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Patellar Tendon Straps Decrease Pain and May Alter Lower Extremity Kinetics in Those With Patellar Tendinopathy During Jump Landing

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1 Patellar tendon straps decrease pain and may alter lower extremity kinetics in those with patellar
2 tendinopathy during jump landing

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5 Key Points:

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7 - Patellar tendinopathy participants had decreased pain with a strap while jumping.

8 - Anteriorly directed ground reaction forces in all participants were decreased while
9 wearing the strap.

10 - Kinetic changes may influence pain reduction in individuals who wear a patellar tendon
11 strap.

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14 Key words: jumper's knee, lower extremity biomechanics, bracing

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17 **ABSTRACT**

18 Patellar tendinopathy is often managed with a patellar tendon strap however, their effectiveness
19 is unsubstantiated. The purpose of this study was to determine if straps altered pain or lower
20 extremity kinetics of individuals with patellar tendinopathy during landing. Thirty participants
21 with patellar tendinopathy and thirty controls completed drop-jumps with and without patellar
22 tendon straps. Wearing the strap, tendinopathy participants demonstrated significantly decreased
23 pain and reduced knee adductor moment; all participants displayed significantly decreased
24 anterior ground reaction force while wearing a strap. Patellar tendon strapping may reduce pain
25 due to alterations in direction and magnitude of loading.

26

27 **INTRODUCTION**

28 Patellar tendinopathies account for approximately 10% of all clinical knee diagnoses in
29 athletes.^{1,2} Patellar tendinopathy occurs with chronic overloading of the quadriceps and/or
30 patellar tendon, leading to degenerative changes within the tendon, potentially without
31 histological signs of inflammation.³⁻⁶ Consequently, excessive internal tensile loading may
32 contribute to further degeneration and debilitating symptoms.^{3,4} Therefore, any movement,
33 especially when requiring eccentric quadriceps force, may cause pain.

34 To assist in pain relief, clinicians advocate use of a patellar tendon strap for pain
35 reduction during physical activity.⁷ However, there is a lack of evidence of the strap's efficacy
36 and mechanisms by which strapping reduces patellar pain.^{4,8-10} The patellar tendon strap is
37 thought to exert compressive pressure on the damaged tendon and, via an unknown
38 mechanism(s), alleviate internal tensile strain and loading created by quadriceps and tibial forces,
39 thus reducing pain.⁹

40 These claims require further assessment to determine if the alterations are manifested in
41 lower extremity mechanics. If, theoretically, compression occurs, the tendon may be pulled
42 posteriorly, and, consequently, decreases the angle of pull and moment arm of the quadriceps
43 force applied to the tibia.⁷ Therefore, due to the linked kinetic chain of the lower extremity and
44 the rectus femoris actions' on the hip and knee, it was anticipated that during landings, strapping
45 would decrease knee and hip extensor moments of healthy or tendinopathy individuals.¹¹ Thus,
46 these changes with the use of the strap may decrease the strain on the patellar tendon.⁷

47 Additionally, relative to healthy participants, to minimize pain, patellar tendinopathy
48 participants were expected to display decreased hip and knee flexion moments during no-strap
49 landings. Less knee and hip flexion motion exhibited by individuals with patellar tendinopathy

50 may reduce tensile tendon strain, hence leading to decreased pain.¹² However, more erect
51 landings in individuals with patellar tendinopathy have been associated with increased ground
52 reaction forces (GRF) that cause unnecessary loading to the patellar tendon.¹³ Increases in GRFs
53 in any direction depending on the knee angle at contact may cause greater shearing or torsional
54 effects on the lower extremity at landing.¹⁴

55 Exploring frontal and transverse plane mechanics at the knee may offer considerable
56 insight into the effectiveness of strapping to compensate for moments produced in these planes.¹⁷
57 Knee frontal and transverse moments are associated with patellar tendinopathy causation.¹⁵ It is
58 believed that higher transverse plane moments generated during jumping contribute to the
59 development of patellar tendinopathy and pain by increasing torsional forces at the knee.¹⁵
60 Correspondingly, tendons are particularly adept at transmitting tensile forces, however they
61 appear ill-suited at dissipating shearing and torsional forces.¹⁶ Therefore

62 Thus, the overall purpose of this study was to determine if patellar tendon straps reduced
63 pain and altered ground reaction forces, peak knee and hip joint moments of individuals with and
64 without patellar tendinopathy compared to a non-strapped condition during a drop-jump landing.

65

66 **METHODS**

67 **Participants**

68 This study was approved by the local Human Subjects Institutional Review Board.
69 Recreationally active individuals volunteered to complete a single-test session (Table 1).
70 Participants in the tendinopathy group had 1) pain completely within the patellar tendon and
71 experienced pain during recreational activity during each of the last three months, 2) continued
72 performance of their self-reported activity despite patellar tendinopathy pain, and 3) < 80 on the

73 Victorian Institute of Sport Assessment Scale-Patella (VISA-P), indicating decreased daily
74 function.¹⁸ Participants in the control group had no knee pain or history of tendinopathy.¹⁸ They
75 were pair-matched to corresponding patellar tendinopathy participants based on gender, age
76 ($\pm 10\%$ years), height ($\pm 10\%$ cm), and mass ($\pm 10\%$ kg). Participants were excluded if they had a
77 history of lower extremity surgery or fracture or were enrolled in a rehabilitation or physical
78 therapy program for knee pain at the time of entering the study.

79 This sample size was recruited based on an a-priori power analysis using G*Power™
80 (Kiel University, Germany). Although previous literature in this area is limited, one study by
81 Bisseling and colleagues investigated kinetics during drop jumps among three groups of
82 participants: controls, previous history of tendinopathy and recent history of tendinopathy.¹⁹ We
83 used the *t*-test family to assess differences in the previous results, with $\alpha = .05$, $1 - \beta = .80$ and
84 Cohen's *d* effect size = 0.81. Based on this data twenty-five control participants and twenty-five
85 with a previous history of patellar tendinopathy during a drop jump were found to be necessary
86 to identify differences in vertical ground reaction forces. Therefore a sample size of 60 (30
87 controls and 30 patellar tendinopathy) was concluded to be appropriate to account for potential
88 dropouts and unforeseeable data issues. As no studies to date have identified differences in
89 kinetics during strapping conditions between control and patellar tendinopathy participants, this
90 was the best available literature comparison to perform an apriori power analysis.

91

92 **Procedures**

93 Participants provided consent and completed a laboratory health history and physical
94 activity questionnaire, VISA-P, and “baseline” 100 mm visual analogue scales (VAS) for knee
95 pain, with “no pain” and “very severe pain” as anchors.²⁰ Retro-reflective markers were

96 attached to sixteen anatomical landmarks of the pelvis and lower extremity for later use with a
97 kinematic model used in the Plug-In-Gait software (Workstation, v5.2.4, OMG Plc., London,
98 UK).^{21,22} To determine vertical jump height for the test task, the participant completed three
99 maximum-vertical jumps (Vertec Jump Trainer™; Sports Imports, Columbus, OH).

100 Participants completed a two-legged drop landing off a 40cm box, with each foot landing
101 onto one of two force platforms (1200 Hz; Bertec 4060-NC®; Bertec Corporation, Columbus,
102 OH, Figure 1), followed by a vertical jump (50-55% maximum height). Marker locations were
103 recorded via a 7-camera motion capture system (120 Hz, Vicon-MX40, Vicon, Oxford, UK).
104 Participants performed five trials for each of the no-strap and strap conditions (Universal Matt
105 Strap™; Hely & Weber, Santa Paula, CA, Figure 2) in a counterbalanced order. Participants
106 completed the VAS after completing no-strap and strap conditions and were blinded to previous
107 scores. There were ≈15 minutes between the VAS declarations.

108

109 **Data Reduction and Analysis**

110 Standard inverse dynamics (Vicon Workstation™ software) were used to calculate joint
111 moments for the knee joint (all planes) and hip joint (sagittal plane) for the vertical jump contact
112 phase (touchdown to take-off).^{11, 23} Dependent variables of interest included peak magnitudes for
113 hip sagittal plane joint moments, knee sagittal, frontal and transverse plane joint moments,
114 (scaled to body mass: Nm•kg⁻¹) and antero-posterior GRF (normalized to body weight [BW]).

115 Statistical significance was set at $p \leq .05$. Independent samples *t*-tests were applied to test
116 for differences in demographic data and VISA-P scores between control and tendinopathy
117 groups. Baseline and test VAS pain scores were compared using Friedman's analysis of
118 variance.²⁴ A two factor, mixed-model (2 tendinopathy groups x 2 no-strap and strap conditions

119 [within-subjects factor]) multivariate analysis of variance (MANOVA) was performed that
120 included all dependent kinetic variables. If a significant interaction or main effect was detected,
121 univariate analysis of variance test was applied. Cohen's d effect size was calculated and
122 interpreted as .1-.3=small, .3-.5=moderate and $>.5$ = large effects.²⁵

123

124 **RESULTS**

125 Patellar tendinopathy participants had more pain ($p < .001$) prior to testing and in the
126 strapping and no-strap trials compared to the control participants. Tendinopathy participants
127 reported less pain at baseline ($p = .05$) and for the strapped compared to the non-strapped
128 condition.

129 The MANOVA exhibited no interaction between strap and tendinopathy conditions ($p = .34$,
130 $1 - \beta = .52$), but strapping was significant ($p = .05$, $1 - \beta = .84$). Only one kinetic variable reached
131 univariate significance. Decreased peak anterior GRF ($p = .01$, $1 - \beta = .75$, $d = 0.28$: moderate effect;
132 Table 2) occurred when participants wore the strap. Compared to no-strap, while wearing the
133 strap, tendinopathy participants tended to have a decrease in peak knee adduction moment
134 ($p = .08$, $1 - \beta = .41$, d : -0.44 to -0.51; Table 3). Qualitatively, they tended to display $\approx 15\%$ greater
135 peak hip flexor moment compared to controls, regardless of strapping condition ($p = .36$, $1 - \beta = .52$,
136 $d = 0.39$; Table 4).

137

138 **DISCUSSION**

139 The purpose of this study was to determine whether patellar tendon straps acutely
140 reduced pain and altered peak joint moments and/or ground reaction forces during a drop-jump
141 landing of participants with patellar tendinopathy versus healthy controls. Patellar tendon straps

142 reduced self-reported pain in those with patellar tendinopathy. Both groups demonstrated
143 moderately decreased anterior GRF during strap wear. Predictions of reduced knee and hip joint
144 moments due to strap wear were not supported; nor were predictions of comparisons between the
145 tendinopathy and control group.

146 Strapping may have a beneficial acute effect on pain. As hypothesized, pain experienced
147 by the tendinopathy participants decreased approximately 25% (VAS: mean difference= 6.7 mm,
148 **no-strap VAS=28.0**) when wearing the strap. Although knee pain was not ameliorated entirely
149 when wearing the patellar strap, the 7mm average decrease is clinically significant, relative to the
150 8mm minimum clinically important difference (MCID) and 15 to 25% reduction reported for
151 studies of similar construct.^{26,27}

152 Reduced anterior ground reaction forces may play a role in the pain reduction observed.
153 Unanticipated, and for reasons unknown, both groups experienced moderately decreased
154 anterior-GRF when wearing the strap. Decreased landing anterior-posterior GRF may reduce
155 shearing or torsional effects on the lower extremity and patellar tendon loading.^{14, 28, 29}
156 Therefore, this may be a positive benefit of strapping but will need to be confirmed.

157 Our prediction that peak knee and hip moments would decrease during strap landings was
158 not supported, as no significant effects were detected. However, potentially relevant was the
159 tendency ($p=.08$, with moderate to large effect sizes d : -0.44 to -0.51) of reduced knee adductor
160 moments during strap compared to no-strap landings of the patellar tendinopathy group. This is
161 supported by previous observations of reduced frontal plane moments with use of a patello-
162 femoral brace or taping during a step-down exercise.^{30,31} Investigators have surmised that this is
163 due to enhanced proprioception via the brace/tape stimulating cutaneous structures near the

164 patellar tendon and knee tendons.^{30,31} However, enhanced proprioception is difficult to prove,
165 and the benefits are likely limited in nature.

166 Sagittal knee and hip joint moments were not affected by strap condition for several
167 potential reasons. First, the strap may not influence knee moments as evidenced by the relative
168 lack of significance and effect size in the data. Perhaps there is not enough compressive force
169 provided by the strap to effectively pull the tendon posteriorly towards the center of rotation to
170 change the quadriceps moment arm length. Second, no differences in knee joint moments with
171 the strap may be beneficial in that more patellar tendon force would be necessary to produce the
172 same joint moment, possibly putting more strain on the tendon. If the moment arm did change,
173 then the quadriceps force through the patellar tendon force could have increased proportionally.
174 Hypothetically, if assumed all else equal (which may or not occur), then patellar tendon force
175 could then be estimated by dividing the knee joint moment by the patellar tendon arm.³² The
176 estimated patellar tendon moment arm at 30° of knee flexion is approximately 4.5cm.³² Then if
177 the strap pulled the tendon posteriorly 1 cm, the patellar tendon forces would correspondingly
178 increase by approximately 20%.

179 As this was a comparative study of acute effects of strapping, and no patellar forces or
180 angle of pull were estimated, there are limitations. Neither long-term consequences nor
181 mechanisms explaining the decrease in pain via landing kinetics can be demonstrated with these
182 data. No sham treatment was applied, so a placebo effect may have also been present.

183 Additionally, inter-participant variability in landing technique may have resulted in lack of
184 statistical significance for the kinetic variables, as evidenced by the large standard deviations
185 across participants.^{33,34} Based on the potential relevance of the strap effects on kinetics, it may
186 also be important to observe kinematic alterations. However, it appears based on a posteriori

187 observations, there were no statistical differences in kinematics with strapping (Table 5).
188 Although no differences in kinematics were observed between participants during strapping, we
189 did detect differences between groups for this same movement task, reported in a previous
190 investigation.¹² Participants with tendinopathy also had varying levels of dysfunction and
191 disability thus may use different landing strategies to prevent pain upon landing.³⁵ Finally, we
192 used a sample of convenience from a recreationally-active, college-student population, 18-35
193 years old; thus the results may not be generalizable to other populations.

194

195 Conclusion

196 The clinical implications of this study are that individuals with existing patellar
197 tendinopathy report decrease knee pain during jump landings when wearing the patellar tendon
198 strap. The reduced anterior-GRF for all participants and decreased knee adductor moment for
199 patellar tendinopathy participants with use of the strap may be related to pain reduction. At
200 present, whether these findings reflect underlying mechanical mechanisms or other factors that
201 cause reduced patellar tendon loading are unknown. Future work is necessary to determine if
202 wearing the strap during landings consistently leads to decreased peak anterior-ground reaction
203 force and knee adductor moment; and if so, whether each of these findings reflects different
204 causational effects that would reduce patellar tendon loading, e.g., reduced shear loading or more
205 axial-directed patellar tendon force, respectively. Conversely, the lack of strap effect on knee
206 extensor joint moments may also have clinical relevance. If there are no clinically-meaningful
207 strap effects for sagittal plane joint moments, then perhaps the strap is not creating abnormal
208 moments that could increase risk of other injuries. A proposed secondary benefit of strap wear, if
209 knee adductor moments decrease, may be less medial-side tibio-femoral compressive force.

210 Future research should identify the long-term effectiveness of patellar tendon strapping, the
211 loading on the patellar tendon and other relevant tissues, and the mechanisms by which pain
212 reduction occurs to support strapping for patients with patellar tendinopathy.

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