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Pain Variability and Subjective Function in Individuals With Patellofemoral Pain: A Short Report

Neal R. Glaviano, PhD, ATC*; Mikayla M. Simon, ATC†; David M. Bazett-Jones, PhD, ATC, CSCS†

*Department of Kinesiology, University of Connecticut, Storrs; †School of Exercise and Rehabilitation Sciences, University of Toledo, OH

Individuals with patellofemoral pain (PFP) experience discomfort during various functional activities. Long-term pain is a common consequence of PFP, yet little is known about daily pain variability. Our study consisted of 25 individuals with PFP who completed the Anterior Knee Pain Scale (AKPS) and recorded their daily pain over 10 days. Pain was evaluated using 2 measures of intensity (baseline pain, 10-day average pain) and 2 measures of variability (mean square of successive differences, probability of acute change). Associations between AKPS and the 4 pain measures were calculated with Pearson correlations. We calculated a linear regression to examine the amount of variance in the AKPS explained by the 4 pain measures. Greater mean square of successive differences values were moderately associated with lesser AKPS scores ($r = -0.648$, $P < .001$). Mean square of successive differences and 10-day averaged pain were the strongest predictors of AKPS ($R^2 = 0.565$, $P < .001$). Pain variability provided a unique perspective on the pain experience and predicted patient-oriented function in individuals with PFP.

Key Words: anterior knee pain, chronic pain, pain fluctuations

Key Points

- Individuals with patellofemoral pain presented with a wide range in their daily pain scores across 10 consecutive days.
- A combination of a common measure of pain plus pain variability accounted for 56.5% of the variance in the Anterior Knee Pain Scale score among individuals with patellofemoral pain.

Patellofemoral pain (PFP) is one of the most common knee injuries, with an annual prevalence of 22.7%.[1] Patellofemoral pain is characterized by peripatellar or retropatellar pain during daily tasks such as walking, stair ambulation, and prolonged sitting. Pain during these tasks has significant implications for an individual's health-related quality of life,[2] knee-related function,[3] physical activity,[3] and social interactions.[4] Therefore, it is essential to understand the pain experience in individuals with chronic pain.

Pain is a common assessment and is used to quantify intensity, classify disability, and evaluate the effectiveness of intervention programs. Pain was also moderately correlated with knee-related function as assessed using the Anterior Knee Pain Scale (AKPS).[5] The Numeric Pain Rating Scale (NPRS) allows clinicians to quantify pain in a quick, efficient, and cost-effective way. Although pain can easily be assessed, no consistency exists regarding the type of pain (best,[5] usual,[5] during or after activity,[5,6] or worst[3]) or temporal characteristics (current,[6] previous week,[3] or previous month[6]) of pain assessments. Thus, comparing pain across patients and studies is difficult. Two patients might report identical worst knee pain scores (ie, pain type), yet one patient's pain may be assessed during a sedentary day compared with the other patient's pain assessed after running 10 miles (ie, temporal characteristic). Without context, pain assessments may be incomplete measures of the individual's pain experience, which may require 2 different, individualized intervention approaches to appropriately treat PFP.

One of the challenges of PFP is the difficulty in predicting and controlling pain due to its variable nature.[4] Discomfort fluctuates in those with chronic pain[7] due to increased physical activity, pain-provoking tasks, and a myriad of nonphysical drivers.[8] Daily changes in pain are not reflected in the isolated pain observations commonly used in research and clinical practice.[7,9] Regular observations of pain over an extended period of time (eg, 2 weeks) would allow quantification of pain variations and provide clinicians with a more complete profile of the patient's pain experience. Pain variability also affects a patient's response to treatment, as more pain variability in other chronic pain conditions predicted the success of placebo treatments.[7] However, how daily pain variability presents in individuals with PFP or if pain variability accounts for a greater influence on subjective function than more discrete pain measures is unknown.

Therefore, the purposes of our study were to (1) characterize pain variability, (2) evaluate the association of discrete and variable pain measures with subjective function, and (3) examine if pain predicted subjective function in individuals with PFP. We hypothesized that (1)

the daily pain scores of individuals with PFP would vary, (2) pain variability would have a strong association with subjective function, and (3) pain variability would predict subjective function.

METHODS

Participants

A convenience sample of 25 participants with PFP were recruited from the university and local community and via social media. Participants completed eligibility criteria screening based on previous studies.[10] The inclusion criteria for PFP were (1) retropatellar or peripatellar pain >2 out of 10 when performing 2 of the following tasks: squatting, jumping, stair ambulation, running, prolonged sitting, compression on the patella, and quadriceps contraction; (2) atraumatic pain lasting >3 months; (3) worst pain in the previous month of ≥3 cm on the visual analog scale; and (4) aged 18 to 35 years.[10] Volunteers were excluded from the study if they had (1) a previous injury to their back, hip, or knees (in addition to PFP) in the last year; (2) a ligamentous injury or instability; (3) a history of patellar dislocation or subluxation; (4) a history of surgery to the low back or lower extremity; (5) internal derangement; or (6) other sources of anterior knee pain (tendinopathy, bursitis, etc). Recruits with bilateral PFP self-selected the more symptomatic limb. The study received institutional review board approval, and all individuals provided written informed consent before enrollment.

Procedures

Participants self-reported their age, height, mass, and symptom duration on a Qualtrics survey. On day 1, they completed the AKPS, a 13-item, region-specific questionnaire that evaluates subjective symptoms and functional limitations associated with PFP. A Qualtrics survey was emailed daily to all participants to record their pain assessment. They also rated their average knee pain every day for a 2-week period on an 11-point NPRS (0–10) that was anchored with 0 representing *no pain* and 10 representing *the worst pain imaginable*. The questions were written in a way that directed participants to record their average daily pain at the same time of day during the 14 days. The AKPS and NPRS are reliable and valid scales in the PFP literature.[5]

Data Analysis

Participants consistently reported their daily pain for the first 10 days (2 data points were missed). However, missing data increased after day 11 (5–8 pain assessments per day were missed for the final 4 days). Thus, we analyzed pain during the first 10 days for all 25 participants. Pain was quantified using 4 approaches: baseline pain (day 1), 10-day averaged pain, mean square of successive differences (MSSD), and probability of acute change (PAC). The MSSD is calculated by averaging the squared successive differences between all daily pain assessments.[9] This measure quantifies the magnitude of pain fluctuations across multiple days and temporal dependency (ability to predict current pain from previous observations).[9] Greater MSSD values reflect more pain variability.[9] The PAC is the sudden change in pain, defined by a clinically meaningful threshold, divided by the total number of successive changes.[9] Although MSSD quantifies fluctuations across averaged measurements of successive changes, the PAC is the likelihood of changes across measurements.[9] We set the PAC pain threshold at 2 on the NPRS; 2 is the minimal clinically important difference in pain for individuals with PFP.[5]

Statistical Analysis

Descriptive statistics were calculated for patient demographics, AKPS score, and pain measures. Pearson correlation coefficients were used to compare the associations between the AKPS score and the 4 pain measures. Correlation coefficients were interpreted as *weak* (<0.4), *moderate* (0.4–0.7), or *strong* (>0.7). Pain measures that demonstrated a significant correlation with the AKPS score were included in the linear backward regression as predictor variables. Pain variability measures were calculated in RStudio (version 4.0.3). Statistical analyses were performed in SPSS (version 27.0; IBM Corp) with an a priori α of .05.

RESULTS

A total of 25 individuals with PFP (20 women and 5 men; age = 24.1 ± 4.0 years, height = 1.67 ± 0.08 m, mass = 75.8 ± 18.2 kg, duration of symptoms = 31.0 ± 36.6 months, range = 3–120 months) completed this study. Subjective function assessed on the AKPS was 73.8 ± 9.8, while baseline and 10-day averaged pain scores were 3.8 ± 2.5 and 3.2 ± 1.6, respectively. Pain variability was 4.5 ± 2.4 (range = 0.0–9.6) for MSSD and 0.2 ± 0.1 (range = 0.0–0.6) for PAC. Pain variability varied across participants (Figure 1), even when we compared representative participants with similar 10-day averages (Figure 2A) and baseline pain levels (Figure 2B).

Greater MSSD scores had a moderate association with lesser AKPS scores ($r = -0.648$, $P < .001$; Figure 3C). Greater baseline pain ($r = -0.599$, $P = .002$), 10-day averaged pain ($r = -0.596$, $P = .002$), and PAC ($r = -0.436$, $P = .029$) were moderately correlated with lesser AKPS scores (Figure 3A, B, and D). Greater baseline pain was moderately related to greater 10-day averaged pain ($r = 0.646$, $P < .001$) and MSSD ($r = 0.429$, $P = .032$). Greater MSSD pain variability was strongly related to greater PAC scores ($r = .740$, $P < .001$). The strongest predictor of AKPS score variance was the combination of 10-day averaged pain and MSSD: AKPS score variance = 90.90 – (2.48 × average pain) – (2.03 × MSSD), $R^2 = 0.565$, $P < .001$.

DISCUSSION

The purposes of our study were to characterize pain variability, evaluate the association of traditional and variability pain measures with the AKPS score, and examine if pain predicted subjective function in individuals with PFP. We demonstrated pain variability across individuals with PFP. Moderate-to-strong correlations existed between AKPS score and the pain measures, yet the MSSD measure had the strongest association with the AKPS score. Additionally, the combination of 10-day averaged pain and MSSD accounted for 56.5% of the variance in the AKPS score among individuals with PFP.

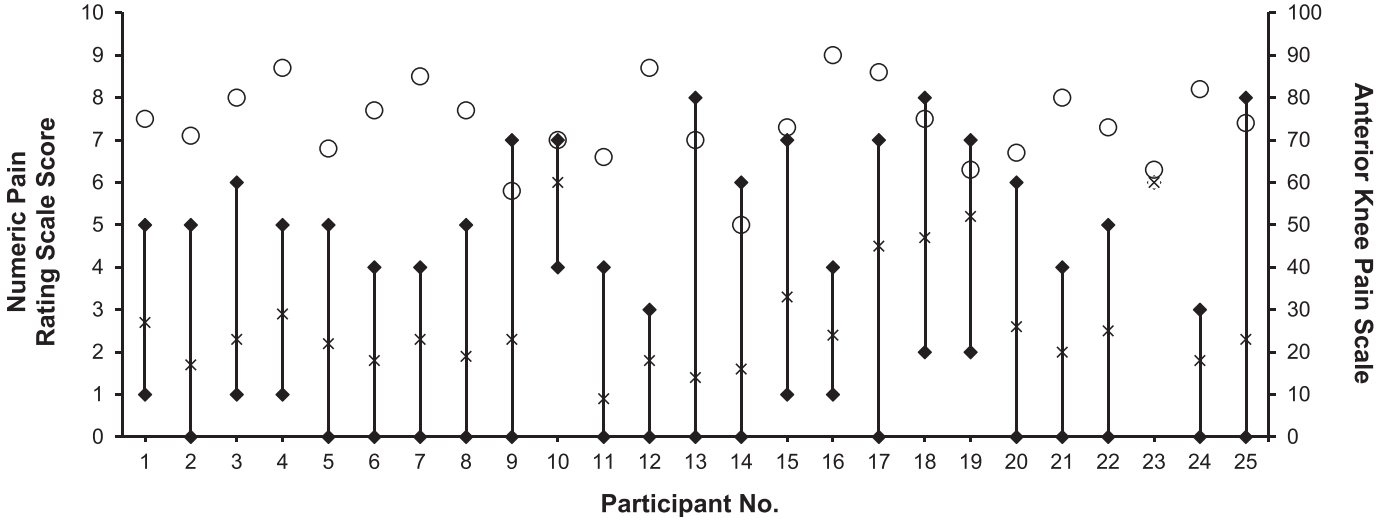

Figure 1. Pain profiles of 25 participants with patellofemoral pain. Diamonds indicate the maximum and minimum pain scores. X denotes the mean pain across the 10-day period. Open circles denote Anterior Knee Pain Scale scores.

We found a range of pain variability across participants. Participants 11 (MSSD = 7.1, PAC = 0.4) and 25 (MSSD = 9.6, PAC = 0.6) had the greatest pain variability, while participant 23 described no pain variability, reporting 6/10 pain for 10 consecutive days. The variability in daily pain was supported by qualitative evidence[4] that patients with PFP were confused about their episodic pain. It is also concerning that 36% of our cohort (9 out of 25) never experienced a pain-free day during the 10-day period (Figure 1). The wide range of pain and large percentage of participants who were not pain free is alarming, as individuals with PFP experience discomfort for years after diagnosis.[11] The inability to predict pain could make coping with pain difficult, resulting in decreased quality of life and increasing the potential for psychosocial factors such as depression and fear avoidance.[8]

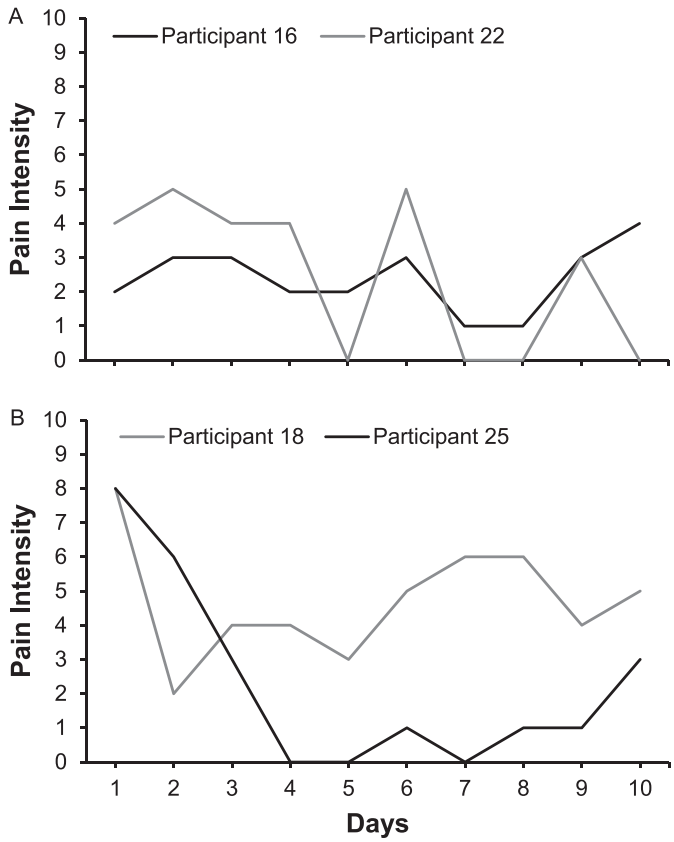

Figure 2. Comparison of individual pain experiences with, A, similar 10-day pain averages (Numeric Pain Rating Scale score = 2.4 for participant 16 and 2.5 for participant 22) and, B, similar baseline pain assessments during initial testing session (Numeric Pain Rating Scale score = 8 for participants 18 and 25).

Greater pain or greater variability was moderately associated with lesser AKPS scores (Figure 3). Multiple potential explanations exist for why greater pain variability could be associated with a lower level of subjective function. A participant with less pain variability may be able to identify pain-provoking tasks and develop specific modifications that would allow for greater subjective function and decreased disruption of daily activities. It is also possible that those with greater pain variability have worse perception of their subjective function. The large fluctuations in daily pain could result in negative attitudes toward their knee function or magnify psychosocial factors such as pain-related fear or fear-avoidance beliefs, which have been moderately related to subjective function in PFP cohorts.[3] Future research is needed to understand the relationship between pain variability and subjective function in this population.

The moderate association between pain variability and AKPS score agrees with previous evidence[5] of a moderate correlation between changes in AKPS scores with usual pain and worst pain after conservative treatment. Although our correlation findings do not support one pain assessment over another in isolation, the regression analysis demonstrated that the combination of 10-day averaged pain and MSSD explained 56.5% of the AKPS score variance. Hence, a more complete picture of pain, including measures of both pain intensity and AKPS score variability, may provide greater insight into subjective function in those with PFP.

Advances in pain assessments are necessary to gain a greater appreciation of the pain profile in individuals with

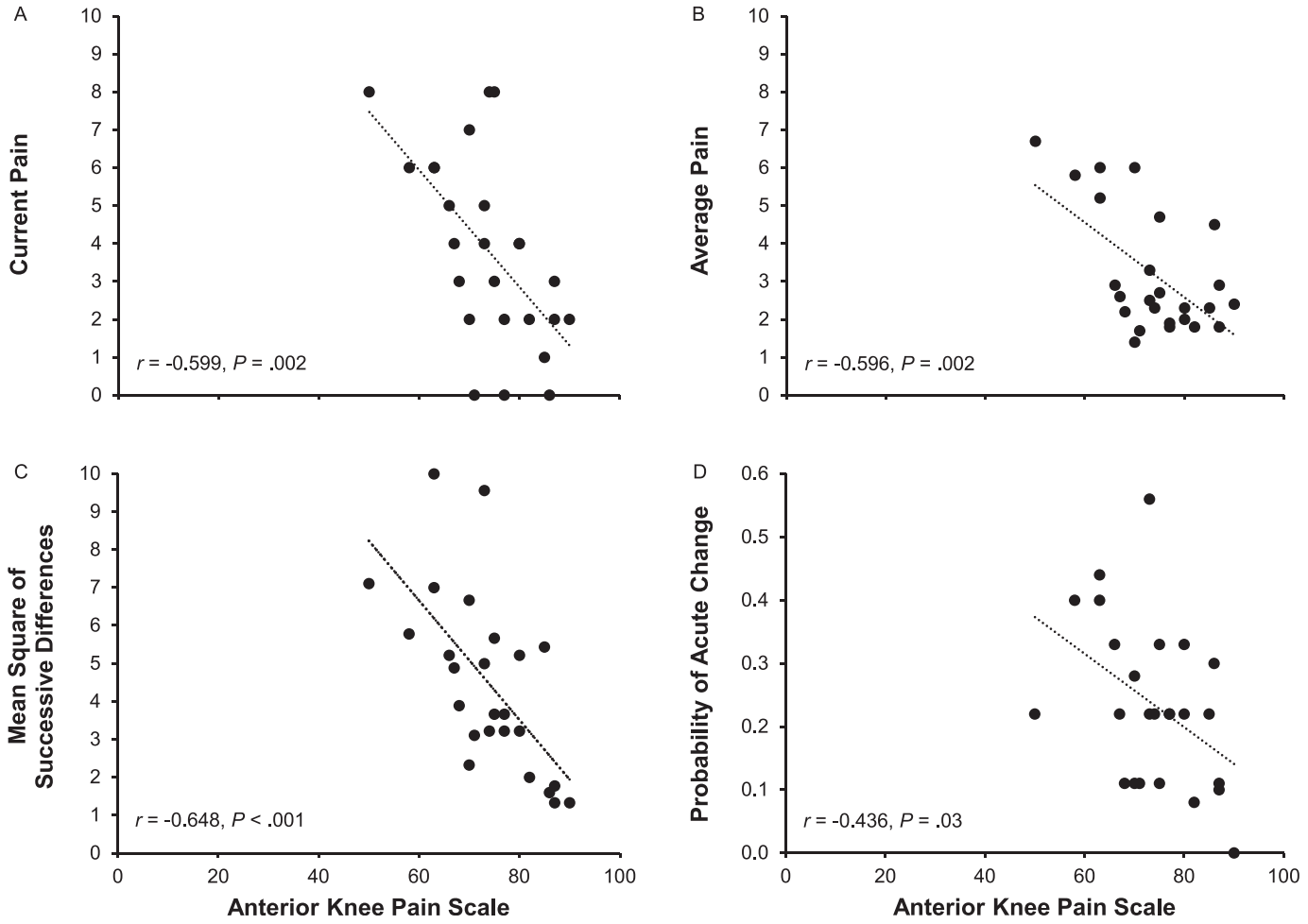

Figure 3. Association between Anterior Knee Pain Scale score and pain.

chronic pain. Novel measures of pain have emerged, such as pain mapping, which demonstrated a distinct distribution of knee pain that was associated with bilateral symptoms and longer symptom duration.[12] This innovation improves our current knowledge about the location of the pain[12] but still omits the change in pain over time. Transitioning away from a single pain measure to a more temporal-based assessment may provide a more complete picture for patients with chronic pain. Longitudinal pain assessments may be challenging, yet advancements in technology (eg, mobile device applications) may provide valuable data for clinicians. A recent athlete-monitoring investigation[13] supported the possibility of longitudinal data collection, with the goal of providing clinicians with evidence to support rehabilitation and return-to-play decisions. If clinicians can compile daily workload assessments for an entire athletic team,[13] collecting daily pain measures is possible.

Physical activity, activities of daily living, or both could account for changes in daily pain, as individuals who are more active have greater pain severity.[6] Increased repetitive daily activities could also increase stress on the patellofemoral joint and result in greater pain.[14] Regular assessments would allow patients to reflect on their pain experience and track provoking activities. The identification of pain-provoking tasks would allow clinicians to target those specific tasks in an individual rehabilitation program.[15] It is also possible that those with higher physical activity levels have better knee function (AKPS scores) or higher pain tolerance. Future researchers should focus on better understanding the relationship of physical activity and pain in conditions such as PFP. It will be important to determine if conservative treatment can decrease pain variability or if changes in pain variability can predict short-term or long-term success.

Our study had limitations that should be considered when interpreting and generalizing the findings. Measuring pain variability in those with PFP is novel, making it difficult to calculate an appropriate sample size. Additionally, the necessary duration of pain-variability assessment in individuals with chronic pain is unknown. Longer-duration pain assessments may provide more stability in the variability calculation. We did see an increase in missing data after 10 days, warranting future studies to identify the ideal duration of data collection. Multiple methods exist for calculating pain variability, and each approach has potential benefits and limits.[9] Researchers should compare the various types of variability to determine the method with the most appropriate calculation based on their research question. Finally, although we selected a pain threshold of 2 on the NPRS for the PAC analysis, the meaningful changes in daily pain for individuals experiencing PFP are unknown.

CONCLUSIONS

Pain variability has a strong association with subjective function and, along with 10-day averaged pain, aids in explaining the variance in subjective function among patients with PFP. Longitudinal pain assessments provide quantitative evidence of pain variability, which offers clinicians insight into the pain experience of individuals who have PFP. When developing a plan of care, clinicians should consider asking patients with lower levels of subjective function about their pain fluctuations. Clinicians and researchers need to better understand how pain variability affects daily activities and other functional deficits commonly seen in the PFP population.

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Address correspondence to Neal R. Glaviano, PhD, ATC, Department of Kinesiology, University of Connecticut, 2095 Hillside Road, U-1110, Storrs, CT 06269. Address email to neal.glaviano@uconn.edu.