[Athletic Training]

Reference Values for the Marx Activity Rating Scale in a Young Athletic Population: History of Knee Ligament Injury Is Associated With Higher Scores

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Background: Activity-related patient-reported outcome measures are an important component of assessment after knee ligament injury in young and physically active patients; however, normative data for most activity scales are limited.

Objective: To present reference values by sex for the Marx Activity Rating Scale (MARS) within a young and physically active population while accounting for knee ligament injury history and sex.

Study Design: Cross-sectional study.

Level of Evidence: Level 2.

Methods: All incoming freshman entering a US Service Academy in June of 2011 were recruited to participate in this study. MARS was administered to 1169 incoming freshmen (203 women) who consented to participate within the first week of matriculation. All subjects were deemed healthy and medically fit for military service on admission. Subjects also completed a baseline questionnaire that asked for basic demographic information and injury history. We calculated means with standard deviations, medians with interquartile ranges, and percentiles for ordinal and continuous variables, and frequencies and proportions for dichotomous variables. We also compared median scores by sex and history of knee ligament injury using the Kruskal-Wallis test. MARS was the primary outcome of interest.

Results: The median MARS score was significantly higher for men when compared with women ($\chi^2 = 13.22$, $df = 1$, $P < 0.001$) with no prior history of knee ligament injury. In contrast, there was no significant difference in median MARS scores between men and women ($\chi^2 = 0.47$, $df = 1$, $P = 0.493$) who reported a history of injury. Overall, median MARS scores were significantly higher among those who reported a history of knee ligament injury when compared with those who did not ($\chi^2 = 9.06$, $df = 1$, $P = 0.003$).

Conclusion: Assessing activity as a patient-reported outcome after knee ligament injury is important, and reference values for these instruments need to account for the influence of prior injury and sex.

Keywords: activity scales; patient-reported outcome measures; knee ligament injury

Patient-reported outcome measures have become increasingly important in evaluating treatment effects in sports medicine clinical practice and research in the past 20 years.[13] When assessing patient-reported outcomes in the knee, it is generally recommended to include a site- or condition-specific instrument (eg, Knee Injury and Osteoarthritis Outcome Score [KOOS], International Knee Documentation Committee [IKDC], Lysholm), a general health-related quality of life instrument (eg, Short Form–36, Short Form–12), and a measure of activity level.[13] The measure of activity level may be

particularly important as a potential confounding variable associated with patient outcomes after knee injury.[8] This is particularly true because activity level and frequency may be associated with knee injury risk, as well as outcomes after knee injury.[8]

While the psychometric properties of several site- and condition-specific instruments for the knee have been thoroughly evaluated, the same is not true for measures of activity.[8] Marx et al[8] noted several limitations in a systematic review of existing measures of activity that had been developed and used in physically active patients with knee injury. At the time of review, the measurement models for most of these instruments had not been described and the psychometric properties of many of the existing measures had not been evaluated.[8] Many of the scales were based on the arbitrary classifications of specific sports rather than sports-related functional activities that were important to patients and clinicians.[8] Furthermore, many of the scales included items that were multidimensional,[8] which can present significant challenges in terms of measurement and interpretation.[12]

The Marx Activity Rating Scale (MARS) was designed to be administered in less than 1 minute to supplement other general health– and site-specific patient-reported outcome measures. MARS includes 4 items that assess the frequency of running, cutting, decelerating, and pivoting based on the subjects "healthiest and most active state in the past year."[8] MARS is not intended to be a measure of general fitness but rather a measure of the types of functional activities that are associated with high-level knee function; a higher score indicates more functional demand on the knee joint and potentially a higher risk of injury. Each item is scored on a 5-point ordinal scale ranging from 0 (less than 1 time in a month) to 4 (4 or more times in a week), and the total scale score is obtained by summing the individual items' scores (range, 0-16). Preliminary data for MARS suggest that it has good test-retest reliability (intraclass correlation coefficient, 0.97) and adequate concurrent and divergent validity[8]; however, the responsiveness of the instrument has not been formally evaluated.[13]

Despite being regularly used in clinical studies, normative data for MARS has not been published, particularly in a young and physically active reference population. Furthermore, it is unclear how a history of knee injury is associated with MARS scores in young athletes. Therefore, the purpose of this study was to provide population-based reference data for MARS in a young and physically active population at high risk for sports-related knee joint injury. A secondary objective of the current study was to compare MARS scores between subjects with a self-reported history of knee ligament injury and those with no history of injury.

METHODS

Design and Setting

This study was reviewed and approved by the institutional review board at our institution. A descriptive study was conducted to document normative reference values for MARS in a young and physically active population at the US Military Academy at West Point among freshmen entering in the summer of 2011. A cross-sectional analysis was performed to evaluate differences in MARS scores between those with a self-reported history of prior knee ligament injury and those with no history of injury.

Subjects

All freshmen entering the US Military Academy in the summer of 2011 were recruited to participate in this study. Subjects were briefed on the purpose of the study and reviewed and completed the informed consent process with members of the study staff on either their first or second day after arrival at the Academy. According to admissions records at our institution, nearly 70% of all incoming freshman participated in varsity athletics in high school. Furthermore, all subjects were deemed healthy and medically fit for military service prior to admission to the Academy through the Department of Defense Medical Evaluation Review Board.

Study Questionnaire and Scoring

A brief questionnaire that included basic demographic information, detailed questions about prior ligamentous injuries to the knee, and any history of prior knee surgery was administered to all subjects. MARS was administered as part of this brief questionnaire.[8] All MARS items were scored from 0 to 4 and summed for all 4 items in the scale. Raw scores ranged from 0 to 16, with higher scores representing higher activity levels. The developers of MARS did not provide guidance on how to deal with missing item scores. Therefore, subjects who did not complete all 4 items were excluded from further analysis. We used data from 5 items included in the questionnaire to identify subjects with a prior history of knee ligament injury. Subjects were instructed that "these questions referred to *knee* injuries or conditions that they had *ever* experienced."

Statistical Analysis

We calculated descriptive statistics, including means with standard deviations, medians with interquartile ranges, and percentiles for ordinal and continuous variables, and frequencies and proportions for dichotomous variables. Because MARS scores were not normally distributed, we used the Kruskal-Wallis method, which is the nonparametric approach analogous to the 1-way analysis of variance, to evaluate differences in the median MARS scores by sex and prior history of knee ligament injury. All statistical analyses were completed using STATA/SE software version 10.1 (StataCorp).

RESULTS

Of the 1268 cadets who entered the US Military Academy in the summer of 2011, 1177 (93%) consented to participate in this study (Figure 1). Descriptive statistics for MARS scores by sex and history of knee ligament injury are presented in Table 1.
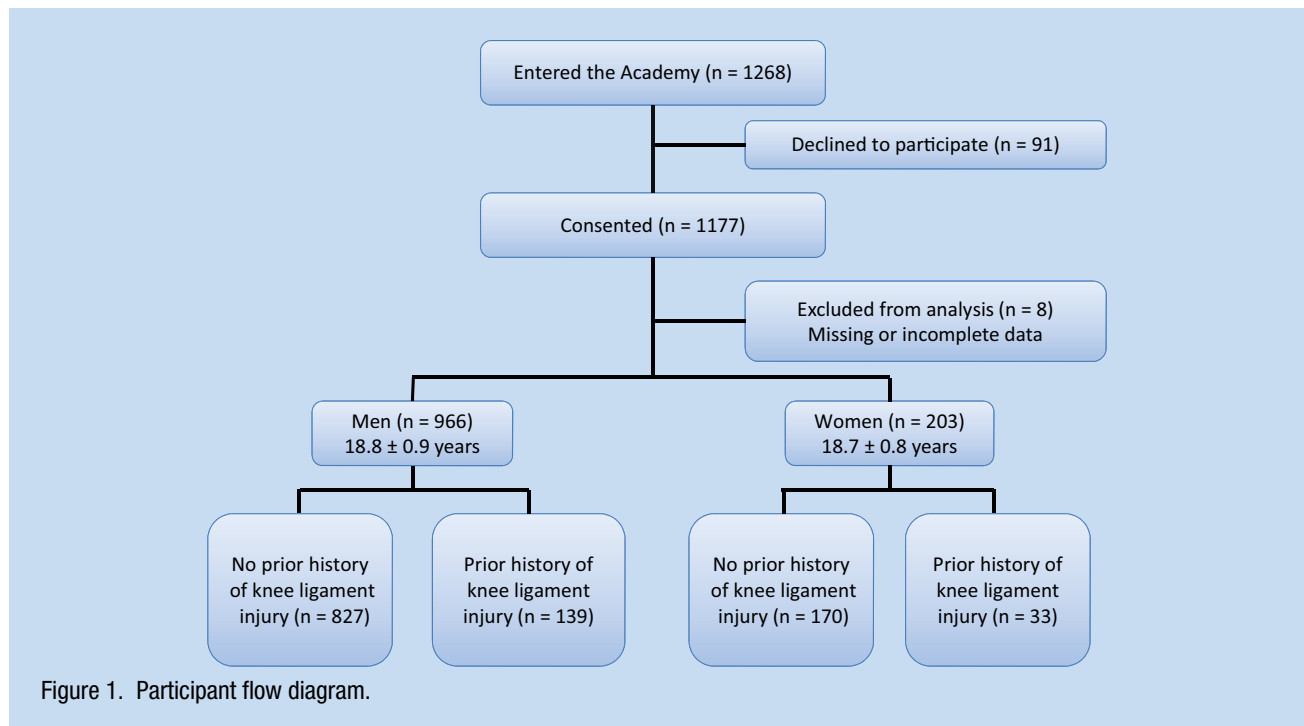
Figure 1. Participant flow diagram.

Table 1. Marx Activity Rating Scale scores by sex and history of knee ligament injury

| | n | Mean | 95% CI | SD | Percentile | | | | | Min | Max | IQR |
					10	25	50	75	90			
Men												
History of injury	139	12.58	11.75, 13.41	4.97	4	12	15	16	16	0	16	4
No history of injury	827	12.17	11.88, 12.46	4.31	6	10	13	16	16	0	16	6
Women												
History of injury	33	12.39	10.89, 13.89	4.23	6	10	13	16	16	0	16	6
No history of injury	170	10.94	10.24, 11.64	4.62	3.5	9	12	15	16	0	16	6

IQR, interquartile range.

The median MARS score was significantly higher for men when compared with women ($\chi^2 = 13.22$, $df = 1$, $P < 0.001$) among those with no prior history of knee ligament injury. The distribution of MARS scores by sex among those with no history of knee ligament injury is presented in Figure 2. There was no significant difference in median MARS scores between men and women ($\chi^2 = 0.47$, $df = 1$, $P = 0.493$) among those who reported a history of knee ligament injury.

Overall, median MARS scores were significantly higher among those who reported a prior history of knee ligament injury when compared with those with no prior history ($\chi^2 = 9.06$, $df = 1$, $P = 0.003$) (Figure 3). Similar results were observed when we compared median MARS scores by history of knee ligament injury for men ($\chi^2 = 6.53$, $df = 1$, $P = 0.011$) and women independently ($\chi^2 = 3.52$, $df = 1$, $P = 0.061$); however, the difference among women was not statistically significant. Among those who reported a prior history of knee ligament injury, there was no significant difference in median MARS scores ($\chi^2 = 0.83$, $df = 1$, $P = 0.844$), regardless of the type of knee ligament injury reported.
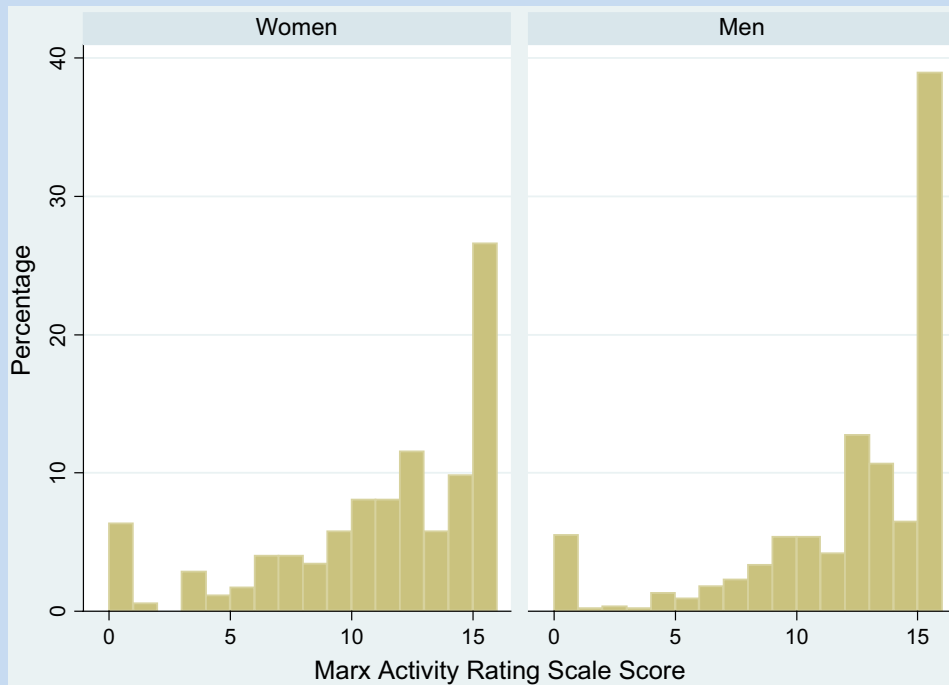
Figure 2. Distribution of Marx Activity Rating Scale scores by sex among those with no prior history of knee ligament injury.
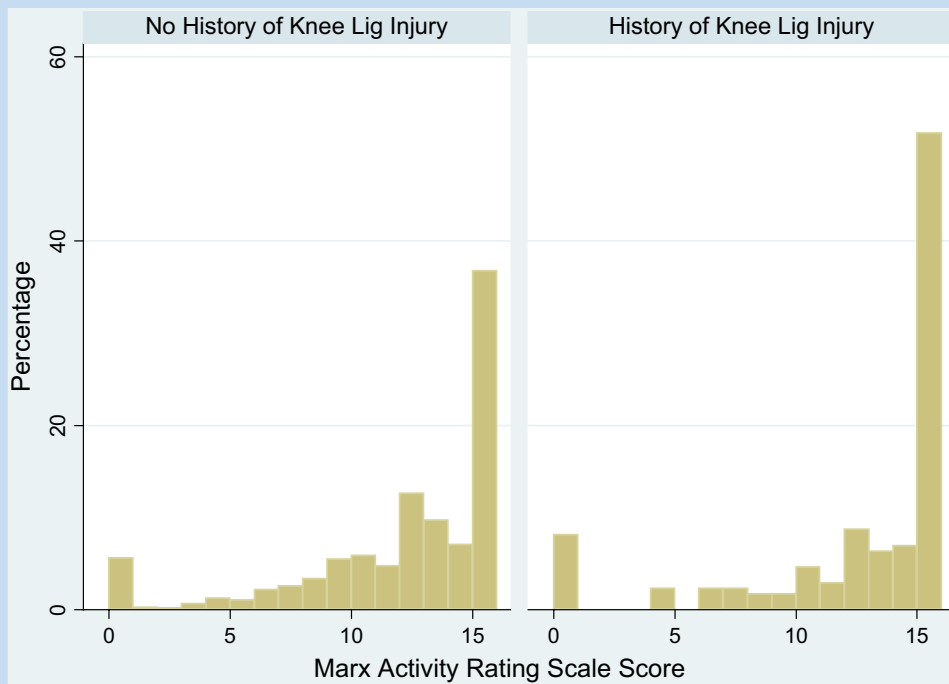

Figure 3. Distribution of Marx Activity Rating Scale scores among those with a history of knee ligament injury. Lig, ligament.

DISCUSSION

Assessing knee-related activity level is important when evaluating treatment outcomes after knee injury,[13] primarily because activity is associated with both injury risk and outcomes after injury.[8] In recent years, MARS has become increasingly used to evaluate activity level associated with knee joint injury in clinical research and practice, largely because of

the instrument's ease of use, psychometric properties, and focus on functional activity rather than sports participation.[13] MARS does not measure general fitness levels but instead measures the types of activities that place high demands on the structures of the knee; a higher score indicates more functional demand and potentially greater risk for knee joint injury.

We observed that men with no history of prior knee ligament injury had significantly higher MARS scores when compared with women with no history of injury. This is consistent with other studies examining other activity scales. A study of the Tegner Activity Scale showed that adults with no history of injury between the ages of 18 and 85 years had scores that were inversely correlated with age and that men had higher activity scores than women.[5] A study of high school and college athletes with no history of injury showed similar results; scores on the Noyes-Cincinnati and Lysholm Activity Scales were higher for men than for women.[7]

The median difference between healthy men and women with no history of knee ligament injury was 1 point in the current study. While the clinically meaningful difference in the MARS score has not been formally evaluated, a 2-point difference has been considered clinically important.[11] It is unclear how preinjury baseline differences in the MARS score between men and women, even though they may not be clinically important, affect outcomes and the interpretation of these scores after knee joint injury.

In contrast, the median difference between men and women who reported a history of knee ligament injury was 2 points on MARS, with men reporting higher scores. While this difference appears to be clinically important, it was not statistically significant in the current study. In a recent study, Spindler et al[11] reported significant differences in MARS scores between men and women after anterior cruciate ligament injury and reconstruction. Furthermore, using the 2-point criteria, they noted a clinically meaningful decline in activity level among women.

In the current study, the overall distribution of scores among subjects with no prior history of knee ligament injury was similar to the results reported by Marx et al.[8] In their original description of MARS, a bimodal distribution of scores was reported, with both floor and ceiling effects representing the most frequently reported scores.[8] Among subjects with no prior history of knee ligament injury, both men and women had notable ceiling effects. This was not surprising given the age and active nature of the study population.

In contrast to activity scales, site-specific questionnaires, such as the KOOS and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), evaluate function and pain in the injured body part. When these questionnaires are administered to healthy individuals without a history of injury, older adults and women tend to have lower scores.[4,10] Subjects in the current cohort with a history of knee ligament injury had lower scores on the KOOS and WOMAC when compared with subjects with no history of knee ligament injury.[6] However, subjects in the same cohort with a history of knee ligament injury had higher scores on MARS when compared with the uninjured subjects in the current study. It appears that the injured subjects, despite having some residual pain and/or limitations reflected in their lower KOOS and WOMAC scores, have been able to return to a very high level of activity. Because of the cross-sectional design of the current study, it remains unclear whether higher activity levels are associated with poorer outcomes on the KOOS and WOMAC, but this inverse relationship warrants further investigation and longer term follow-up in subjects sustaining knee ligament injury.

The differences in scores between the previously reported site-specific questionnaire[6] and MARS highlight the importance of including an activity rating instrument in the postinjury assessment of patient-reported outcomes. Some patients may have some pain and functional limitations but may be able to return to a high level of activity. Furthermore, returning to a higher level of activity may be associated with poorer patient-reported outcomes, as measured by the KOOS and WOMAC. This may be an acceptable result for elite athletes who desire to return to their sport. On the contrary, patients may report good outcomes in the areas of pain and function, but report lower activity scores; these lower scores may be the result of lifestyle changes made because of fear of reinjury or to avoid symptoms and achieve an acceptable quality of life.

One likely explanation for the higher MARS scores reported by previously injured subjects is that subjects who participate in more high-risk cutting and pivoting activities, which are the focus of MARS, are more likely to report a history of injury. These subjects may have had higher preinjury activity levels and postinjury MARS scores reflecting their successful return to sport. These subjects may also be at increased risk for reinjury. An alternative explanation for this difference is that there may have been selection bias that affected our results.[6] Not all athletes who sustain knee ligament injury are able to return to their previous level of sport. Studies that have examined the ability of anterior cruciate ligament–injured athletes to return to their preinjury level of sport participation have reported rates between 45% and 67%.[1-3,9] Individuals with a history of knee ligament injury who were not able to return to their sport may not have matriculated into the academy, or may have been excluded during medical screening and were therefore not included in this study. Finally, while we observed statistically significant differences between groups for many of our comparisons, some of these differences may not be clinically significant in the short term; however, the longer term impact of these differences over time remains unclear.

CONCLUSION

This study affirms the importance of including an activity rating scale in postinjury patient-reported outcome assessments. Patients with a prior knee ligament injury may report higher MARS scores but lower KOOS and WOMAC scores after injury. In addition to assessing symptoms and function, measuring activity level is an important consideration when assessing outcomes after knee ligament injury.

ACKNOWLEDGMENT

REFERENCES

1. Ardern CL, Taylor NF, Feller JA, Webster KE. Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. *Am J Sports Med.* 2012;40:41-48.

2. Ardern CL, Webster KE, Taylor NF, Feller JA. Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play. *Br J Sports Med.* 2011;45:596-606.

3. Ardern CL, Webster KE, Taylor NF, Feller JA. Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery: two-thirds of patients have not returned by 12 months after surgery. *Am J Sports Med.* 2011;39:538-543.

4. Bellamy N, Wilson C, Hendrikz J. Population-based normative values for the Western Ontario and McMaster (WOMAC) Osteoarthritis Index: part I. *Semin Arthritis Rheum.* 2011;41:139-148.

5. Briggs KK, Steadman JR, Hay CJ, Hines SL. Lysholm score and Tegner activity level in individuals with normal knees. *Am J Sports Med.* 2009;37:898-901.

6. Cameron KL, Thompson BS, Peck KY, Owens BD, Marshall SW, Svoboda SJ. Normative values for the KOOS and WOMAC in a young athletic population: history of knee ligament injury is associated with lower scores. *Am J Sports Med.* 2013;41:582-589.

7. Demirdjian AM, Petrie SG, Guanche CA, Thomas KA. The outcomes of two knee scoring questionnaires in a normal population. *Am J Sports Med.* 1998;26:46-51.

8. Marx RG, Stump TJ, Jones EC, Wickiewicz TL, Warren RF. Development and evaluation of an activity rating scale for disorders of the knee. *Am J Sports Med.* 2001;29:213-218.

9. Myklebust G, Holm I, Maehlum S, Engebretsen L, Bahr R. Clinical, functional, and radiologic outcome in team handball players 6 to 11 years after anterior cruciate ligament injury: a follow-up study. *Am J Sports Med.* 2003;31:981-989.

10. Paradowski PT, Bergman S, Sunden-Lundius A, Lohmander LS, Roos EM. Knee complaints vary with age and gender in the adult population. Population-based reference data for the Knee injury and Osteoarthritis Outcome Score (KOOS). *BMC Musculoskelet Disord.* 2006;7:38.

11. Spindler KP, Huston LJ, Wright RW, et al. The prognosis and predictors of sports function and activity at minimum 6 years after anterior cruciate ligament reconstruction: a population cohort study. *Am J Sports Med.* 2011;39:348-359.

12. Streiner DL, Norman GR. Selecting the items. In: *Health Measurement Scales: A Practical Guide to Their Development and Use.* 4th ed. New York, NY: Oxford University Press; 2008:77-102.

13. Wright RW. Knee injury outcomes measures. *J Am Acad Orthop Surg.* 2009;17:31-39.