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Pain during prolonged sitting in subjects with patellofemoral pain in Dutch physical therapy clinics: an online questionnaire-based analysis

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ABSTRACT

Objectives This study aimed to describe (1) differences between subjects with patellofemoral pain (PFP) with and without pain during prolonged sitting (PDPS), (2) minimum knee flexion angle and time to onset/disappearance of PDPS and (3) differences between those with PDPS at smaller/greater flexion angles and with fast/slow onset and disappearance of PDPS.

Design Patient-reported online questionnaire.

Setting Private physical therapy clinics in the Netherlands between May 2021 and March 2023.

Participants 87 participants (61 (70%) females, mean age 22.0 years (IQR 4.0), body mass index 23.1 (4.7)).

Outcome measures Visual Analogue Scale for worst pain (VAS-W) and sitting pain (VAS-W sitting), the Anterior Knee Pain Scale (AKPS), knee flexion angle to provoke PDPS and time to onset/disappearance of PDPS.

Results 63 of 87 (72%) participants reported PDPS. Participants with PDPS experienced bilateral symptoms of PFP more frequently (71% vs 46%, p=0.44) and scored 12 points lower on the AKPS (p<0.001). Most participants (85%) reported a minimum knee flexion angle of ≥90°, median time to PDPS onset of 16–20 min and 6–10 min for disappearance. Participants experiencing PDPS at smaller flexion angles exhibited higher VAS-W and VAS-W sitting scores (7.0 (1.0), 6.8 (1.1)) than those at greater flexion angles (5.0 (3.0), for both) (p=0.002, p=0.001). Participants with fast onset of PDPS reported higher VAS-W and VAS-W sitting scores (7.0 (2.0), 6.0 (2.0)) than those with slow onset (5.0 (3.0), 5.0 (4.0)) (p<0.001, p=0.025).

Conclusions Participants with PDPS reported higher levels of disability than those without. PDPS was typically induced at knee flexion of ≥90°, with delayed onset/disappearance. Higher pain levels were reported by those experiencing PDPS at smaller knee flexion angles or with faster onset. Future research should explore the mechanisms of PDPS and develop targeted interventions to improve long-term outcomes.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Characteristics of pain during prolonged sitting were evaluated using an online patient-reported questionnaire rather than clinician-based measures.
⇒ Subgroups of participants with pain during prolonged sitting were created by dichotomising item response options, based on clinical experience, which may be arbitrary and subject to debate.
⇒ The final sample size was slightly smaller than the commonly accepted guideline for an appropriate sample size for online questionnaires, which may lead to a lower external validity of the current study.
⇒ Subjects were recruited from Dutch private physical therapy clinics, which may explain why participants were slightly younger compared with those in other studies.
⇒ The reliability and validity of self-reported items evaluating the characteristics of pain during prolonged sitting are not yet known.

INTRODUCTION

Patellofemoral pain (PFP) is a common musculoskeletal condition that has an annual prevalence of up to 36%.[1] A significant proportion of subjects with PFP experience 'pain during prolonged sitting' (PDPS), which is also referred to as the 'movie goers' sign' due to the extended periods of sitting with flexed knees in a seat with little leg space during a cinema visit.[2] A large study of 458 subjects with PFP reported a prevalence of PDPS in 80% of the sample population.[3]

The mechanisms underlying PDPS in subjects with PFP are unelucidated. No data were found regarding patellofemoral joint reaction forces (PFJRFs) during sitting. It is well established that PFJRFs increase with greater knee flexion angles and higher quadriceps muscle forces.[4] For example, PFJRFs in subjects with PFP are higher during stair ascent (3.2 (SD±0.7) times body weight (BW)) compared with walking (0.9 (SD±0.4) BW).[4] Given that quadriceps muscle forces decrease during sitting relative to walking, and that patellofemoral contact area increases with greater knee flexion,[4] PFJRFs during sitting are expected to be lower than during walking. Although PFJRFs are not entirely absent

during sitting, their small magnitude calls into question whether they sufficiently reflect the underlying mechanism of PDPS. Additionally, a recent study employing MRI found no association of any morphological parameters, such as alignment or structural characteristics of the PFJ, with PDPS in subjects with PFP.[5]

Previously, only one study evaluated differences in characteristics between subjects with and without PDPS.[3] It reported that subjects with PFP and PDPS were younger, more likely to be female, had a lower body mass index (BMI), higher pain severity, lower Anterior Knee Pain Scale (AKPS) scores and more problems with squatting compared with subjects without PDPS.[3] Given that this study analysed participants from four distinct cohorts, each recruited in different settings, replicating and evaluating the findings in a more homogeneous cohort could yield valuable insights. Furthermore, the existing literature lacks specific details such as the degree of knee flexion required to elicit PDPS, and the duration between seating and the onset of PDPS. A delayed onset of symptoms, for instance, may indicate disturbed homeostasis of structures of the anterior knee due to increased intraosseous pressure of the patella, as previously described.[6 7] Moreover, subjects with PDPS at smaller knee flexion angles may exhibit demographic or symptom characteristics distinct from those with PDPS at greater flexion angles. These differences could have prognostic value and clinical implications.

Therefore, in this patient-reported questionnaire study, we aimed to describe (1) differences in characteristics between subjects with PFP with and without PDPS, (2) minimum knee flexion angles to provoke symptoms of PDPS and time to onset and for disappearance of PDPS and (3) differences between those with PDPS at smaller versus greater flexion angles, with fast onset versus slow onset, and fast disappearance versus slow disappearance, respectively.

METHODS

Patient and public involvement

Four subjects with PFP and PDPS (median age 22.5 years (IQR 1.5); three females and one male) who met the inclusion and exclusion criteria were interviewed to identify criteria for assessing PDPS characteristics. Then they reviewed the developed preliminary questionnaire and assessed it for readability and item clarity. Minor changes were made to two items to ensure their readability and feasibility. Following publication, enrolled participants will receive a comprehensive manuscript encompassing the full text, as part of our commitment to patient involvement.

Participants

Subjects were recruited by nine physical therapists (PTs) working in private clinics in the Netherlands with a special interest in the rehabilitation of knee injuries and PFP. These PTs were informed about the inclusion and exclusion criteria (table 1) and asked to carefully evaluate the history of knee pain, perform clinical examination (hip and knee including the exact site of pain), and consecutively invite subjects with PFP to participate in the current study as they became available (using convenience sampling). The inclusion and exclusion criteria are based on the Manchester consensus statement (definition of PFP, exclusion of other pathologies).[8] A minimum pain level was established as an inclusion criterion to prevent the enrolment of participants with symptoms of PDPS that are too mild to be effectively evaluated. The invitation was sent between May 2021 and March 2023. Informed consent was obtained online as the first item of the survey questionnaire.

Table 1 Criteria for the inclusion and exclusion of potential participants

Inclusion	Exclusion
► Age: 18–40 years. ► Pain: – Experienced around and/or behind the patella. – Aggravated by one or more of the following activities: squatting, stair ambulation, jogging/running, hopping/jumping. – Lasting for ≥3 months. – That did not arise from trauma. ► Worst pain levels ≥3/10 on a VAS (VAS-W) during the past 7 days. ► Electronic informed consent.	► Previous or current clinical diagnosis of serious pathology (eg, malignancy). ► Previous or current other clinical diagnosis of specific knee conditions (eg, Osgood-Schlatter, Sinding-Larsson, patellar instability or dislocation, jumper's knee, meniscal tears or ligament injury). ► History of surgery (eg, ankle, knee, hip or lower back).

VAS-W, Visual Analogue Scale for Worst pain.

Questionnaire

The online questionnaire comprised three parts. The first part contained eight items and evaluated general patient characteristics (eg, sex, age, body weight and length, and hours of sport participation per week). The activity level was rated according to the Tegner Score,[9–11] which contains 11 response options ranging from 0 to 10. Higher scores indicated higher activity levels. The Dutch version of the Tegner Score is reliable (intraclass correlation, ICC=0.97) with moderate correlations with other knee-related and quality-of-life-related questionnaires (r=0.42–0.48).[12]

The second part of the questionnaire contained seven items and evaluated specific PFP characteristics, such as symptom duration, history of other knee injuries and worst pain in the past 7 days on a Visual Analogue Scale (VAS-W), which is a continuous 10 cm line to indicate the intensity of pain perception when at its worst (score from '0 cm' (no pain) to '10 cm' (maximal pain)).[13]

Additionally, the AKPS and Tampa Scale for Kinesiophobia (TSK) were followed. The AKPS measures pain and disability and contains 13 items with 3–5 response options.[14] Scores between '0' and '10' were allocated to each response option. The overall score was normalised on a 0–100 scale, where '100' indicated no problems at all and '0' indicated the maximum number of knee problems experienced.[13] The Dutch Version of the AKPS is reliable (ICC=0.98) with good internal consistency (r=0.78–0.80).[15] Item 8 of the AKPS refers to 'prolonged sitting' and contains five response options. Two groups were formed based on these response options: (1) the presence of PDPS ('pain after exercise', 'constant pain', 'pain forces to extend knees temporarily' and 'unable') and (2) the absence of PDPS ('no difficulty').

A previous study found no PFJ loading variables (eg, peak PFJ contact force), but kinesiophobia was associated with self-reported pain and disability in subjects with PFP.[16] Since prolonged sitting lacks PFJ loading, evaluation of kinesiophobia in subjects with PDPS may be relevant. Therefore, the TSK was also administered. The TSK is a 17-item questionnaire for evaluating pain-related fear and avoidance behaviour.[17] Participants were asked to rate their level of agreement with statements regarding fear of movement behaviour on a 4-point Likert scale from 'strongly disagree' to 'strongly agree'. Scores range from 17 to 68 points, with higher scores indicating greater levels of kinesiophobia.[17]

The third section contained four items and specifically evaluated the characteristics of PDPS (online supplemental file 1). Participants were asked to rate their worst sitting pain in the past 7 days (VAS-W sitting) on a 10 cm line with a continuous score from '0 cm' (no pain) to '10 cm' (maximal pain).[13] The minimum degree of knee flexion required to provoke PDPS was evaluated by presenting four pictures with the knees flexed at 0°, 45°, 90°, or beyond 90°. The minimum time to onset of PDPS with the knees at 90° was evaluated in seven response options ('0–5 min', '6–10 min', '11–15 min', '16–20 min', '21–30 min', '31–40 min' and '>40 min'). The minimum time required for disappearance of PDPS after extending the knees from 90° flexion was evaluated using the same response options. Items of this category were dichotomised by defining a 'smaller flexion angle' group (<90°) and a 'greater flexion angle' group (≥90°); a 'fast-onset' group (≤10 min) and a 'slow-onset' group (>10 min); and a 'fast-disappearance' group (≤10 min) and a 'slow-disappearance' group (>10 min).

The questionnaire was administered online via Castor (Castor EDC, Amsterdam, Netherlands).

Sample size

A commonly accepted guideline for an appropriate sample size for online questionnaires is a minimum of n=100 participants.[18] Given that subjects are invited by their treating PTs, it was hypothesised that this would foster commitment to promptly complete the questionnaire. Nonetheless, we projected that 20% of invited subjects would either not complete the questionnaire or only partially complete it. Consequently, we aimed to recruit a sample size of n=125 participants. Considering that this online questionnaire would be conducted concurrently with multiple other PFP studies over a 2-year period, we anticipated the enrolment of 100 participants.

Statistical analysis

Only data from participants who completed the questionnaire were analysed. The normality of the data distribution was evaluated using the Shapiro-Wilk test. Normally distributed data (p>0.05) were analysed parametrically and presented as mean (±SD and range (R)). When data were not normally distributed, they were analysed non-parametrically and presented as the median (IQR 25%–75%). Differences between groups (with and without PDPS, smaller and greater flexion angles, fast and slow onset, fast and slow disappearance) in continuous characteristics were analysed using Student's t-test (normally distributed data) or the Mann-Whitney U test (non-normally distributed data). Differences in dichotomous characteristics were analysed using the Fisher's exact test. A priori, a significance level of p<0.05 was established as the criterion for statistical significance. The effect sizes (ESs) for normally distributed data were calculated using Cohen's d to determine the magnitude of the differences. For non-normally distributed data, ES r using the formula $r = Z\sqrt{(n_a + n_b)}$, with Z being the Z-score from the Mann-Whitney U test and n_a and n_b being sample sizes of both groups, has been determined.[19] For dichotomous variables, phi has been calculated based on the χ^2 statistic.[19] An ES of 0.2, 0.5 and ≥0.8 was considered small, medium and large, respectively.[20] Statistical analyses were performed by using SPSS V.25.0 (SPSS).

RESULTS

A total of 107 subjects with PFP were invited to participate, of whom 20 were excluded (patella dislocation (n=1), symptom duration <3 months (n=2), traumatic origin (n=1), VAS-W<3 (n=8) and non/partial respondents (n=8)) (online supplemental figure 1). The remaining 87 (81%) subjects were eligible for inclusion (61 (70%) females, mean age 22.0 years (IQR 4.0), BMI 23.1 (IQR 4.7)).

Based on the responses to item 8 of the AKPS, 63 (72%) participants reported PDPS (table 2). More participants with PDPS had bilateral symptoms (71%), compared with those without PDPS (46%) (p=0.044). Participants with PDPS demonstrated a median total score on the AKPS that was 12 points lower when compared with participants without PDPS, a difference that was statistically significant (small-to-medium ES (0.41)). This included statistically significant lower scores on items 3 'walking' (small ES (0.31)), 5 'squatting' (small ES (0.28)), 8 'prolonged sitting' (medium ES (0.51)) and 9 'pain' (small ES (0.24)). Most participants with PDPS (n=52 (85%)) reported symptoms that occurred when the knees were

Table 2 Baseline characteristics of the participants

Characteristics	Participants with PDPS	Participants without PDPS	P value	ES
Participants, n (%)	63 (72)	24 (28)	n/a	n/a
Female, n (%)	46 (73)	15 (63)	0.433	Phi=0.10
Age (years)	22.0 (IQR 6.0)	23.0 (IQR 9.3)	0.242	r=0.13
BMI (kg/m^2)	23.5 (IQR 4.9)	21.7 (IQR 4.0)	0.207	r=0.14
Sport participation (h/week)	3.0 (IQR 3.0)	3.5 (IQR 1.9)	0.466	r=0.08
Tegner Score (0–10)	4.0 (IQR 3.0)	5.0 (IQR 2.0)	0.138	r=0.16
VAS-W (0–10)	6.0 (IQR 3.0)	5.0 (IQR 2.0)	0.212	r=0.13
Bilateral PFP, n (%)	45 (71)	11 (46)	0.044	Phi=0.24
Symptom duration (months)	40.0 (IQR 64.0)	20.0 (IQR 45.0)	0.337	r=0.07
AKPS (0–100)	74.0 (IQR 14.0)	86.0 (IQR 11.5)	<0.001	r=0.41
Item 1 ‘limp’ (0–5)	5.0 (IQR 2.0)	5.0 (IQR 2.0)	0.197	r=0.14
Item 2 ‘support’ (0–5)	5.0 (IQR 2.0)	5.0 (IQR 0.0)	0.207	r=0.014
Item 3 ‘walking’ (0–5)	3.0 (IQR 2.0)	5.0 (IQR 2.0)	0.004	r=0.31
Item 4 ‘stairs’ (0–10)	8.0 (IQR 3.0)	8.0 (IQR 5.0)	0.992	r=0.00
Item 5 ‘squatting’ (0–5)	4.0 (IQR 1.0)	4.0 (IQR 1.0)	0.009	r=0.28
Item 6 ‘running’ (0–10)	6.0 (IQR 2.0)	7.0 (IQR 2.0)	0.286	r=0.11
Item 7 ‘jumping’ (0–10)	7.0 (IQR 3.0)	7.0 (IQR 3.0)	0.090	r=0.18
Item 8 ‘prolonged sitting’ (0–10)	6.0 (IQR 4.0)	10.0 (IQR 0.0)	<0.001	r=0.51
Item 9 ‘pain’ (0–10)	8.0 (IQR 5.0)	8.0 (IQR 0.0)	0.025	r=0.24
Item 10 ‘swelling’ (0–10)	10.0 (IQR 2.0)	10.0 (IQR 0.0)	0.077	r=0.19
Item 11 ‘subluxations’ (0–10)	10.0 (IQR 4.0)	10.0 (IQR 0.0)	0.128	r=0.16
Item 12 ‘atrophy’ (0–5)	5.0 (IQR 0.0)	5.0 (IQR 2.0)	0.337	r=0.10
Item 13 ‘flexion deficiency’ (0–5)	5.0 (IQR 0.0)	5.0 (IQR 0.0)	0.357	r=0.10
TSK (17–68)	33.0 (IQR 8.0)	33.0 (IQR 10.0)	0.853	r=0.20

Data are presented as numbers (percentages) and median (IQR 25%–75% (IQR)).
AKPS, Anterior Knee Pain Scale; BMI, body mass index; ES, effect size; h/week, hours per week; n, number; n/a, not applicable; PFP, patellofemoral pain; TSK, Tampa Scale for Kinesiophobia; VAS-W, Visual Analogue Scale for Worst pain.

flexed to 90° or beyond. Only a small proportion (n=9 (15%)) of participants with PDPS experienced symptoms in smaller knee flexion positions (0° or 45°). Two participants with PDPS omitted this item.

Among those with PDPS, 44 (70%) participants experienced sitting-related pain in 90° or more knee flexion and thus were capable to answer questions regarding time to onset and disappearance with the knees at 90° of flexion. These participants reported a median time to PDPS onset of 16–20 min, and a median time for disappearance of 6–10 min.

Participants with PDPS at smaller flexion angles were 2 years younger (small ES (0.30)), scored 2 points higher on the VAS-W (small to medium ES (0.39)), had an 11 points lower total score on the AKPS (small-to-medium ES (0.36)), higher scores on the TSK (small ES (0.28)) and almost 2 points higher VAS-W sitting score (small-to-medium ES (0.41)), compared with those with PDPS at greater flexion angles (table 3).

Participants with fast-onset PDPS exhibited VAS-W and VAS-W sitting scores that were 2 points and 1 point higher (medium ES (0.50), small ES (0.31)), respectively, compared with those with slow-onset PDPS (table 4). Participants with fast-disappearance PDPS reported an additional 1.3 (95% CI 0.01 to 2.44) hours of weekly sports participation (medium-to-large ES (0.66)) and an 8 points higher total score on the AKPS (small-to-medium ES (0.43)), compared with those with slow disappearance (table 5).

DISCUSSION

Participants with PDPS more often reported bilateral PFP and higher levels of disability, compared with those without PDPS. Participants typically described PDPS to be induced when the knees were flexed to 90° or beyond. The median time to reported onset of PDPS was 16–20 min, and the time for disappearance of PDPS was generally 6–10 min. Participants with PDPS at smaller knee flexion angles were younger and had higher levels of pain, disability and kinesiophobia, compared with participants with PDPS at greater flexion angles. Participants with

Table 3 Characteristics of participants with PDPS in smaller and greater knee flexion angles

Characteristics	Smaller flexion angle (<90°)	Greater flexion angle (≥90°)	P value	ES
Participants, n (%)	9 (15)	52 (85)	n/a	n/a
Female, n (%)	7 (78)	37 (71)	0.515	Phi=0.05
Age (years)	20.0 (IQR 4.0)	22.0 (IQR 5.8)	0.018	r=0.30
BMI (kg/m^2)	23.2 (IQR 4.8)	23.8 (IQR 5.2)	0.190	r=0.17
Sport participation (h/week)	3.0 (SD±2.1, R 6.0)	3.6 (SD±2.2, R 10.0)	0.400	d=0.11
Tegner Score (0–10)	4.0 (IQR 5.0)	4.0 (IQR 3.0)	0.452	r=0.10
VAS-W (0–10)	7.0 (IQR 1.0)	5.0 (IQR 3.0)	0.002	r=0.39
Bilateral PFP, n (%)	9 (100)	36 (69)	0.096	Phi=0.25
Symptom duration (months)	48.0 (IQR 74.5)	38.0 (IQR 64.0)	0.445	r=0.10
AKPS (0–100)	66.0 (IQR 13.5)	77.0 (IQR 13.0)	0.005	r=0.36
TSK (17–68)	36.0 (IQR 14.5)	32.0 (IQR 8.0)	0.029	r=0.28
VAS-W sitting (0–10)	6.8 (IQR 1.1)	5.0 (IQR 3.0)	0.001	r=0.41

Data are presented as numbers (percentages), mean (±SD and range (R)) or median (IQR 25%–75%).
AKPS, Anterior Knee Pain Scale; BMI, body mass index; ES, effect size; h/week, hours per week; n, number; n/a, not applicable; PDPS, pain during prolonged sitting; PFP, patellofemoral pain; TSK, Tampa Scale for Kinesiophobia; VAS-W, Visual Analogue Scale for Worst pain.

PDPS with faster onset experienced higher levels of pain, compared with those with slower onset. Participants with PDPS with slower disappearance of PDPS reported to be less physically active and had higher levels of disability, compared with participants with faster disappearance of PDPS.

In the present study, the prevalence of PDPS in subjects with PFP was 72%. This is in line with the previously reported prevalence of 77%–80%.[3 21] Bilateral symptoms occurred more frequently in participants with PDPS than in those without. As bilateral PFP is a prognostic factor for an unfavourable course,[22] PDPS may similarly exert prognostic influence. Nonetheless, definitive establishment necessitates a prospective study design.

Furthermore, participants with PDPS exhibited a median total score on the AKPS that was 12 points lower, compared with those participants without PDPS. This is in line with the findings of Collins *et al*.[3] The lower AKPS score holds clinical significance, as the smallest clinically important difference in the AKPS has been established to be at least 10 points.[23] Since this group comparison is based on item 8 'prolonged sitting' of the AKPS a lower AKPS total score of participants with PFP and PDPS is inevitable. But the difference on item 8 'prolonged sitting'

Table 4 Characteristics of participants with PDPS with faster and slower onset of symptoms

Characteristics	Fast onset (≤10 min)	Slow onset (>10 min)	P value	ES
Participants, n (%)	14 (32)	30 (68)	n/a	n/a
Female, n (%)	8 (57)	22 (73)	0.316	Phi=0.16
Age (years)	21.5 (IQR 7.0)	22.0 (IQR 6.3)	0.577	r=0.08
BMI (kg/m^2)	24.0 (IQR 3.0)	24.0 (IQR 5.9)	0.821	r=0.03
Sport participation (h/week)	3.1 (SD±2.1, R 6.0)	3.0 (SD±2.0, R 7.0)	0.934	d=0.03
Tegner Score (0–10)	4.0 (IQR 2.3)	3.0 (IQR 4.0)	0.096	r=0.25
VAS-W (0–10)	7.0 (IQR 2.0)	5.0 (IQR 3.0)	<0.001	r=0.50
Bilateral PFP, n (%)	10 (71)	24 (80)	0.701	Phi=0.10
Symptom duration (months)	42.0 (IQR 87.0)	40.0 (IQR 48.0)	0.696	r=0.06
AKPS (0–100)	68.0 (IQR 10.0)	74.0 (IQR 16.3)	0.109	r=0.24
TSK (17–68)	32.5 (IQR 8.0)	32.5 (IQR 10.5)	0.940	r=0.01
VAS-W sitting (0–10)	6.0 (IQR 2.0)	5.0 (IQR 4.0)	0.038	r=0.31

Data are presented as numbers (percentages), mean (±SD and range (R)) or median (IQR 25%–75%).
AKPS, Anterior Knee Pain Scale; BMI, body mass index; ES, effect size; h/week, hours per week; n, number; n/a, not applicable; PFP, patellofemoral pain; TSK, Tampa Scale for Kinesiophobia; VAS-W, Visual Analogue Scale for Worst pain.

Table 5 Characteristics of participants with PDPS with faster and slower disappearance of symptoms

Characteristics	Fast disappearance (≤10 min)	Slow disappearance (>10 min)	P value	ES
Participants, n (%)	25 (57)	19 (43)	n/a	n/a
Female, n (%)	16 (64)	14 (74)	0.534	Phi=0.10
Age (years)	22.0 (IQR 6.0)	20.0 (IQR 5.0)	0.229	r=0.18
BMI (kg/m^2)	24.1 (IQR 4.1)	22.4 (IQR 5.0)	0.112	r=0.24
Sport participation (h/week)	3.6 (SD±2.0, R 7.0)	2.3 (SD±1.9, R 6.0)	0.036	d=0.66
Tegner Score (0–10)	4.0 (IQR 3.0)	3.0 IQR (2.0)	0.197	r=0.19
VAS-W (0–10)	5.0 (IQR 3.0)	6.0 (IQR 2.0)	0.379	r=0.13
Bilateral PFP, n (%)	17 (68)	17 (90)	0.148	Phi=0.25
Symptom duration (months)	36.0 (IQR 54.5)	42.0 (IQR 60.0)	0.406	r=0.13
AKPS (0–100)	74.0 (IQR 16.0)	67.0 (IQR 12.0)	0.005	r=0.43
TSK (17–68)	32.0 (IQR 8.0)	33.0 (IQR 14.0)	0.374	r=0.13
VAS-W sitting (0–10)	5.0 (IQR 4.0)	6.0 (IQR 2.0)	0.156	r=0.21

Data are presented as numbers (percentages), mean (±SD and range (R)) or median (IQR 25%–75%).
AKPS, Anterior Knee Pain Scale; BMI, body mass index; ES, effect size; h/week, hours per week; n, number; n/a, not applicable; PFP, patellofemoral pain; TSK, Tampa Scale for Kinesiophobia; VAS-W, Visual Analogue Scale for Worst pain.

between both groups was only four points. Participants with PDPS scored also lower on item 3 'walking' and 5 'squatting'. Higher levels of problems with squatting were also identified in the PDPS group by Collins *et al*,[3] while they did not evaluate differences on item 3 'walking'.

Additionally, Collins *et al* noted that subjects with PDPS were younger, predominantly female, had lower BMI and worse levels of knee pain, compared with subjects without PDPS.[3] The reasons for the current study's inability to confirm these findings may stem from the slightly different categorisation of AKPS item 8 'prolonged sitting'. In the current study, participants experiencing PDPS only after exercise were not treated and analysed as a distinct category. In contrast, Collins *et al* considered this subgroup as a distinct category in their study.[3] Another reason for not confirming these findings could be the smaller sample size in the current study (n=87) compared with that in the study by Collins *et al* (n=458).[3]

A smaller proportion of participants with PDPS reported experiencing knee pain at smaller flexion angles, and with faster onset of PDPS. They also reported higher pain levels (VAS-W and VAS-W sitting). Various theories have been proposed to explain the underlying mechanisms of PDPS in subjects with PFP. Biomechanical theories often attribute PFP to increased PFJRF. While PFJRFs are not entirely absent during sitting, they are expected to be lower than 0.9 times bodyweight,[4] with an even greater reduction likely in subjects with PDPS at smaller knee flexion angles. Although the patellofemoral contact area decreases in smaller flexion angles, overall, increased PFJRF seems to be a less satisfactory explanation for PDPS. The homeostasis model[24] may be a more suitable construct because it proposes disturbed homoeostasis of osseous and soft tissues in the anterior knee after supraphysiologic loading. Homeostatic disturbance is then induced by vascular stress and stretching of the peripatellar anastomotic ring, resulting in increased intraosseous water content and pressure of the patella, and triggering a cascade of ischaemic nociceptive responses.[6 7 25–30] This would not only explain the delayed onset of PDPS but also the shorter time for disappearance of PDPS after prolonged sitting.

Research and clinical implications

The results of the current study have significant implications for both research and clinical practice. Previous experiments assessing disturbance of the patellar bone blood flow evaluated rather short episodes (seconds to minutes)[26 31 32] and/or with the knee in extension,[31 32] future studies should focus on evaluating patellar blood flow beyond 20 min of prolonged sitting with the knee in 90° of flexion.

According to the 2017 Gold Coast Consensus Statement on Treating PFP, hip-focused and knee-focused exercise therapy is a key component in the management of all subjects with PFP.[33] In a subgroup of subjects with PDPS at smaller flexion angles and with faster onset, knee-focused exercise therapy to improve quadriceps muscle function may exacerbate knee pain. This is because continuous quadriceps muscle training increases the haemodynamic load on the patellar bone,[34] thereby provoking homeostatic pain.[35] Since intermittent quadriceps muscle training (2 s of rest between repetitions) reduces patellar bone blood flow in healthy participants,[34] this could be a valuable alternative for subjects with PFP and PDPS at smaller flexion angles and with faster onset. This approach may even be valuable in subjects with PFP and PDPS in general. However, this aspect should be further investigated.

Additionally, healthcare professionals should advise subjects with PDPS at smaller flexion angles and with faster onset to avoid these provocative postures altogether,

or at the very least, to minimise the duration spent in such positions. Even if patients cannot avoid these positions, this may provide a plausible explanation for why an otherwise well-designed multimodal treatment programme may fail to result in improvements in pain and disability. Offering explanations for failure often serves as a starting point for changes in treatment strategies.

Strengths and limitations

The current study marks the first attempt to evaluate key characteristics of PDPS in subjects with PFP, thereby offering more detailed insights into this clinical phenomenon. The study also acknowledges certain limitations. First, we do not have information on which subjects were eligible for invitation but were not approached by the participating PTs. This may introduce selection bias, potentially impacting the internal validity of the current study's results. Additionally, in the available study period, we did not manage to invite 125 subjects as anticipated, but only 107 subjects. With 20 out of 107 subjects (19%) being excluded, the exclusion rate in the current study was as estimated. Thus, the final sample size (n=87) is slightly smaller than the commonly accepted guideline for an appropriate sample size for online questionnaires (n=100), which may lead to a lower external validity of the current study.

Furthermore, eight (7%) invited subjects with PFP were excluded because their worst pain levels were too low at the moment of completion of the questionnaire. Though the time between invitation and study participation was usually 1 week, the worst pain level at the time of invitation may have been higher than that at the time of completion of the questionnaire. We underestimated, this change in worst pain level as being a factor for successful recruitment. Future studies should take this into account when determining sample size. Only four (4%) subjects with PFP were excluded due to the presence of other knee problems or too short symptom duration, indicating a generally accurate procedure of recruitment by experienced PTs.

Second, subgroups of participants with PFP and PDPS (smaller/greater flexion angle, fast/slow onset and fast/slow disappearance) were created by dichotomising the response options. This approach was based on our clinical experience with a large number of subjects in our clinics. The choice to aggregate response options into one or more subgroup categories may be arbitrary and subject to debate.

Third, though the PTs responsible for inviting subjects with PFP were allocated to several regions of the Netherlands, the sampling method applied in the current study was a non-probability (convenience) sampling method. This sampling method may have introduced bias into the study's results. Additionally, subjects were recruited in private physical therapy clinics. In the Netherlands, the majority of patients use the direct access option to see their PT, bypassing the general practitioner or sports medicine physician.[36] This option is more frequently used by younger adults compared with older adults.[36] In the sitting pain study conducted by Collins *et al*, participants from several different cohorts were analysed.[3] The included Dutch cohorts from van Linschoten *et al* (n=131) and van der Heijden *et al* (n=64) were recruited through general practitioners and sports medicine physicians.[37 38] This difference in recruitment setting may explain why participants with and without PDPS in the current study were younger (median age 22.0 years, IQR 6.0 and median age 23.0 years, IQR 9.3, respectively) compared with the participants from the Collins study (mean age 27.5, SD 8.1 and mean age 30.0 years, SD 8.6, respectively). Therefore, due to the convenience sampling method and the differences in recruitment settings, generalisations based on the results of the current study should be made with caution.

Lastly, although subjects with PFP were involved in the construction of the four items assessing PDPS characteristics, the reliability and validity of these items remain unknown. This may have led, for instance, to the overestimation or underestimation of both minimum knee flexion angles and the time to reported onset of PDPS, indicating the need for further research.

CONCLUSION

Participants with PDPS more often reported bilateral PFP and higher levels of disability. PDPS typically occurs when the knees are flexed 90° or beyond. Participants identified a delayed onset of PDPS occurring after 16–20 min, whereas the time for its disappearance was shorter, between 6 and 10 min. Participants with PDPS at smaller knee flexion angles were younger, reported higher pain, disability and kinesiophobia than those with PDPS at greater flexion angles. Additionally, participants with faster onset of PDPS experienced higher pain levels, while those with slower PDPS disappearance were less physically active and had greater disability than those with faster disappearance. This study provides a detailed description of the characteristics of PDPS as experienced by subjects with PFP. Future research should focus on understanding the underlying mechanisms of PDPS and developing targeted interventions to improve long-term outcomes in subjects with PFP.

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