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Self-reported bio-psycho-social factors partially distinguish patellar tendinopathy from other knee problems and explain patellar tendinopathy severity in jumping athletes: A case-control study

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ABSTRACT

Objective: To determine what combinations of self-reported factors distinguish patellar tendinopathy (PT) from other knee problems, and explain PT severity variance.
Design: Case-control study.
Setting: Social media, private practice and National Health Service.
Participants: An international sample of jumping athletes diagnosed with either PT (n = 132; 30.7 ± 8.9 years; 80 males; VISA-P = 61.6 ± 16.0) or another musculoskeletal knee condition (n = 89; 31.8 ± 9.9 years; 47 males; VISA-P = 62.9 ± 21.2) by a clinician in the last 6 months.
Main outcome measures: We considered clinical diagnosis (case = having PT vs control = having other knee problems) as the dependent variable. Severity and sporting impact were defined by VISA-P and availability, respectively.
Results: A model comprising seven factors distinguished PT from other knee problems; training duration (OR = 1.10), sport type (OR = 2.31), injured side (OR = 2.28), pain onset (OR = 1.97), morning pain (OR = 1.89), condition acceptability (OR = 0.39) and swelling (OR = 0.37). Sports-specific function (OR = 1.02) and player level (OR = 4.11) explained sporting availability. 44% of PT severity variance was explained by quality of life (β = 0.32), sports-specific function (β = 0.38) and age (β = −0.17).
Conclusion: Sports-specific, biomedical and psychological factors partially distinguish PT from other knee problems. Availability is mainly explained by sports-specific factors, while psychosocial factors impact on

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severity. Adding sports-specific and bio-psycho-social factors into assessments could help better identification and management of jumping athletes with PT.

1. Background

Patellar tendinopathy (PT) is especially common in athletes performing repeated jumping and landing (Lian et al., 2005; Zwerver et al., 2011). Recovery rates are unsatisfactory, with observational studies showing resolution in ~65% at 6 months irrespective of intervention (Cook et al., 1997; Kettunen et al., 2002). Up to 60% of athletes with PT take more than 4 weeks off sport (Cook et al., 1997; Hägglund et al., 2011), with greater than 25% suffering from recurrence (Hägglund et al., 2011). Furthermore, PT can be a career-ending condition in up to 50% of affected jumping athletes (Kettunen et al., 2002). Intriguingly, causal explanation of PT non-recovery and recurrence remain elusive (Cook et al., 2009), despite its high prevalence in well-defined, accessible populations and many research studies.

PT presence has been shown to be associated with self-reported variables such as sex, hours of training, hamstring flexibility, previous knee injury, current or previous back pain, family history, and age (Morton et al., 2017). There are also factors associated with both PT and other knee problems (e.g. patellofemoral pain, anterior cruciate ligament injury or osteoarthritis) such as quadriceps strength (Neal et al., 2019; Witvrouw et al., 2001), playing surface (Bahr & Reeser, 2003; Smith et al., 2012), age (HamrinSenorski et al., 2019; Morton et al., 2017; van der Worp et al., 2011), sex (HamrinSenorski et al., 2019; Jones & Spindler, 2017; Morton et al., 2017; van der Worp et al., 2011) or body mass index (Crossley et al., 2007; Jones & Spindler, 2017; Malliaras et al., 2007; Silverwood et al., 2015). The commonality of these associations means that we do not know which factors are specifically associated with PT presence. Recent research has focussed on physical examination and imaging, with the absence of statistical models (van der Worp et al., 2011) considering combinations of various risk factors potentially obscuring understanding of how jumping athletes with PT present and differ from athletes with other knee problems. This lack of tendinopathy specific information limits the understanding of PT presence and therefore management.

In addition to the specificity of PT from other knee problems, we also lack a clear understanding of why some athletes present with worse severity than others. Morton et al. (Morton et al., 2017) reported some associated variables (i.e. sex, previous knee injury, family history) with PT presence, but found no association between these variables and PT severity. PT symptoms such as pain or functional limitation generally occur insidiously, and athletes often continue to play through symptoms (Clarsen et al., 2013). Additionally, there is a mismatch between tendon abnormalities seen on imaging and symptoms, although the presence of abnormalities is a risk for symptom development (McAuliffe et al., 2016). This limited understanding is likely to partly explain poor treatment outcomes. Therefore, investigating the factors that explain PT severity variance would be helpful to understand the condition better, and inform efforts to improve treatment.

The primary aim was to improve our understanding of jumping athletes with PT by determining what combination of self-reported factors distinguishes jumping athletes with PT from athletes with other knee problems. In other words, bio-psycho-social factors that are specific to PT presence were primarily looked for, rather than differentiating PT diagnosis from other knee problems. The secondary aim was to investigate the variance in PT severity.

2. Methods

The STROBE statement (von Elm et al., 2014), Strengthening the Reporting of Observational Studies in Epidemiology, guided the design and reporting of this case-control study.

2.1. Participants

This study was approved by Queen Mary Ethics of Research Committee (QMERC2018/92), the UK National Health Service (NHS) (264615) and University of Liège Hospital-Faculty Ethics Committee (2019/182). A previously validated, reliable online questionnaire battery (Tayfur et al., 2020) yielded data from an international sample of jumping athletes recruited via social media, private practice, sporting teams and the NHS through a large network of collaborators (Supplement 1). Eligibility was checked after consent had been granted, with the inclusion criteria being: aged 18 and over; performing any jump-related sport with a minimum of an hour of training once per week; having a clinical diagnosis of PT or another musculoskeletal condition affecting the knee from a clinician in the last 6 months. The exclusion criterion was having any neurological disorders.

2.2. Online questionnaire battery

The composite battery included 10 patient-reported outcome measures (PROMs) and miscellaneous questions concerning demographics, condition related details, treatments and training load in the previous 3 weeks (Tayfur et al., 2020). Participant completed the online questionnaire battery by using SmartTrial (version 4.0, MEDEI ApS, Aalborg, Denmark). We collected pain related details such as location, pain type and severity with digital online self-reported pain map drawings by using Navigate Pain (Aalborg University, Version 1). Questionnaires were carefully translated to Turkish, Spanish and French to optimise recruitment (Supplement 2). If PROMs have already been translated into targeted languages, their existing versions were used. The online survey is available upon request from the first author (AT).

The Victorian Institute of Sport Assessment Questionnaire-Patellar Tendon (VISA-P)(Visentini et al., 1998) and the Knee injury and Osteoarthritis Outcome Score (KOOS) (Roos et al., 1998) with Patellofemoral subscale (KOOS-PF) (Crossley et al., 2018) were used to measure knee-specific condition severity. For the global knee assessment, Patient Acceptable Symptom State (PASS) (De Vos Andersen et al., 2017), a single-item binary (yes/no) question, was used to define the global satisfaction over time, while the Single Assessment Numeric Evaluation (SANE) (Williams et al., 2000) rating scale was used for the degree of normal. Psychosocial factors are associated with rehabilitation outcomes (Forsdyke et al., 2016) while kinesiophobia (Tampa Scale for Kinesiophobia-11 (TSK-11))(Tkachuk & Harris, 2012) and catastrophisation (Pain Catastrophizing Scale (PCS)) (Sullivan et al., 1995) have not been investigated in PT but have in other tendinopathies (Mallows et al., 2017; Sancho et al., 2022). Health-related Quality of Life (EQ-5D-5L)(Herdman et al., 2011) was included due to likely chronicity

(Kettunen et al., 2002). General Self Efficacy Scale (GSE)(Scholz et al., 2002) was used as a cognitive factor that facilitates the recovery as it has been found useful in other knee conditions such as anterior cruciate ligament injuries (TeWierike et al., 2013) or osteoarthritis (Magklara et al., 2014). The eHealth Literacy Scale (eHEALS)(Norman & Skinner, 2006) was used as a check of online health self-efficacy.

2.3. Main outcome measurements

For the primary aim, we considered clinical diagnosis (having PT vs having other knee problems) as the dependent variable for the regression model. Thus, cases were defined as athletes with a clinical diagnosis of PT by a clinician in the last 6 months, while controls were defined as athletes with a clinical diagnosis of another musculoskeletal knee condition but not PT by a clinician in the last 6 months.

For the secondary aim, we used the VISA-P (Visentini et al., 1998) score as the main dependent variable for tendon specific severity. As many athletes continue to train and compete despite injury (Clarsen et al., 2013), consensus has identified *'Full availability for training and competition'* as the preferred marker of recovery in athletic populations (Timpka et al., 2014), and so we included this as a second dependent variable to understand the factors associated with the sporting impact of PT.

2.4. Variables of interest

We considered over 100 potentially plausible self-reported factors as independent variables in the regression models (Table 1). These were derived from published literature suggesting an association with PT (Crossley et al., 2007; Edwards et al., 2012; Malliaras et al., 2007; Morton et al., 2017; Tayfur et al., 2022; van der Worp et al., 2011; Van Der Worp et al., 2016; Witvrouw et al., 2001; Zwerver et al., 2011) or other musculoskeletal problems (Bahr & Reeser, 2003; Besier et al., 2001; Forsdyke et al., 2016; Gabbett, 2016; Mallows et al., 2017; Neal et al., 2019; Silverwood et al., 2015; Smith et al., 2012), and categorized under five different subheadings: demographics, sports specific, biomedical, psychological and social.

2.5. Data analysis

Total score calculations for PROMs have been previously published (Tayfur et al., 2020). Pain map drawings were manually converted into binary categorical (i.e. focal pain on inferior patella pole) and continuous (i.e. number of body regions) variables for location (Hannington et al., 2020), and directly exported the data for pain severity and pain type from the software (Matthews et al., 2018) (Supplement 3). For training load details, range of duration and number of jumps were collected with categorical miscellaneous questions (feasible (Tayfur et al., 2020), validity and reliability have not been tested). Then, the mid-point of ranges were took and treated as continuous data. Acute:chronic workload ratio (ACWR) were also calculated with the rolling average method in both minutes and jumps (Gabbett, 2016). ACWR was categorised as low 0–0.8, optimal 0.8–1.3 and high >1.3 severity as per recommendations (Gabbett, 2016). Other categories in certain categorical factors were shown in Table 1. Sparsely populated sub-categories that were sufficiently similar were combined prior to analysis (Frank, 2015). For instance, injured side was categorised as unilateral (right or left sides) and bilateral (both sides), while sport type was categorised as court base jumping sports (volleyball, basketball and handball) and other jump related sports (athletics, football, running, dance, fitness etc.).

2.6. Statistical analysis

Statistical analysis was conducted using STATA (version 16.0, StataCorp LP, College Station, TX, USA). We commenced with calculation of descriptive statistics to profile each study group, visualised the data and compared groups with independent t-tests or chi square procedures according to data type. Univariate regression was used to analyse associations between each plausible independent variable and having PT (logistic), sporting impact (logistic) or severity (linear).

Independent variables with $p < 0.10^{46}$ in the univariate regression analysis were retained for multivariable regression using a manual forward approach (Delen et al., 2022). The order of forward inclusion of independent variables into multivariable model was from demographic to social factors. Independent variables which improved the model were retained, as determined with the likelihood-ratio test (Hélie, 2013) at the 5% significance level. To avoid multicollinearity, correlations between independent variables were tested with Pearson or Cramer's V based on data type and variance inflation factor (VIF) (Hosmer et al., 2010; Kennedy et al., 2006). If correlation (Hosmer et al., 2010) or individual VIF (O'Brien, 2007) was greater than 0.75 or 10, respectively, for any two independent variables, they were not used together in the model, and the variable with better explanatory power retained.

For the final multivariable logistic model performance, we tested goodness of fit with the Hosmer-Lemeshow test (>0.05), model accuracy with the area under the receiver operating characteristic curve (AUC; >0.7 acceptable, >0.8 excellent) and model sensitivity and specificity (Hosmer et al., 2010). For the final multivariable linear model performance, we reported R^2 as a measure of the proportion of explained variance, and checked normality of residuals. We used the odds ratio (logistic) and beta coefficient values (linear) of individual items to interpret the models.

3. Results

3.1. Participants

We reached 380 international jumping athletes between April 5, 2019 and November 16, 2020. A total of 253 athletes consented and 221 completed the survey giving a completion rate of 87% (Supplement 1). Due to missing data, 32 responses were excluded from analysis. On the other hand, 74% participants (n = 163) completed the separate pain map drawing (Supplement 1).

Reported ability to use electronic health resources was similar between PT and other knee problem groups according to the eHEALS responses (Table 1). Height, sport type, player level, full availability to training and competitions, some training details and symptoms differed ($p < 0.05$) between groups. There was no difference between groups in any PROMs measuring knee condition severity (VISA-P, KOOS, KOOS-PF), global knee assessment (SANE) and psychosocial factors (TSK-11, PCS, EQ5D5L, GSE), except PASS ($p = 0.03$, $V = -0.14$).

Localised inferior patella pole pain was more commonly reported by PT group (OR = 10.2, 95%CI 4.4–23.6, $p < 0.001$), while pain around the patella was more commonly reported by the other knee problems group (OR = 0.28, 95%CI 0.13–0.58, $p < 0.001$). Patellofemoral pain, osteochondral lesions, cruciate ligament, collateral ligament and meniscus injuries were the common diagnoses in the other knee problems group (Supplement 4).

3.2. Model development

3.2.1. Model to distinguish jumping athletes with PT from those with other knee problems

Univariate logistic regression analysis was performed for each

Table 1
Self-reported baseline participant characteristics. Mean ± SD values for the continuous variables. P-values for differences in means between groups calculated using Independent t-test or Mann-Whitney *U* test based on normal distributions with Cohen's d effect size. Chi-square was used for categorical variables with Cramer's V effect size. Higher score means worse outcome for PCS and TSK-11, but better outcome for the rest of the PROMs. (n, number of participants; N, no; Y, yes; EN, English; TR, Turkish; SP, Spanish; FR, French; RPE, rating of perceived exertion; ACWR, acute: chronic workload ratio; VISA-P, Victorian Institute of Sport Assessment Questionnaire-Patellar Tendon; KOOS, Knee injury and Osteoarthritis outcome score; EQ-5D-5L, Health-related Quality of Life; VAS, visual analogue scale; NA, not applicable; DNK, do not know).

VARIABLES	Patellar Tendinopathy (n = 132)	Other knee problems (n = 89)	Effect sizes
A) DEMOGRAPHICS	*p < 0.05 vs other knee problems		
Age (years)	30.7 ± 8.9	31.8 ± 9.9	d = 0.11
Body Mass (kg)	79.1 ± 14.8	76.3 ± 16.8	d = −0.18
Height (cm)	*182.7 ± 12.9	178.3 ± 11.6	d = −0.35
Sex (Female: Male)	52: 80	42: 47	V = 0.08
Dominance (Right: Left: Not sure)	110: 21: 1	75: 11: 3	V = 0.11
Language (EN: TR: SP: FR)	28: 90: 6: 8	18: 62: 2: 7	V = 0.07
Ethnicity (White: Arab: Asian: Black: Mixed: Others: Prefer not to say)	71: 2: 6: 6: 5: 22: 20	58: 0: 4: 0: 1: 12: 14	V = 0.19
B) SPORTS SPECIFIC			
Sporting Age (years)	13.1 ± 7.3	13.3 ± 8.9	d = 0.02
KOOS - sports subscale score (0–100)	56.2 ± 21.6	58.8 ± 27.1	d = 0.11
Sport Type (Other: Court base Jumping Sports)	*61: 71	57: 32	V = 0.18
Player Level (Amateur: Professional)	*49: 83	52: 37	V = 0.21
Training details (including competition)			
Weekly hours trained	*5.3 ± 6.5	3.3 ± 4.5	d = −0.35
Average hours trained in the last 3 weeks	*5.6 ± 5.8	3.9 ± 4.7	d = −0.31
Weekly number of jumps	327.3 ± 678.1	168.8 ± 471.7	d = −0.26
Average number of jumps in the last 3 weeks	374.7 ± 627.3	229.0 ± 542.5	d = −0.25
Intensity in the last week (RPE)	4.3 ± 3.4	3.6 ± 3.2	d = −0.21
Average intensity in the last 3 weeks (RPE)	4.3 ± 2.8	3.7 ± 2.8	d = −0.22
ACWR minutes (n = 185)	0.99 ± 0.64	0.87 ± 0.75	d = −0.17
ACWR jumps (n = 187)	0.83 ± 0.79	0.67 ± 0.82	d = −0.19
ACWR minutes (Low: Optimal: High) (n = 185)	32: 54: 25	27: 36: 11	V = 0.11
ACWR jumps (Low: Optimal: High) (n = 187)	51: 36: 24	42: 23: 11	V = 0.11
Playing surface (multiple response)			
Artificial grass (N: Y)	*115: 17	66: 23	V = −0.17
Natural grass: Tartan: Polished hardwood or marple: Multi-purpose plastic: Taraflex: Sand: Concrete: Asphalt: Others (Yes)	25: 9: 53: 16: 40: 5: 19: 13: 12	19: 10: 28: 8: 19: 4: 13: 14: 13	V_{range} = −0.09 to 0.10
Shoes (multiple response)			
Basketball sneakers (N: Y)	*83: 49	70: 19	V = 0.17
Cross-trainer shoes (N: Y)	*125: 7	77: 12	V = −0.14
Volleyball shoes: Soccer cleats: Running shoes: Walking shoes: Tennis shoes: Hiking boots: Cycling shoes: Minimalist/Lacrosse shoes: Others (Yes)	37: 22: 48: 9: 4: 2: 3: 0: 9	15: 18: 34: 9: 3: 0: 3: 0: 8	V_{range} = −0.06 to 0.13
C) BIOMEDICAL			
Body Mass Index (kg/m^2)	23.6 ± 3.2	23.8 ± 3.5	d = 0.05
Injured side (Right: Left: Both)	*57: 31: 44	43: 32: 14	V = 0.21
VISA-P score (0–100)	61.6 ± 16.0	62.9 ± 21.2	d = 0.07
KOOS - symptom subscale score (0–100)	54.3 ± 12.5	55.1 ± 11.7	d = 0.06
KOOS - pain subscale score (0–100)	73.3 ± 15.9	75.8 ± 18.7	d = 0.15
KOOS - activity daily life subscale score (0–100)	82.6 ± 14.0	82.7 ± 18.0	d = 0.004
KOOS - Patellofemoral score (0–100)	58.8 ± 20.8	62.8 ± 25.1	d = 0.18
Patient Acceptable Symptom State (N: Y)	*77: 55	39: 50	V = −0.14
Single Assessment Numeric Evaluation (0–100)	60.1 ± 24.0	61.0 ± 24.5	d = 0.04
Current condition duration (months)	19.3 ± 13.3	17.6 ± 13.7	d = −0.12
Time-off from sport (weeks)	*5.1 ± 5.0	7.4 ± 5.0	d = 0.46
Previous injury presence (N: Y)	91: 41	65: 24	V = 0.04
Adequate recovery time from previous injury (N: Y: No previous injury)	26: 25: 81	22: 11: 56	V = 0.10
Direct hit to the knee (N: Y)	116: 16	71: 18	V = −0.11
Family tendon disorder history (N: Y)	118: 14	82: 7	V = 0.05
Family systemic disease history (N: Y)	114: 18	71: 18	V = −0.09
Having any systemic disease (N: Y)	95: 37	61: 28	V = −0.04
Tendon problem other than PT (Currently: Previously: Never)	15: 33: 84	10: 15: 64	V = 0.10
Symptoms (N: Y)			
Pain	12: 120	13: 76	V = 0.09
Stiffness	114: 18	69: 20	V = −0.12
Swelling	*105: 27	60: 29	V = −0.14
Pain Onset (Sudden: Gradual)	*51: 81	50: 39	V = 0.17
Morning pain (N: Y)	*38: 94	39: 50	V = 0.16
Morning stiffness (N: Y)	67: 65	42: 47	V = −0.04
Pain at night (N: Y)	*85: 47	71: 18	V = 0.17
Movement effect on pain (Get better: Get worse: No effect)	46: 58: 28	29: 30: 30	V = 0.15
Medicine (Currently: Previously: Never)			
Statin use	0: 1: 131	0: 2: 87	V = 0.06
Glucocorticoid use	0: 1: 131	0: 4: 85	V = 0.12
Fluoroquinolone use	*0: 2: 130	1: 7: 81	V = 0.18
Others			
Hormonal contraception use (NA: Y: N)	44: 7: 81	32: 9: 48	V = 0.10

Table 1 (*continued*)

VARIABLES	Patellar Tendinopathy (n = 132)	Other knee problems (n = 89)	Effect sizes
Menopausal status (NA: Pre: Current: Post)	95: 34: 2: 1	60: 28: 0: 1	V = 0.10
Hormone replacement therapy (NA: Y: N)	54: 1: 77	43: 0: 46	V = 0.09
Low back pain presence (Current: Previous: N)	16: 77: 39	14: 53: 22	V = 0.07
Low back pain association with leg pain (N: Y)	*64: 29	60: 7	V = 0.22
Smoking (Active: Passive: Ex-smoker: Never)	39: 16: 13: 64	19: 5: 13: 52	V = 0.16
Daily sleep time (hours)	7.7 ± 1.1	7.6 ± 1.2	d = −0.10
Sleep difficulty (N: Y)	100: 32	66: 23	V = −0.02
Feeling rested after sleep (Y: Partially: N)	51: 67: 14	35: 45: 9	V = 0.01
D) PSYCHOLOGICAL			
Full availability (N: Y)	*58: 74	54: 35	V = 0.16
KOOS - quality of life subscale score (0–100)	53.7 ± 20.6	54.8 ± 24.1	d = 0.05
EQ5D5L index score (−1 to 1)	0.76 ± 0.20	0.74 ± 0.23	d = −0.12
EQ5D5L VAS score (0–100)	77.7 ± 20.9	78.0 ± 17.3	d = 0.01
Pain Catastrophizing score (0–52)	13.9 ± 11.7	12.4 ± 11.2	d = −0.13
Tampa-11 Kinesiophobia score (11–44)	23.6 ± 6.8	23.2 ± 6.2	d = −0.05
General Self-Efficacy score (10–40)	31.8 ± 5.1	31.6 ± 5.0	d = −0.03
Patient recovery predictions			
Get better: Stay the same: Get worse: DNK	82: 19: 9: 22	53: 15: 7: 15	V = 0.04
If better,			
Confidence on recovery prediction (%) (n = 134)	82.6 ± 20.1	86.6 ± 13.6	d = 0.22
Time prediction (months) (n = 93)	*4.6 ± 4.8	6.8 ± 5.5	d = 0.44
Confidence on time prediction (%) (n = 91)	75.4 ± 24.3	83.0 ± 16.9	d = 0.35
E) SOCIAL			
E-Health Literacy score (8–40)	28.9 ± 6.2	27.6 ± 6.8	d = −0.21
Education level (Did not attend or Elementary school: High school: Undergraduate: Postgraduate)	3: 45: 63: 21	0: 20: 48: 21	V = 0.17
Work Status (Full time: Part time: N)	67: 19: 46	49: 13: 27	V = 0.05
Change in work participation (N: Y)	115: 17	70: 19	V = −0.11
F) PAIN MAP DRAWING	**Patellar Tendinopathy (n = 105)**	**Other knee problems (n = 58)**	**Effect sizes**
Number of body regions	2.0 ± 1.4	1.9 ± 1.5	d = −0.04
Number of sites around the knee (anterior/posterior/medial/lateral)	1.8 ± 1.1	1.7 ± 1.1	d = −0.14
Focal pain on inferior patella pole (N: Y)	*40: 65	50: 8	V = 0.46
Focal pain on superior patella pole (N: Y)	*80: 25	52: 6	V = 0.16
Diffuse pain around the patella (N: Y)	*51: 54	12: 46	V = −0.27
Current pain level (VAS)	3.8 ± 2.2	3.4 ± 2.4	d = −0.16
Usual pain level (VAS)	3.7 ± 2.3	3.5 ± 2.5	d = −0.09
Pain Type (Pain: Dull aching: Stabbing: Tingling: Electric: Throbbing: Numbness: Burning: Other/Multiple)	69: 17: 7: 0: 1: 4: 2: 2: 3	33: 12: 6: 2: 2: 0: 0: 0: 3	V = 0.26

plausible independent variable (Supplement 5), with twenty-one being retained for model construction. The final model consisted of seven variables (Table 2A); hours trained in the last week (OR = 1.10, 95%CI = 1.03–1.17, p = 0.01), sport type (OR for court base jumping sports = 2.31, 95%CI = 1.24–4.32, p = 0.01), injured side (OR for bilateral = 2.28, 95%CI = 1.09–4.77, p = 0.03), pain onset (OR for gradual = 1.97, 95%CI = 1.07–3.60, p = 0.03), morning pain (OR for yes = 1.89, 95%CI = 1.01–3.53, p = 0.047), PASS (OR for yes = 0.39, 95%CI = 0.21–0.73, p = 0.003) and swelling (OR for yes = 0.37, 95%CI = 0.18–0.74, p = 0.01). Therefore, jumping athletes with PT tend to train/play more, to play court base jumping sports (volleyball, basketball and handball), to have bilateral injury, to have gradual pain onset, to have morning pain, not to be satisfactory and not to have swelling in comparison to other knee problems. Model fit was good (Hosmer-Lemeshow = 0.33, p < 0.001) with acceptable accuracy (AUC = 0.76), specificity (70.8%) and sensitivity (70.5%).

We also constructed a mini model with pain map drawing data (n = 163) to explore whether pain location has any role to distinguish injured groups. The final multivariable model consisted of six variables (Table 2B). Model fit was good (Hosmer-Lemeshow = 0.47, p < 0.001) with excellent accuracy (AUC = 0.85) and acceptable specificity (77.8%) and sensitivity (76.2%).

3.2.2. *Model to explain sporting availability in jumping athletes with PT*

Individual relationships between each plausible independent variable and full availability were calculated (Supplement 6), with twenty-six being retained for multivariable model construction. The final multivariable model consisted of two variables (Table 2C); KOOS - sports (OR = 1.02, 95%CI = 1.01–1.04, p = 0.01) and player level (OR for professional = 4.11, 95%CI = 1.90–8.87, p < 0.001); meaning better sporting availability in jumping athletes with PT was associated with a better sports specific function and being professional athlete. Model fit was good (Hosmer-Lemeshow = 0.73, p < 0.001) with acceptable accuracy (AUC = 0.72), specificity (65.5%) and sensitivity (66.2%).

3.2.3. *Model to explain severity in jumping athletes with PT*

Individual relationships between each plausible independent variable and VISA-P score were calculated (Supplement 6), with twenty-eight being retained for multivariable model construction. The final multivariable model consisted of three variables (Table 2D); EQ5D5L index (β coef = 0.32, p < 0.001), KOOS-sports (β coef = 0.38, p < 0.001) and age (β coef = −0.17, p = 0.02); meaning higher PT severity was associated with a lower quality of life, a worse sports specific function and being older. Overall, multivariable linear regression model was explaining 44% of PT severity variance (p < 0.001, $R^2 = 0.44$, Fig. 1).

4. Discussion

This case-control study aimed to explore what distinguishes jumping athletes with patellar tendinopathy from those with other

Table 2
Final models' properties. A&B) Multivariavle logistic regression analysis: dependent variable is having PT vs having other knee problems. Odds ratios were the likelihood of having PT, meaning >1.00 increases the possibility of having PT, while <1.00 decreases the possibility of having PT. C) Multivariable logistic regression analysis: dependent variable is Full availability. Odds ratios were the likelihood of being fully available, meaning >1.00 increases the possibility of being fully available, while <1.00 decreases the possibility of being fully available. D) Multivariable linear regression analysis: dependent variable is VISA-P. Key: PT, patellar tendinopathy; OP, other knee problems; OR, odds ratio; CI, confidence interval; coef, coefficient values.

FINAL MULTIVARIABLE REGRESSION MODELS				
A) Model to distinguish jumping athletes with PT from those with other knee problems (n = 221; PT = 132, OP = 89)				
Independent Variables	OR (95% CI)	Beta coef.	P > |z|	Interpretation: Jumping athletes with PT … in comparison to other knee problems
Hours trained in the last week	1.10 (1.03–1.17)	0.09	0.01	Tend to train/play more
Sport Type (Court base jumping sport)	2.31 (1.24–4.32)	0.84	0.01	Play court base jumping sports
Injured side (Bilateral)	2.28 (1.09–4.77)	0.83	0.03	Tend to have bilateral injury
Pain onset (Gradual)	1.97 (1.07–3.60)	0.68	0.03	Tend to have gradual pain onset
Morning Pain (Yes)	1.89 (1.01–3.53)	0.63	0.047	Tend to have morning pain
Patient Acceptable Symptom State (Yes)	0.39 (0.21–0.73)	−0.94	0.003	Tend not to be satisfactory
Swelling (Yes)	0.37 (0.18–0.74)	−1.01	0.01	Tend not to have swelling
B) Mini model with pain map drawing data to distinguish jumping athletes with PT from those with other knee problems (n = 163; PT = 105, OP = 58)				
Independent Variables	**OR (95% CI)**	**Beta coef.**	**P > |z|**	**Interpretation: Jumping athletes with PT … in comparison to other knee problems**
Full availability (Yes)	2.80 (1.22–6.46)	1.03	0.02	Tend to be more available to train/compete
Focal pain on inferior patella pole (Yes)	9.08 (3.66–22.5)	2.21	<0.001	Tend to have focal pain on inferior patella pole
Pain onset (Gradual)	2.95 (1.25–6.94)	1.08	0.01	Tend to have gradual pain onset
Morning Pain (Yes)	2.95 (1.16–7.46)	1.08	0.02	Tend to have morning pain
Swelling (Yes)	0.29 (0.11–0.75)	−1.25	0.01	Tend not to have swelling
Daily sleep time (hours)	1.74 (1.16–2.61)	0.55	0.01	Tend to sleep more
C) Model to explain sporting availability in jumping athletes with PT (n = 132; PT = 132)				
Independent Variables	**OR (95% CI)**	**Beta coef.**	**P > |z|**	**Interpretation: Better sporting availability was associated with …**
KOOS - sports	1.02 (1.01–1.04)	0.02	0.01	A better sports specific function
Player Level (Professional)	4.11 (1.90–8.87)	1.41	<0.001	Being professional athlete
D) Model to explain severity in jumping athletes with PT (n = 132; PT = 132)				
Independent Variables	**Coef. (95% CI)**	**Beta coef.**	**P > |z|**	**Interpretation: Higher PT severity was associated with …**
EQ5D5L index	25.1 (12.1–38.1)	0.32	<0.001	A lower quality of life
KOOS - sports	0.28 (0.16–0.40)	0.38	<0.001	A worse sports specific function
Age	−0.30 (−0.54 to −0.06)	−0.17	0.02	Being older

knee problems by determining the best combination of self-reported demographics, sports specific and bio-psycho-social factors to inform clinical profiling. Secondary aim was to explain PT severity variance as defined either by condition severity or sporting availability. Patient-reported measurements are easy, cheap and quick to collect (Streiner et al., 2015), and we found that various sports specific, biomedical and psychological factors partially distinguish PT from other knee problems. In other words, the combination of these factors were specific to jumping athletes with PT presence and differentiated their profile from those with other knee problems, rather than having a diagnostic role between conditions. An international effort with many collaborators enabled sufficient data collection to build multivariable models. These models are associative, so the reported findings should not be taken as being causal, but adding sports specific and bio-psycho-social assessments into athlete monitoring in at-risk cohorts, individual assessment and future research will likely improve our understanding of the presentation in jumping athletes with PT.

Analysis of the data revealed an interesting and complex relationship between athlete groups, pain, function and availability. Within our study, jumping athletes with PT play more despite having equal severity to those with other knee problems yet are less satisfied with their condition. It has been previously reported in anterior cruciate ligament injuries (Ardern et al., 2016) that satisfaction is associated with return to pre-injury physical activity level, which we do not observe in jumping athletes with PT. This could be one of the reasons for the reported low satisfaction level in jumping athletes with PT as they do not present with marked functional limitations and sudden changes in symptoms compared to acute onset knee problems. Another reason could be that the typically used PROMs may not be sensitive enough to the correct condition-specific factors as neither the VISA-P nor the KOOS and KOOS-PF differentiated between the conditions. For instance, many symptoms associated with PT presence in our model are not represented in the VISA-P. Therefore, investigating sports specific and bio-psychological factors in addition to knee pain and function PROMs might improve the identification and grading of PT.

The mini model analysis showed that the combination of pain location with sport specific/psychological and biomedical factors also distinguishes jumping athletes with PT from those with other knee problems. Despite lower numbers due to incomplete data, the mini model had better accuracy, specificity and sensitivity compared to the larger model therefore illustrating the importance of pain location. The biomedical symptoms (pain onset, morning pain and swelling) were similar between the models, with the exception of 'injured side'. The addition of pain location and reduced numbers meant full availability, daily sleep time and pain location were included instead of training duration, sport type and symptom satisfaction. Full availability could be equivalent to training duration as they both show jumping athletes with PT to be more active. Daily sleep time seemed to explain the variance otherwise attributed to playing level and a sensitivity analysis found that professional athletes in PT group have higher daily sleep time. It is plausible that professional jumping athletes with PT with more availability and busy training schedule require, and can take, more rest. Localised inferior patella pole pain was expected since it is an important diagnostic criterion (Figueroa et al., 2016) for PT. However, self-reported pain map data is also another factor missing from typically used musculoskeletal PROMs. Collecting the data found to be useful in the modelling could complement the more

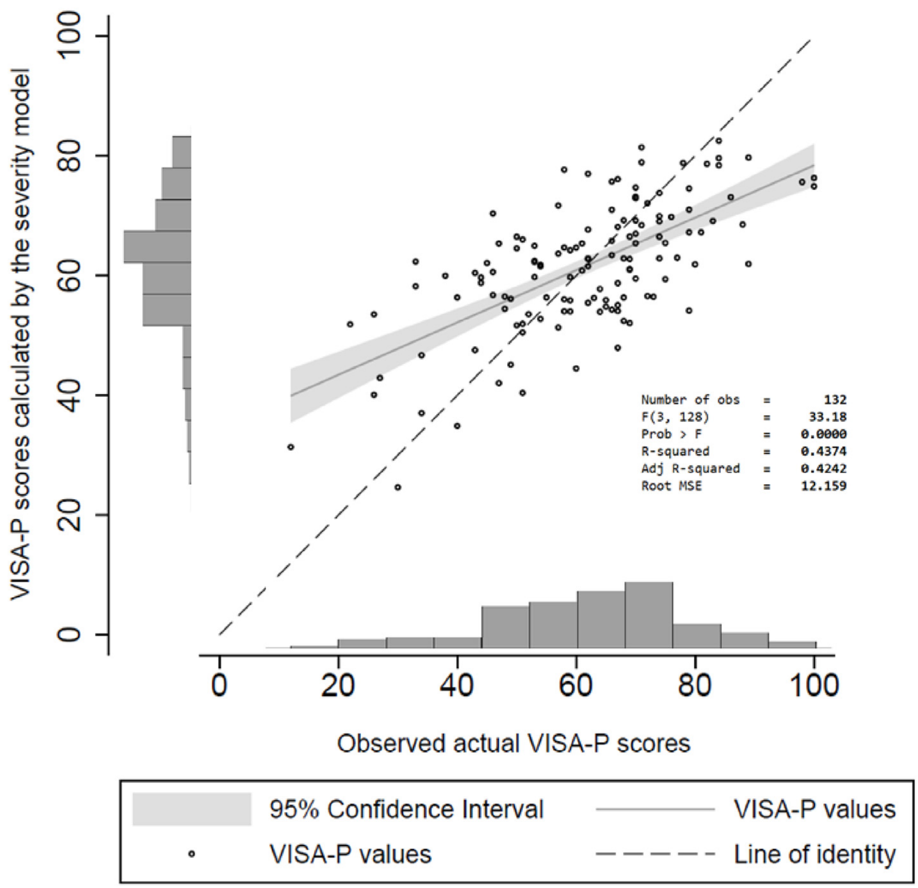

Fig. 1. The final multivariable linear regression model visualization for PT severity. The model consisted of three variables: EQ5D5L index, KOOS-sports and age. There is an over-estimation at the lower values and an under-estimation at the higher values in the results. This suggests there is potential a/some hidden variable/s (e.g. clinical and/or biomechanical assessments) that we are not capturing yet.

commonly collected physical examination in usual clinical care as well as future research.

Sporting availability within jumping athletes with PT was partially explained by associations with a combination of sports specific function and player level. Better sports specific function and being a professional athlete were associated with better sporting availability. It is plausible that better sports specific function could result in better availability. However, player level may represent reverse causality. It is unknown whether amateur athletes are more likely to stop playing or professional athletes have better access to medical professionals, which result in better tendinopathy management, hence better availability. Therefore, investigating sports specific factors could be useful to help explain the availability, and yield a better understanding of the interaction of sporting level and PT severity.

The variance in PT severity was partially explained by associations with a combination of age, sports specific function and quality of life. Being older was expected to be associated with higher severity due to accumulated pathology and longer recovery times (Smith et al., 2002). Possibility of recurrence might also increase with age, in association with reduced tendon health (Smith et al., 2002), hence increasing severity. Better sports specific function and quality of life may cause, but also result from, lower severity. Associations between quality of life and the severity of other tendinopathies have been widely investigated and aligned with our findings. For example, it was reported that musculoskeletal conditions impact on health related quality of life, especially physical function compromise, pain level, and role limitations caused by physical problems (Picavet & Hoeymans, 2004). Poorer quality of life was present in people with Achilles tendinopathy (Ceravolo et al., 2020) and associated with higher severity in gluteal tendinopathy (Plinsinga et al., 2018). A recent systematic review also showed that various psychological factors were associated with quality of life in people with rotator cuff tendinopathy (Wong et al., 2020). Quality of life, perhaps measured with EQ5D5L or KOOS-QoL, could be another useful assessment to help explain the psychosocial aspects of patients' presentation – irrespective of whether the relationship is causal or not.

The majority of human health conditions are complex. The multifactorial nature of sports injuries has been proposed (Bittencourt et al., 2016) as it arises from the interaction of a web of determinants on timescales that differ from one athlete to another, but not from linear interactions between explanatory factors. There were some variables, which despite having univariate associations with PT and a plausible rationale, did not help explain either PT presence or the variance in severity. For instance, it was reported that PT was more prevalent in elite (Lian et al., 2005) and non-elite (Zwerver et al., 2011) male jumping athletes, and being male (Morton et al., 2017) was a risk factor for PT. Similarly, a positive family history of tendon disorders (Kraemer et al., 2012; Morton et al., 2017) or previous knee injury (Morton et al., 2017) were suggested as risk factors. However, these variables do not contribute to our explanatory models, which is a study strength that arises due to the variety of measures made in a large sample. Additionally, we used multivariable regression analysis which has been recommended (van der Worp et al., 2011) to identify outcome predictors while accounting for other pertinent variables with previous literature (van der Worp et al., 2011) mainly employing univariate statistical approaches and often yielding conflicting findings. Effectively, confounded or indirectly related measures were identified and removed prior to settling on the final associative model rather than being retained and misleading the interpretation of results.

One of the study limitations was that diagnosis was established by self-report of prior consultation with a medical professional, instead of verifying in person. In terms of analysis, diagnostic groups may not be homogenous, but having a large sample size and robust analysis are a trade-off for heterogeneity. Another limitation was that we could not fully include the variables from the pain maps in our main models due to unequal participant numbers. The main reason for this was that we collected pain map drawings with a second software package that could not be fully integrated from the online survey and increased participant effort. However, we constructed a mini model with pain map data by removing missing data from all dataset. The main limitation was the lack of variables from physical examination, imaging and biomechanical assessments. These assessments were initiated, and would be expected to give stronger models, but data collection had to be curtailed due to the COVID-19 pandemic.

5. Conclusion

This study showed that self-reported sports specific and bio-psycho-social factors partially distinguish PT from other knee problems and partially explain both the variance of condition severity and compromised participation in jumping athletes. These findings could complement the more commonly collected physical examination and imaging findings in clinical care and research. The findings are generalizable because of the uniquely large sample size, diverse range of analysed variables enabling multivariable analysis and relevant international sample of elite and non-elite athletes (van der Worp et al., 2011). Adding sports specific (training duration, sport type, sports specific function, playing level) and bio-psycho-social factors (age, injured side, pain onset, morning pain, swelling, condition satisfaction, quality of life) into assessments might help better identification and management of jumping athletes with patellar tendinopathy.

Ethical approval

This study was approved by Queen Mary Ethics of Research Committee (QMERC2018/92), the UK National Health Service (NHS) (264615) and University of Liège Hospital-Faculty Ethics Committee (2019/182).

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Declaration of competing interest

None declared.

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Appendix ASupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2023.02.009.

References

Ardern, C. L., Österberg, A., Sonesson, S., Gauffin, H., Webster, K. E., & Kvist, J. (2016). Satisfaction with knee function after primary anterior cruciate ligament reconstruction is associated with self-efficacy, quality of life, and returning to the preinjury physical activity. *Arthroscopy: The Journal of Arthroscopic & Related Surgery, 32*(8), 1631–1638. https://doi.org/10.1016/j.arthro.2016.01.035

Bahr, R., & Reeser, J. C. (2003). Injuries among world-class professional beach volleyball players: The Federation Internationale de Volleyball beach volleyball injury study. *The American Journal of Sports Medicine, 31*(1), 119–125. https://doi.org/10.1177/03635465030310010401

Besier, T. F., Lloyd, D. G., Cochrane, J. L., & Ackland, T. R. (2001). External loading of the knee joint during running and cutting maneuvers. *Medicine & Science in Sports & Exercise, 33*(7), 1168–1175.

Bittencourt, N. F. N., Meeuwisse, W. H., Mendonça, L. D., Nettel-Aguirre, A., Ocarino, J. M., & Fonseca, S. T. (2016). Complex systems approach for sports injuries: Moving from risk factor identification to injury pattern recognition - narrative review and new concept. *British Journal of Sports Medicine, 50*(21), 1309–1314. https://doi.org/10.1136/bjsports-2015-095850

Ceravolo, M. L., Gaida, J. E., & Keegan, R. J. (2020). Quality-of-Life in Achilles tendinopathy: An exploratory study. *Clinical Journal of Sport Medicine, 30*(5), 495–502. https://doi.org/10.1097/JSM.0000000000000636

Clarsen, B., Myklebust, G., & Bahr, R. (2013). Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: The oslo sports trauma research centre (OSTRC) overuse injury questionnaire. *British Journal of Sports Medicine, 47*(8), 495–502. https://doi.org/10.1136/bjsports-2012-091524

Cook, J. L., Khan, K. M., Harcourt, P. R., Grant, M., Young, D. A., & Bonar, S. F. (1997). A cross sectional study of 100 athletes with jumper's knee managed conservatively and surgically. *British Journal of Sports Medicine, 31*(4), 332–336. https://doi.org/10.1136/bjsm.31.4.332

Cook, J. L., Purdam, C. R., & Cook, J. (2009). Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. *British Journal of Sports Medicine, 43*, 409–416. https://doi.org/10.1136/bjsm.2008.051193

Crossley, K. M., Macri, E. M., Cowan, S. M., Collins, N. J., & Roos, E. M. (2018). The patellofemoral pain and osteoarthritis subscale of the KOOS (KOOS-PF): Development and validation using the COSMIN checklist. *British Journal of Sports Medicine, 52*(17), 1130–1136. https://doi.org/10.1136/bjsports-2016-096776

Crossley, K. M., Thancanamootoo, K., Metcalf, B. R., Cook, J. L., Purdam, C. R., & Warden, S. J. (2007). Clinical features of patellar tendinopathy and their implications for rehabilitation. *Journal of Orthopaedic Research, 25*(9), 1164–1175. https://doi.org/10.1002/jor.20415

De Vos Andersen, N. B., Kent, P., Hjort, J., & Christiansen, D. H. (2017). Clinical course and prognosis of musculoskeletal pain in patients referred for physiotherapy: Does pain site matter? *BMC Musculoskeletal Disorders, 18*(1), 1–11. https://doi.org/10.1186/s12891-017-1487-3

Delen, M., Şendil, A., Kaux, J. F., et al. (2022). *Self-reported bio-psycho-social factors partially distinguish rotator cuff tendinopathy from other shoulder problems and explain shoulder severity: A case-control study*. Musculoskeletal Care. https://doi.org/10.1002/MSC.1679. Published online.

Edwards, S., Steele, J. R., Cook, J. L., Purdam, C. R., McGhee, D. E., & Munro, B. J. (2012). Characterizing patellar tendon loading during the landing phases of a stop-jump task. *Scandinavian Journal of Medicine & Science in Sports, 22*(1), 2–11. https://doi.org/10.1111/j.1600-0838.2010.01119.x

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2014). The strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. *International Journal of Surgery, 12*(12), 1495–1499. https://doi.org/10.1016/j.ijsu.2014.07.013

Figueroa, D., Figueroa, F., & Calvo, R. (2016). Patellar tendinopathy: Diagnosis and treatment. *Journal of the American Academy of Orthopaedic Surgeons, 24*(12), e184–e192. https://doi.org/10.5435/JAAOS-D-15-00703

Forsdyke, D., Smith, A., & Jones, M. (2016). Psychosocial factors associated with outcomes of sports injury rehabilitation in competitive athletes: A mixed studies systematic review. *British Journal of Sports Medicine, 50*(9), 537–544. https://doi.org/10.1136/bjsports-2015-094850

Frank, E. (2015). *Regression modeling strategies with applications to linear models, logistic and ordinal regression, and survival analysis*. SPRINGER.

Gabbett, T. J. (2016). The training-injury prevention paradox: Should athletes be training smarter and harder? *British Journal of Sports Medicine, 50*(5), 273–280. https://doi.org/10.1136/bjsports-2015-095788

Hägglund, M., Zwerver, J., & Ekstrand, J. (2011). Epidemiology of patellar tendinopathy in elite male soccer players. *The American Journal of Sports Medicine, 39*(9), 1906–1911. https://doi.org/10.1177/0363546511408877

Hamrin Senorski, E., Svantesson, E., Baldari, A., et al. (2019). Factors that affect patient reported outcome after anterior cruciate ligament reconstruction-a systematic review of the Scandinavian knee ligament registers. *British Journal of Sports Medicine, 53*(7), 410–417. https://doi.org/10.1136/bjsports-2017-098191

Hannington, M., Docking, S., Cook, J., Edwards, S., & Rio, E. (2020). Self-reported jumpers' knee is common in elite basketball athletes – but is it all patellar tendinopathy? *Physical Therapy in Sport, 43*, 58–64. https://doi.org/10.1016/j.ptsp.2020.01.012

Hélie, S. (2013). An introduction to model selection: Tools and algorithms. *Tutor Quant Methods Psychol, 2*(1), 1–10.

Herdman, M., Gudex, C., Lloyd, A., et al. (2011). Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Quality of Life Research, 20*(10), 1727–1736. https://doi.org/10.1007/s11136-011-9903-x

Hosmer, D., Lemeshow, S., & Cook, E. (2010). *Applied logistic regression* (2nd ed.). NY: John Wiley & Sons.

Jones, M. H., & Spindler, K. P. (2017). Risk factors for radiographic joint space narrowing and patient reported outcomes of post-traumatic osteoarthritis after ACL reconstruction: Data from the MOON cohort. *Journal of Orthopaedic Research, 35*(7), 1366–1374. https://doi.org/10.1002/jor.23557

Kennedy, C. A., Manno, M., Hogg-Johnson, S., et al. (2006). Prognosis in soft tissue disorders of the shoulder: Predicting both change in disability and level of disability after treatment. *Physical Therapy, 86*(7), 1013–1032. https://doi.org/10.1093/ptj/86.7.1013

Kettunen, J. A., Kvist, M., Alanen, E., & Kujala, U. M. (2002). Long-term prognosis for jumper's knee in male athletes: A prospective follow-up study. *The American Journal of Sports Medicine, 30*(5), 689–692. https://doi.org/10.1177/03635465020300051001

Kraemer, R., Wuerfel, W., Lorenzen, J., Busche, M., Vogt, P. M., & Knobloch, K. (2012). Analysis of hereditary and medical risk factors in Achilles tendinopathy and Achilles tendon ruptures: A matched pair analysis. *Archives of Orthopaedic and Trauma Surgery, 132*(6), 847–853. https://doi.org/10.1007/s00402-012-1476-9

Lian, O. B., Engebretsen, L., & Bahr, R. (2005). Prevalence of jumper's knee among elite athletes from different sports: A cross-sectional study. *The American Journal of Sports Medicine, 33*(4), 561–567. https://doi.org/10.1177/0363546504270454

Magklara, E., Burton, C., & Morrison, V. (2014). Does self-efficacy influence recovery and well-being in osteoarthritis patients undergoing joint replacement? A systematic review. *Clinical Rehabilitation, 28*(9), 835–846. https://doi.org/10.1177/0269215514527843

Malliaras, P., Cook, J. L., & Kent, P. M. (2007). Anthropometric risk factors for patellar tendon injury among volleyball players. *British Journal of Sports Medicine, 41*(4), 259–263. https://doi.org/10.1136/bjsm.2006.030049

Mallows, A., Debenham, J., Walker, T., & Littlewood, C. (2017). Association of psychological variables and outcome in tendinopathy: A systematic review. *British Journal of Sports Medicine, 51*(9), 743–748. https://doi.org/10.1136/bjsports-2016-096154

Matthews, M., Rathleff, M. S., Vicenzino, B., & Boudreau, S. A. (2018). Capturing patient-reported area of knee pain: A concurrent validity study using digital technology in patients with patellofemoral pain. *PeerJ. Published online.* , Article e4406. https://doi.org/10.7717/peerj.4406

McAuliffe, S., McCreesh, K., Culloty, F., Purtill, H., & O'Sullivan, K. (2016). Can ultrasound imaging predict the development of Achilles and patellar tendinopathy? A systematic review and meta-analysis. *British Journal of Sports Medicine, 50*(24), 1516–1523. https://doi.org/10.1136/bjsports-2016-096288

Morton, S., Williams, S., Valle, X., Diaz-Cueli, D., Malliaras, P., & Morrissey, D. (2017). Patellar tendinopathy and potential risk factors: An international database of cases and controls. *Clinical Journal of Sport Medicine, 27*(5), 468–474. https://doi.org/10.1097/JSM.0000000000000397

Neal, B. S., Lack, S. D., Lankhorst, N. E., Raye, A., Morrissey, D., & Van Middelkoop, M. (2019). Risk factors for patellofemoral pain: A systematic review and meta-analysis. *British Journal of Sports Medicine, 53*(5), 270–281. https://doi.org/10.1136/bjsports-2017-098890

Norman, C. D., & Skinner, H. A. (2006). eHEALS: The eHealth literacy scale. *Journal of Medical Internet Research, 8*(4), e27. https://doi.org/10.2196/jmir.8.4.e27

O'Brien, R. M. (2007). A caution regarding rules of thumb for variance inflation factors. *Quality and Quantity, 41*(5), 673–690. https://doi.org/10.1007/s11135-006-9018-6

Picavet, H. S. J., & Hoeymans, N. (2004). Health related quality of life in multiple musculoskeletal diseases: SF-36 and EQ-5D in the DMC3 study. *Annals of the Rheumatic Diseases, 63*(6), 723–729. https://doi.org/10.1136/ard.2003.010769

Plinsinga, M. L., Coombes, B. K., Mellor, R., et al. (2018). Psychological factors not strength deficits are associated with severity of gluteal tendinopathy: A cross-sectional study. *European Journal of Pain, 22*(6), 1124–1133. https://doi.org/10.1002/ejp.1199

Roos, E. M., Roos, H. P., Lohmander, L. S., Ekdahl, C., & Beynnon, B. D. (1998). Knee injury and osteoarthritis outcome score (KOOS) - development of a self-administered outcome measure. *Journal of Orthopaedic & Sports Physical Therapy, 28*(2), 88–96. https://doi.org/10.2519/jospt.1998.28.2.88

Sancho, I., Morrissey, D., Willy, R., et al. (2022). Recreational runners with Achilles tendinopathy have clinically detectable impairments: A case-control study. *Physical Therapy in Sport, 55*, 241–247.

Scholz, U., Dona, B. G., Sud, S., & Schwarzer, R. (2002). Is general self-efficacy a universal construct? Psychometric findings from 25 countries. *European Journal of Psychological Assessment, 18*(3), 242–251.

Silverwood, V., Blagojevic-Bucknall, M., Jinks, C., Jordan, J. L., Protheroe, J., & Jordan, K. P. (2015). Current evidence on risk factors for knee osteoarthritis in older adults: A systematic review and meta-analysis. *Osteoarthritis and Cartilage, 23*(4), 507–515. https://doi.org/10.1016/j.joca.2014.11.019

Smith, R. K. W., Birch, H. L., Goodman, S., Heinegård, D., & Goodship, A. E. (2002). The influence of ageing and exercise on tendon growth and degeneration - hypotheses for the initiation and prevention of strain-induced tendinopathies. *Comparative Biochemistry and Physiology - A Molecular and Integrative Physiology, 133*, 1039–1050. https://doi.org/10.1016/S1095-6433(02)00148-4

Smith, H. C., Vacek, P., Johnson, R. C., et al. (2012). Risk factors for anterior cruciate ligament injury: A review of the literature—part 2: Hormonal, genetic, cognitive function, previous injury, and extrinsic risk factors. *Sport Health, 4*(2), 155–161. https://doi.org/10.1177/1941738111428282

Streiner, D., Norman, G., & Cairney, J. (2015). *Health measurement scales: A practical guide to their development and use.* USA: Oxford University Press.

Sullivan, M. J. L., Bishop, S. R., & Pivik, J. (1995). The pain catastrophizing scale: Development and validation. *Psychological Assessment, 7*(4), 524–532. https://doi.org/10.1037/1040-3590.7.4.524

Tayfur, A., Haque, A., Salles, J. I., Malliaras, P., Screen, H., & Morrissey, D. (2022). Are landing patterns in jumping athletes associated with patellar tendinopathy? A systematic review with evidence gap map and meta-analysis. *Sports Medicine, 52*, 123–137. https://doi.org/10.1007/S40279-021-01550-6

Tayfur, A., Salles, J. I., Miller, S. C., Screen, H., & Morrissey, D. (2020). Patellar tendinopathy outcome predictors in jumping athletes: Feasibility of measures for a cohort study. *Physical Therapy in Sport, 44*, 75–84. https://doi.org/10.1016/j.ptsp.2020.05.004

Te Wierike, S. C. M., Van Der Sluis, A., Van Den Akker-Scheek, I., Elferink-Gemser, M. T., & Visscher, C. (2013). Psychosocial factors influencing the recovery of athletes with anterior cruciate ligament injury: A systematic review. *Scandinavian Journal of Medicine & Science in Sports, 23*(5), 527–540. https://doi.org/10.1111/sms.12010

Timpka, T., Alonso, J. M., Jacobsson, J., et al. (2014). Injury and illness definitions and data collection procedures for use in epidemiological studies in Athletics (track and field): Consensus statement. *British Journal of Sports Medicine, 48*(7), 483–490. https://doi.org/10.1136/bjsports-2013-093241

Tkachuk, G. A., & Harris, C. A. (2012). Psychometric properties of the tampa scale for kinesiophobia-11 (TSK-11). *The Journal of Pain, 13*(10), 970–977. https://doi.org/10.1016/j.jpain.2012.07.001

Van Der Worp, H., Van Der Does, H. T., Brink, M. S., Zwerver, J., & Hijmans, J. M. (2016). Prospective study of the relation between landing biomechanics and jumper's knee. *Int J Sports Med, 37*(3), 245–250. https://doi.org/10.1055/s-0035-1555858

Visentini, P. J., Khan, K. M., Cook, J. L., Kiss, Z. S., Harcourt, P. R., & Wark, J. D. (1998). The VISA score: An index of severity of symptoms in patients with jumper's knee (patellar tendinosis). *Journal of Science and Medicine in Sport, 1*(1), 22–28. https://doi.org/10.1016/S1440-2440(98)80005-4

Williams, G. N., Taylor, D. C., Gangel, T. J., Uhorchak, J. M., & Arciero, R. A. (2000). Comparison of the single assessment numeric evaluation method and the lysholm score. *Clinical Orthopaedics and Related Research, 373*, 184–192.

Witvrouw, E., Bellemans, J., Lysens, R., Danneels, L., & Cambier, D. (2001). Intrinsic risk factors for the development of patellar tendinitis in an athletic population: A two-year prospective study. *The American Journal of Sports Medicine, 29*(2), 190–195. https://doi.org/10.1177/03635465010290021201

Wong, W. K., Li, M. Y., Yung, P. S. H., & Leong, H. T. (2020). The effect of psychological factors on pain, function and quality of life in patients with rotator cuff tendinopathy: A systematic review. *Musculoskelet Sci Pract, 47*, Article 102173. https://doi.org/10.1016/j.msksp.2020.102173

van der Worp, H., van Ark, M., Roerink, S., Pepping, G.-J., Van Den Akker-Scheek, I., & Zwerver, J. (2011). Risk factors for patellar tendinopathy: A systematic review of the literature. *British Journal of Sports Medicine, 45*(5), 446–452. https://doi.org/10.1136/bjsm.2011.084079

Zwerver, J., Bredeweg, S. W., & Van Den Akker-Scheek, I. (2011). Prevalence of jumper's knee among nonelite athletes from different sports: A cross-sectional survey. *The American Journal of Sports Medicine, 39*(9), 1984–1988. https://doi.org/10.1177/0363546511413370