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The relationship between acute pain and dynamic postural stability indices in individuals with patellar tendinopathy

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Background: Patellar tendinopathy is a common condition resulting in persistent pain, frequently reported during physical activity. The relationship between dynamic postural stability and pain in these individuals is unclear and how it may affect postural stability. **Research Question:** Is there a relationship between acute pain and dynamic postural stability indices in individuals with patellar tendinopathy? **Methods:** Twenty-two recreationally active individuals with patellar tendinopathy participated. Participants performed a two-legged jump and landed on a single test-limb on a force platform. They completed 100mm visual analogue scales (VAS) before and after landing trials. Anterior-posterior (APSI), medial-lateral (MLSI), vertical (VSI), and composite (DPSI) stability indices were calculated from ground reaction force data. The relationship between stability indices and VAS for pain as well as pain change scores were assessed via non-parametric Spearman's rho (ρ) rank correlations ($p \leq .05$). **Results:** Baseline pain was not significantly correlated with any stability indices. Post-landing pain was significantly correlated with MLSI ($\rho = .540$, $p = .004$) while, VSI ($\rho = .353$, $p = .053$) and DPSI ($\rho = .347$, $p = .057$, Figure 1) had moderate, yet insignificant correlations. Pain change scores demonstrated a large correlation with MLSI ($\rho = .598$, $p = .002$). **Significance:** As pain increased in individuals with patellar tendinopathy, dynamic postural stability indices values increased, indicating more difficulty transitioning from a dynamic to static state. Although balance deficits are not typically associated with patellar tendinopathy, it appears pain and dynamic postural stability may be related in these individuals. **<u>Word Count</u>**: 234

Introduction

Patellar tendinopathy is a degenerative condition characterized by persistent pain in physically active individuals.[1] Many athletes inflicted with patellar tendinopathy suffer from long-term pain and disability, which frequently causes athletes to limit or discontinue sport participation.[2] However, many often continue to play and perform their preferred physical activity despite their pain while receiving treatment, challenging clinicians to identify treatments that are effective while tendon loading is occurring.[3]

The etiology of patellar tendinopathy is poorly understood but strength deficits, poor flexibility of the quadriceps and hamstrings, and alterations in movement patterns are often associated with patellar tendinopathy.[4-7] A number of other lower extremity orthopedic conditions, such as chronic ankle instability (CAI) and ACL ruptures have noted deficits in dynamic postural stability, but there is little to no evidence documenting if deficits exist in individuals with patellar tendinopathy.[8-10] More similarly, in a population with patellofemoral pain syndrome individuals have demonstrated worse dynamic balance as assessed by the star-excursion balance test.[11,12] However, it is unknown how patellar tendinopathy related pain, a common symptom in this population, affects dynamic postural stability.

This exploratory study will be used to establish a link between patellar tendinopathy related pain and dynamic postural stability when landing on a single-limb. As patellar tendinopathy often affects athletes involved in jumping sports such as basketball and volleyball players, it important to stress the tendon during jumping and landing activities. Single-limb hopping tests require dynamic stabilization, more closely resemble athletic activity and will significantly stress the patellar tendon.[15] This may provide insight to improve rehabilitation paradigms for these patients as well as to drive future research. For instance, although balance exercises and training are commonly advocated as part of a comprehensive treatment plan for those with patellar tendinopathy,[13] little evidence is available that demonstrates postural stability deficits exist in this population and thus should be treated. Therefore, the purpose of this study was to determine the relationship between pain and dynamic postural stability in individuals with patellar tendinopathy.

Methods

Twenty-two recreationally active individuals with patellar tendinopathy were recruited to participate in this study (Table 1). Participants first completed institution approved human subjects consent, followed by a health history questionnaire, a Victorian Institute of Sport Assessment Scale-Patella (VISA-P) and a baseline pain visual analogue scale (VAS) for their involved knee. The VISA-P was designed to assess the severity of symptoms in patients with patellar tendinopathy. The questionnaire is eight questions; six questions being a modified VAS and two questions being multiple-choice. A score is given as a range of 0-100 with a score of 100 indicating that the individual is pain-free and without restrictions from physical activity, and ≤80 indicating an individual has patellar tendinopathy.[14] Participants completed two VAS at baseline, one asking regarding their pain at its worst in the past month and one how severe their pain was today.

Inclusion criteria included 1) self-reported pain within the patellar tendon for a minimum of the previous 3-months, 2) no pain in any other aspect of their knee, 3) ≤80 on the VISA-P, and 4) increased pain during single-limb jump landing compared to baseline as indicated by higher levels of pain on their blinded VAS.[3] Those who had a history of lower-extremity surgery or fracture, were receiving formal treatment at the time of participation and participated in less than 90 minutes of physical activity per week were excluded.[6] For those who reported bilateral tendinopathy, their worse limb was used as the test-limb. As this was part of a larger investigation, we also excluded individuals who reported symptoms consistent with patellar tendinopathy but did not report higher levels of pain after the single-limb jump landing when compared to the day of testing baseline VAS. Thus, participants in this analysis were only those who demonstrated increased pain post-landing or acute pain symptoms.

Procedures

Participants first completed institution approved human subjects consent, followed by health history questionnaires and a baseline pain VAS for their involved knee. Participants first performed a maximum vertical jump. They then stood 70cm from the force platform and jumped off two legs to 50% of their maximum vertical leap as a target height. Participants raised one arm touched the Vertec© jump trainer (Sports Imports, Columbus, OH) and landed on a single-limb.[8,15] These two-legged jumps to single-limb landing were onto a force platform (1200Hz; Bertec 4060-NC®; Bertec Corporation, Columbus, OH). Post-landing they were instructed to stabilize as quickly as possible and balance for 10 seconds.[8,15] Participants completed 5 jump-landing trials with a successful trial being when participants completed the landing, holding the position for 10 seconds without falling or stumbling off the force platform.[8,15] After the completion of the landing trials, participants completed another VAS for pain and were blinded to previous scores. A single-limb landing maneuver was chosen for several reasons. First, several individuals reported unilateral patellar tendinopathy and we felt a single-limb landing would elicit a greater response. Second, energy-storage activities such as a single-limb landing with loading is common and recommended as part of a comprehensive evaluation protocol for individuals with patellar tendinopathy.[16] Lastly, this particular protocol has been used and validated previously in individuals with other orthopedic conditions.[8,15]

Data and statistical analysis

A custom written MatLAB program (v7.0; the MathWorks, Natick, MA, USA) was used to reduce and calculate dynamic postural stability indices from ground reaction force (GRF) data. Data from the initial 3 seconds post-ground contact (>10N) were assessed.[8] Calculations included anterior-posterior (APSI), medial-lateral (MLSI), vertical (VSI), and composite (DPSI) stability indices according to previously established formulae.[8,15]

All statistical analyses were performed using IBM Statistical Package for the Social Sciences software (v23.0, IBM, Inc., Armonk, NY). A paired t-test and change scores were used to assess differences in VAS pain. The relationship between stability indices and VAS for baseline and post-landing pain, as well as change scores, were evaluated via non-parametric Spearman's rho (ρ) rank correlations. Statistical significance was set a-priori at $p \leq .05$. Correlational coefficients were assessed as <0.3=small, 0.3-0.5=medium and >0.5= large.[17]

Results

Demographic data from the included participants is in Table 1, while means and standard deviations of VAS, change scores and stability indices are in Table 2. Participants indicated greater pain post-landing compared to baseline ($t=7.20$, $p<.001$), which was anticipated. Baseline pain was not significantly correlated with any stability indices (Table 2). Post-landing pain had a large significant correlation with MLSI ($\rho=0.540$, $p=0.004$). While VSI ($\rho=0.353$, $p=0.053$) and DPSI ($\rho=0.347$, $p=0.057$, Figure 1) had moderate, yet insignificant correlations. Pain change scores had a large correlation with MLSI ($\rho=0.598$, $p=0.002$) (Figure 2).

Discussion

As post-landing pain increased in individuals with patellar tendinopathy, stability indices values also increased, indicating more difficulty transitioning from a dynamic to static state. Those with higher levels of pain and greater change in pain scores demonstrated increasingly worse dynamic postural stability. The degree of patellar tendinopathy related pain one has may have some influence on their dynamic postural stability.

Although previous studies have not directly assessed postural stability in patients with patellar tendinopathy, those with other forms of knee pain have demonstrated alterations in postural control. Most similarly, women with unilateral patella-femoral pain syndrome previously demonstrated worse static posture in their symptomatic compared to their asymptomatic limb.[18] In those with knee osteoarthritis poorer function and more pain were related to worse postural control and the postural control is worse compared to matched controls.[19,20] Experimentally induced knee pain also negatively altered static postural stability in a healthy, young adult population.[21] Therefore, knee pain, regardless of its source, may have a negative impact on lower extremity postural control, likely due to its influence on sensorimotor function. Pain signals may interfere with proprioceptive input controlling stability.[21]

The MLSI direction demonstrated the strongest correlations with pain. While the patellar tendon has primary responsibilities to stabilize the knee in the anterior-posterior direction, in general tendons have limited ability to transmit shearing and torsional forces compared to tensile.[22] With additional medial-lateral sway, the tendon may not be able to handle this additional strain and perhaps, as pain increases, allowing more body motion or a longer duration of motion in the medial-lateral direction may be an off-loading strategy. However, this requires further investigation to determine.

Both proprioceptive and strength deficits are hallmarks of patellar tendinopathy which may impact the dynamic postural stability. Effectively stabilizing during dynamic movement is heavily dictated by one's strength and proprioceptive function.[23,24] In individuals with patellar tendinopathy, those who report higher levels of dysfunction also have been shown to have less strength and worse joint position sense.[6,25] Consequently, dynamic postural stability likely suffers as well. Additionally, subtle deficits in dynamic postural stability may develop as pain acutely increases, decreasing stability performance, which has been linked to poor joint function.

Conclusion

In this preliminary analysis, pain moderately correlated with stability indices, indicating as pain increased, stability worsened. Considering many individuals with patellar tendinopathy continue to perform their preferred physical activity despite the persistent pain, they may be performing demanding tasks but exhibiting a dynamic stability deficit.

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