termed "competitive," "recreational," and "weekend." Competitive was defined as organized competition or participation in a sports activity six or seven times per week. Recreational was defined as participation in a sports activity three to five times per week or two times per week and more than 2 hours per session or seasonal sports five or more times per month. Weekend was defined as participation in a sports activity two or less times per week with each session lasting approximately an hour, or participation in seasonal sports an average of 4 or less days per month. There was no mention of how the authors arrived at this scale. The type of sport is not mentioned, which could lead to potential misclassifications (for example, a "competitive" bowler would be rated higher than a subject who plays "recreational" tennis four times a week).

The Tegner activity level rating scale is perhaps the most widely used.[40] The purpose of this scale is to document activity levels of ACL-insufficient patients because it was thought that limitations in knee function could be masked in sedentary patients. The development of this rating scale involved a survey of 43 patients with ACL injuries who were asked to grade activities as to how troublesome they were to perform. Generalizability to other diagnoses is limited since all the subjects involved in the development of the scale had ACL injuries. Furthermore, the arbitrariness of ranking different sports in terms of activity level remains. Contrary to the Straub and Hunter scale, the Tegner scale ranks squash (a sport similar to racquetball) ahead of basketball. The Tegner scale also discriminated between competitive and recreational sports, a differentiation that can often be difficult to make.[40] We are not aware of any studies documenting the reliability or validity of this instrument.

The Cincinnati scale describes the actual activities involved in sport.[28] The methods used to arrive at the final instrument are not detailed. This scale lumps together jumping, hard pivoting, and cutting to distinguish sports that involve these activities from sports that involve "no running, twisting, or jumping." This instrument was one of only two scales that took the frequency of activity into account, which is important to differentiate among subjects. However, this scale rated subjects who participated in sports with no running, twisting, or jumping four to seven times per week at 90 points, while patients who participated in jumping, hard pivoting, or cutting sports one to three times per week were rated as 85. One could argue that the cutting sports one to three times per week would place much greater demands on the knee than the less-demanding sports at a slightly greater frequency. A recent study found the Cincinnati scale to be reliable and valid.[6]

Daniel et al.[13] defined three levels of sport to stratify subjects in their report describing the outcome of ACL-injured patients. Level one sports were described as jumping, pivoting, and hard cutting sports. However, as with the Cincinnati scale, the fact that these components of function were grouped together can be confusing because some patients may participate in sports that require pivoting or jumping or both, but not cutting. Level two sports were considered sports that involve lateral motion, but with less jumping or hard cutting than level one, again indicating a certain level of arbitrariness. Level three was described as other sports, listing jogging, running, and swimming as examples. Frequency of activity was not taken into account and the methods used to derive the scale were not mentioned.

A Rationale for Measuring Activity Levels

Multi-item scales involve addition of the scores of each individual item to form the final score.[41] Alternatively, the Gutman method[30] involves a hierarchical arrangement in which any single item subsumes those below it, as in the Tegner scale.[40] Although Gutman scales are intuitively attractive for their simplicity, there are limitations in their validity when applied to rating patient activity levels. Ranking of sports on Gutman scales becomes somewhat arbitrary.

By asking patients what sports they play, the investigator may not be asking each patient the same question because the activity level for a given sport varies among individual players.[40] For example, playing in a game of basketball involves jumping, running, and cutting. However, patients can consider themselves to be "playing basketball" if they are practicing shots on their own without placing high loads across the knee. The differentiation between recreational and competitive sports can also be unclear. A subject can be very active and place high demands on his or her knee at a low level of "competition" for a given sport.

Various cultural groups play different sports. Although the sport "bandy" (which is popular in Sweden but is not known to most North Americans) is listed in the Tegner activity rating scale, baseball is not mentioned.[40] Omissions such as this may lead to serious misclassifications.

For these reasons, it may be advantageous to measure specific components of function, such as jumping or running, which may allow more accurate comparisons among patients. By identifying the common threads of sporting movements that apply universally to the lower limb, the pitfall associated with a comparison of specific sports can be averted.

Results of Item Generation and Item Reduction

Item generation was performed by interviewing 10 orthopaedic surgeons who specialize in sports medicine, 5 physical therapists and athletic trainers who specialize in sports medicine, and 20 athletic patients with disorders of the knee. Nine relevant items were identified: getting out of a low chair, going up stairs, going down stairs, running, cutting, pivoting, jumping, decelerating, and doing a deep knee bend or a squat.

Fifty patients (27 men and 23 women), with a mean age of 32.8 years (range, 12 to 57), were interviewed for item reduction. Twenty-three of these patients had ACL injuries, nine had meniscal tears, seven had patellofemoral pain, three had osteochondritis dissecans, two had medial collateral ligament injuries, two had patellar tendinitis, and one each had iliotibial band syndrome, PCL injury, tibial plateau fracture, and a chondral defect. The top four items rated by importance and severity were running, cutting, decelerating, and pivoting (Table 1). The results of this analysis were similar for patients with the three most common diagnoses. The four top items were selected for the scale because the goal was an instrument composed of approximately four items that were clinically relevant. We elected not to remove or add further items based on clinical sensibility.[17] For example, although patients rated going up stairs extremely important, this item was not very problematic for the patients and we elected not to include it.

To arrive at a questionnaire that was easily understood, we reviewed the questionnaire format with 25 athletic patients with knee disorders. After each administration we modified the introduction of the questionnaire, the definition of each item, and the number of response categories, as required for comprehension. In the final version, we included five choices for frequency of each functional component of activity (see "Appendix").

If an interviewer were to administer the questionnaire, it would likely facilitate comprehension; however, this would complicate data collection significantly. We elected to use a self-administered format to allow administration along with other questionnaires in the office setting. Therefore, the introductory sentence is particularly important to ensure that the patients understand the questions. The font size of the instructions at the top of the form (20 point) is much larger than the rest of the wording in the questionnaire (12 point). In addition, part of the introduction is printed in bold to further emphasize its importance. This led patients to focus on the instructions and respond appropriately to the questions (see "Appendix").

In general, specific sports were not used as examples, to focus on the patients' actual activity rather than participation in a sport. Pivoting was particularly difficult to define for patients and therefore we used several examples of sports that involve pivoting to aid comprehension. The items were weighted equally, and one point was allocated for each category of frequency, starting with "one time in a month." For example, if a patient responded "less than one time in a month" for one of the items, they were accorded zero points for that item; "one time in a month," one point; "one time in a week," two points; and so on. There are four items so the maximum score is 16 (if they answer "four or more times in a week" for all four) and the minimum score is zero. The median baseline score of the 40 subjects tested for the reliability and validity testing was 7.0 and the range was 0 to 16 (Fig. 1).

Results of Reliability and Validity Testing

The responses of 40 volunteers (27 men and 13 women), with a mean age of 33.7 years (range, 18 to 50), were studied for the reliability and validity testing. Twenty-eight of the volunteers participated in sports on a regular basis. Of these, the most common sports were baseball or softball (six subjects), basketball (five subjects), and tennis (three subjects). The test-retest reliability at 1 week was excellent (intraclass correlation coefficient [ICC] = 0.97). The scale was significantly correlated ($P < 0.05$) with all of the activity rating scales studied (Tegner scale, $r = 0.66$; Cincinnati scale, $r = 0.67$; Daniel scale, $r = 0.52$). When all four scales were correlated with each other, the new scale had the highest correlation with both the Cincinnati and Tegner scale and the second highest correla-

TABLE 1
Item Reduction by Determining Mean (Range) Importance and Severity Scores for the Nine Activities from Item Generation

Activity	Mean importance score (possible range, 1–10)	Mean severity score (possible range, 1–10)	Sum of mean importance and severity (possible range, 2–20)
Running	9.0 (5–10)	7.6 (1–10)	16.6 (9–20)
Cutting	7.9 (1–10)	8.3 (1–10)	16.2 (6–20)
Decelerating	8.1 (2–10)	7.3 (1–10)	15.4 (6–20)
Pivoting	8.6 (2–10)	5.8 (1–10)	14.4 (6–20)
Squatting	8.9 (5–10)	5.2 (1–10)	14.2 (7–20)
Going downstairs	9.6 (2–10)	4.5 (1–10)	14.1 (7–20)
Jumping	7.1 (1–10)	6.5 (1–10)	13.6 (7–20)
Going upstairs	9.5 (2–10)	3.6 (1–10)	13.1 (7–20)
Getting up from a low chair	9.2 (2–10)	2.6 (1–8)	11.8 (3–20)

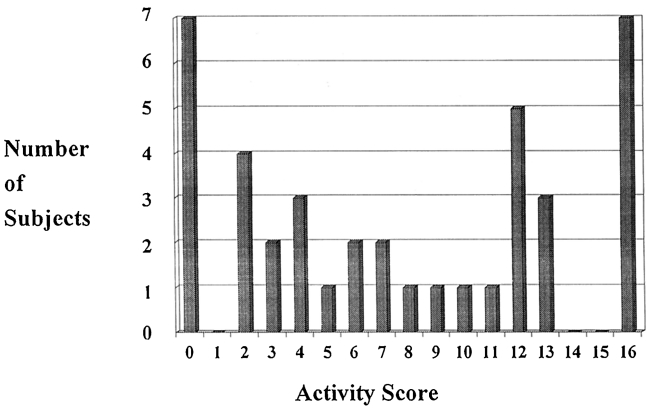

Figure 1. Distribution of scores on the activity rating scale.

tion with the Daniel scale. Importantly, the new scale was the only one that was statistically significantly inversely correlated with age (older patients rated as less active, $r = -0.48$, $P = 0.002$). Although the other scales were inversely related to age as well (Tegner, $r = -0.14$, $P = 0.41$; Cincinnati, $r = -0.25$, $P = 0.12$; Daniel, $r = -0.12$, $P = 0.47$), their correlations with age were less strong.

DISCUSSION

This study describes the development and evaluation of a new rating scale for patients' activity levels. This scale is different from most previous measures of activity because it is not based on participation in specific sports. Instead, patients are asked about components of physical function that are common to different sporting activities. This strategy was selected for several reasons. First, people participate in different sports for a variety of social or cultural reasons. Second, it is difficult to objectively rank sports by intensity or difficulty. Further, people who participate in the same sport do so with varying frequencies or intensities or both. By assessing the frequency of specific physical tasks, such as running or jumping, patients can be compared more readily. This scale does not assess ability because we are measuring participation rather than competence.

The goal of the instrument is to target the general activity level of the patient, not the most recent activity level in the previous days or weeks. A patient's activity level at a given point in time can be affected by the season (winter or summer), recent injury, illness, or surgery. Therefore, we chose to ask patients their highest (or peak) activity level in the past year to obtain a more accurate estimate of their baseline activity when participating in their sport (see "Appendix"). The highest level of activity required by the patient to participate in their sport is important for quantifying their activity without confusing frequency of activity with ability.

This activity scale measures patients' activity levels with a particular emphasis on activities that are difficult for someone who has a pathologic condition of the knee such as ACL insufficiency, a meniscal tear, or a chondral defect. Although the majority of sports that are difficult for patients with knee problems involve running, pivoting, cutting, and deceleration, there are a few exceptions to this rule, such as swimming. In the case of a patient who swims frequently but who never participates in running, cutting, pivoting, or decelerating sports, their activity level would potentially be underestimated.

The newly developed scale can be completed in a very short time frame, allowing it to be used in conjunction with other health status instruments. The scale demonstrated excellent construct validity, as the correlations among it and the other activity scales (Tegner, Cincinnati, and Daniels) were greatest with the new instrument. This scale was the only one to have a statistically significant inverse correlation with age, which was one of the constructs identified a priori.

This instrument should be used as a baseline measure of activity, as a patient characteristic, to describe the subjects studied in clinical research. The scale is designed to measure activity (what patients are doing) rather than health status (how patients are doing). Although the two are related, the latter is better accomplished by a site- or condition-specific health-related quality of life questionnaire.[24] The use of this tool for studies in sports medicine will allow appropriate generalizability of results and improve the scientific validity of the conclusions of clinical research in this field.

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Appendix. The Activity Rating Scale

Please indicate how often you performed each activity in your healthiest and most active state, **in the past year.**

	Less than one time in a month	**One time in a month**	**One time in a week**	**2 or 3 times in a week**	**4 or more times in a week**
Running: running while playing a sport or jogging					
Cutting: changing directions while running					
Decelerating: coming to a quick stop while running					
Pivoting: turning your body with your foot planted while playing a sport; For example: skiing, skating, kicking, throwing, hitting a ball (golf, tennis, squash), etc.					