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Pain During Prolonged Sitting Is a Common Problem in Persons With Patellofemoral Pain

STUDY DESIGN: Retrospective cohort.

BACKGROUND: Although persons with patellofemoral pain (PFP) often report pain with prolonged sitting, little is known about the prevalence and characteristics of sitting pain.

OBJECTIVES: To describe the proportion of persons with PFP who experience problems with prolonged sitting and to determine patient characteristics associated with sitting pain.

METHODS: Four hundred fifty-eight participants with a diagnosis of PFP from 4 separate studies were included. Item 8 of the Anterior Knee Pain Scale was used to define the presence of problems with prolonged sitting with knee flexion, based on 3 categories: (1) "no difficulty," (2) "pain after exercise," or (3) "problems with prolonged sitting." Differences in demographic and clinical variables between categories were evaluated using Kruskal-Wallis tests ($P<.05$).

RESULTS: Two hundred forty-nine (54.4% of the study sample) participants reported problems with prolonged sitting, and 121 (26.4%) reported sitting pain after exercise. Compared to those with no difficulty sitting (n = 88), participants classified as having problems with prolonged sitting were significantly younger ($P = .038$), more likely to be female ($P = .033$), had a lower body mass index ($P = .027$), reported higher pain severity ($P<.001$) and lower Anterior Knee Pain Scale scores ($P<.001$), and more frequently reported problems with squatting ($P<.001$).

CONCLUSION: Problems with prolonged sitting are evident in more than half of persons with PFP. Findings highlight the need to identify and adequately manage PFP associated with prolonged sitting. Further research should explore mechanisms of sitting pain and evaluate targeted interventions to reduce PFP with prolonged sitting.

LEVEL OF EVIDENCE: Symptom prevalence study, level 2b. *J Orthop Sports Phys Ther 2016;46(8):658-663. Epub 3 Jul 2016. doi:10.2519/jospt.2016.6470*

KEY WORDS: *aggravating activities, knee pain, prevalence*

Patellofemoral pain (PFP) is common, affecting a large proportion of adolescents and young and middle-aged adults.[1,16] This condition is characterized by pain around the patella that is generally aggravated by patellofemoral joint–loading activities, such as sustained knee flexion, sitting, squatting, stair ambulation, and running.[19] Patellofemoral pain can have a negative impact on participation in daily, occupational, and physical activities. The chronicity of PFP has been highlighted in multiple studies,[4,12,15] with symptoms persisting up to 20 years.[15] Greater severity of pain and longer pain duration predict poor outcomes at 1 year[4] and 5 to 8 years.[12]

Prolonged sitting is an activity that is frequently reported to aggravate PFP; therefore, pain with sitting is often used as one of the inclusion criteria in studies of PFP.[3,18] Despite this, the majority of research in this area has focused primarily on the mechanisms of pain during dynamic tasks. Currently, little is known about sitting pain in persons with PFP and particular patient characteristics that may be associated with sitting pain. Furthermore, the mechanisms by which sitting pain occurs in this population are unknown. Because interventions for PFP typically address the mechanics of weight-bearing activities, knowledge of the mechanisms of sitting pain

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is important. Given the limited work in this area, the aim of this study was to (1) describe the proportion of patients with PFP who experience pain associated with prolonged sitting and (2) determine differences in patient demographics and PFP characteristics between those who experience pain with sitting and those who do not.

METHODS

Study Design

This cross-sectional analysis included the baseline data from 4 separate studies (**TABLE 1**): van Linschoten et al[18] (n = 131), van der Heijden et al[17] (n = 64, longitudinal cohort), Collins et al[3] (n = 179), and unpublished data from a longitudinal cohort (n = 84) (**TABLE 1**). All participants for whom baseline data were available were included in the current study. Institutional ethics approval was obtained for each study, and all participants provided written informed consent prior to enrollment.

Participants

TABLE 1 presents details of the recruitment methods and eligibility criteria for each study. All included participants were recruited via referral from health professionals (eg, general practitioners, sports physicians, physical therapists) and community advertising. All studies included participants with insidious-onset peripatellar or retropatellar pain of at least 6 weeks in duration and aggravated by activities that load the patellofemoral joint. Overall, participants were 14 to 50 years of age. Both van Linschoten et al[18] and van der Heijden et al[17] included study participants between 14 and 40 years of age, Collins et al[3] included participants between 18 and 40 years of age, and the unpublished longitudinal cohort included participants between 26 and 50 years of age. The study by Collins et al[3] and the unpublished longitudinal cohort excluded volunteers who rated their pain severity as less than 30 mm on a 100-mm visual analog scale (VAS).

Outcome Measures

Demographic data were collected, including age, sex, height, and weight. Body mass index (BMI) was calculated (kg/m^2). Pain characteristics included the duration of PFP and bilaterality. Participants recorded their knee pain severity (usual/resting or worst/during activity) over the previous week using a 100-mm VAS or an 11-point numeric rating scale (NRS).[5] Pain scores rated on an NRS were rescaled to a 0-to-100 VAS to facilitate data pooling.

The Anterior Knee Pain Scale (AKPS) is a patient-reported outcome measure of knee-specific disability that consists of 13 items assessing the symptoms and aggravating activities associated with PFP (eg, stairs, squatting, running, jumping, prolonged sitting with flexed knees, pain, thigh muscle atrophy).[11] Each item is scored on a weighted basis, with scores on all items summed for a total score out of 100, ranging from 0 (maximal disability) to 100 (no disability).

Data Management and Statistical Analysis

Item 8 of the AKPS was used to define the presence of problems with prolonged sitting with the knees flexed. Three categories were formed from 5 possible responses: (1) "no difficulty," (2) "pain after exercise," or (3) "problems with prolonged sitting" ("constant pain," "pain forces to extend the knees temporarily," or "unable"). Pain after exercise represented a separate category, as the wording indicates that exercise, as distinct from sitting, influenced the pain. The presence of problems with other functional activities also was described. Squatting (item 5) was categorized as (1) "no difficulty" or (2) "problems with squatting" ("repeated squatting painful," "painful each time," "possible with partial weight bearing," or "unable"). Running (item 6) was categorized as (1) "no difficulty" or (2) "problems with running" ("pain after more than 2 km," "slight pain from start," "severe pain," or "unable"). Stairs (item 4) was categorized as (1) "no difficulty" or (2) "problems with stairs" ("slight pain when descending," "pain both when descending and ascending," or "unable").

The proportion of participants assigned to each category, for each activity, was described in percentages. Differences in demographic and PFP variables, as well as AKPS classification for squatting, running, and stair ambulation, between participants in each of the 3 sitting categories were evaluated using 1-way analysis of variance for continuous variables and Kruskal-Wallis tests with post hoc Bonferroni tests for categorical variables. All analyses were performed using SPSS Version 21.0 (IBM Corporation, Armonk, NY), and the significance level was set at .05.

RESULTS

Of the 458 study participants with PFP, 249 (54.4%) reported problems with prolonged sitting, 121 (26.4%) reported pain with sitting after exercise, and 88 (19.2%) reported no difficulty with sitting.

Overall significant differences between the 3 patient groups were found for age, sex, BMI, usual and worst pain, and AKPS score (**TABLE 2**). Post hoc analyses revealed that participants who reported problems with prolonged sitting were significantly younger ($P = .038$), more likely to be female ($P = .033$), had a lower BMI ($P = .027$), and reported higher pain severity (VAS) ($P<.001$) and lower AKPS score ($P<.001$) compared to those who had no difficulty with sitting. Similarly, study participants who had pain with sitting after exercise also had significantly higher worst/activity pain scores (VAS) ($P<.001$) and lower AKPS scores ($P = .001$) compared to those who had no difficulty with prolonged sitting. Study participants with problems with prolonged sitting had significantly higher usual/resting pain severity (VAS) ($P = .01$) and lower AKPS scores ($P<.01$) than those who experienced pain with sitting after exercise (**TABLE 2**).

TABLE 3 presents the proportion of study participants who had problems

TABLE 1 Recruitment and Eligibility Characteristics of the 4 Cohorts

	van Linschoten et al[18] (n = 131)	van der Heijden et al[17] (n = 64)	Collins et al[3] (n = 179)	Unpublished Longitudinal Cohort (n = 84)
Recruitment	Patients who consulted a GP or sports physician for PFP	Patients who visited a sports physician, physical therapist, or GP for PFP	Volunteers who responded to advertisements in print media, radio and television media releases, notice boards, and referrals from practitioners	Volunteers who responded to paid advertisements, flyers on community notice boards and university electronic bulletins, and referrals from health care practitioners
Inclusion criteria				
Age	14-40 y	14-40 y	18-40 y	26-50 y
Symptoms	Presence of at least 3 of the following symptoms: pain when walking up or down stairs, pain when squatting, pain when running, pain when cycling, pain when sitting with knees flexed for a prolonged time, grinding of the patella, positive clinical patellar test (eg, Clarke's test, patellofemoral grind test)	Presence of at least 3 of the following symptoms: peripatellar or retropatellar pain while walking up or down stairs, squatting, running, cycling, sitting with knees flexed for a prolonged time, or grinding of the patella	Insidious onset of anterior knee or retropatellar pain, provoked by at least 2 of the following: prolonged sitting or kneeling, squatting, running, hopping, or stair walking Tenderness on palpation of the patella or pain with step-down or double-leg squat	Anteropatellar or retropatellar knee pain aggravated by at least 2 activities that load the PFJ (eg, stair ambulation, squatting, and/or rising from sitting) Pain during these activities present on most days during the past month
Pain severity	...	...	Worst pain over the previous week of at least 30 mm on a 100-mm visual analog scale	Knee pain severity of at least 30 mm on a 100-mm visual analog scale during aggravating activities
Duration of PFP	Longer than 2 mo but no longer than 2 y	Longer than 2 mo but no longer than 2 y	Longer than 6 wk	Current AKPS symptoms longer than 3 mo
Exclusion criteria				
Concomitant or previous injury/surgery	Knee OA, patellar tendinopathy, Osgood-Schlatter disease, or other defined pathological conditions of the knee Previous knee injuries or surgery	Knee OA, patellar tendinopathy, Osgood-Schlatter disease, or other defined pathological conditions of the knee Previous knee injuries or surgery	Concomitant injury or pain from the hip, lumbar spine, or other knee structures Patellofemoral instability Knee joint effusion Any foot condition precluding use of foot orthoses Previous knee surgery	Concomitant pain from other knee structures, the hip, or the lumbar spine that may impede testing procedures Planned or previous knee surgery Moderate to severe concomitant TFJ OA (Kellgren-Lawrence grade greater than 3 on anteroposterior radiograph)
Interventions	Already treated with supervised exercise therapy	...	Physical therapy or foot orthoses within the previous year Use of anti-inflammatory drugs	Recent knee injections (prior 3 mo)
Other	...	Absolute and relative contraindications to undergo MRI Insufficient knowledge of the Dutch language	Allergy to strapping tape	Contraindications to X-ray (eg, pregnancy, breastfeeding) Physical inability to undertake testing procedures Inability to understand written and spoken English

Abbreviations: AKPS, Anterior Knee Pain Scale; GP, general practitioner; MRI, magnetic resonance imaging; OA, osteoarthritis; PFJ, patellofemoral joint; PFP, patellofemoral pain; TFJ, tibiofemoral joint.

with stairs, squatting, and running, stratified by sitting classification. An overall significant difference between the 3 groups for reported problems while squatting was found ($P<.01$). Post hoc analyses revealed that participants classified as having problems with prolonged sitting more frequently reported problems while squatting (97.6%) compared to those with no difficulty sitting (84.1%, $P<.001$). In addition, participants who had pain with prolonged sitting after exercise more frequently reported problems with squatting (92.6%) compared to those who had no difficulty with sitting (84.1%, $P = .035$).

DISCUSSION

The majority of study participants with PFP reported some difficulty with prolonged sitting, and more than half reported problems with prolonged sitting (ie, "constant pain," "pain forces to extend the knees tem-

TABLE 2 Characteristics of Study Participants*

	Total (n = 458)	No Difficulty With Sitting (n = 88)	Pain With Sitting After Exercise (n = 121)	Problems With Prolonged Sitting (n = 249)	*P* Value†
Age, y	28.2 ± 8.2	30 ± 8.6	28.4 ± 7.9	27.5 ± 8.1	.043‡
Sex (female), n (%)	273 (59.6)	44 (50)	66 (54.5)	163 (65.5)	.017‡
BMI, kg/m^2	24.2 ± 4.5	25.2 ± 4.7	24.3 ± 4.6	23.8 ± 4.3	.031‡
Bilaterality, n (%)§	214 (46.7)	32 (36.4)	62 (51.2)	120 (48.2)	.736
Duration of pain, n (%)‖					.723
1-2 mo	62 (13.5)	16 (18.2)	12 (9.9)	34 (13.7)	
2-6 mo	78 (17)	14 (15.9)	25 (20.7)	39 (15.7)	
6-12 mo	83 (18.1)	14 (15.9)	19 (15.7)	50 (20.1)	
>12 mo	231 (50.4)	44 (50)	64 (52.9)	123 (49.4)	
Usual pain (0-100)	36 ± 21	26.9 ± 18.3	33.7 ± 19.2	40.3 ± 21.6	<.001‡¶
Worst pain (0-100)	57.5 ± 22.1	46.5 ± 23.5	58.9 ± 19.6	60.7 ± 21.7	<.001‡#
AKPS (0-100)	69.3 ± 12.4	78.4 ± 10	72.8 ± 10.3	64.4 ± 11.6	<.001‡¶#

Abbreviations: AKPS, Anterior Knee Pain Scale; BMI, body mass index.
**Values are mean ± SD unless otherwise indicated.*
†*Analysis of variance/Kruskal-Wallis test.*
‡*Post hoc significant difference between "no difficulty" and "pain with prolonged sitting."*
§*Missing data, n = 84.*
‖*Missing data, n = 4.*
¶*Post hoc significant difference between "pain after exercise" and "pain with prolonged sitting."*
#*Post hoc significant difference between "no difficulty" and "pain after exercise."*

porarily," or "unable"). A quarter of the sample reported experiencing pain with prolonged sitting after exercise. Those affected tended to be younger and female and to have a lower BMI, worse knee pain severity, and worse function. These individuals also more frequently reported problems with squatting, but not with running or stair ambulation.

This is the first study to report the prevalence of pain with prolonged sitting in a large cohort of patients with PFP. Our findings are consistent with 2 previous studies. One study reported the severity of knee pain after 20 minutes of prolonged sitting in 28 people with chronic PFP compared to 14 healthy control participants.[8] While no change in knee pain was observed in the control group, the PFP group reported an increase in knee pain after sitting. In the other study, Brushøj et al[2] evaluated PFP severity in 30 military recruits with a short history of PFP. Although higher-level functional activities (eg, squatting, stairs, running) were associated with higher pain severity scores, the median score for 20 minutes of sitting with knees bent was 25 out of 100 (VAS). The data from Brushøj et al[2] suggest that in patients with acute and more chronic PFP, prolonged sitting generally results in pain of clinically meaningful magnitude. Taken together, data from the current study and previous investigations highlight the need to consider strategies to manage sitting pain when treating persons with PFP.

There are a number of potential mechanisms by which prolonged sitting with the knee in sustained flexion may induce PFP. One proposed mechanism is increased patellar intraosseous pressure. Ho et al[10] reported that after 1 hour of sitting, recreational runners with PFP had significantly higher patellar water content than those without pain, which was proposed to increase intraosseous pressure. This is supported by an earlier study that reported higher patellar intraosseous pressure during sustained knee flexion compared to extension, as well as significantly greater patellar intraosseous pressure in sustained knee flexion in people with PFP compared to pain-free individuals.[9] An increase in intraosseous pressure is proposed to stimulate mechanical nociceptors in the subchondral bone, which conceivably contribute to nociception and PFP.[9,10] Another potential mechanism is local tissue ischemia during sitting. Näslund et al[14] found that pulsatile blood flow in the patella was decreased in patients with PFP when seated with 90° of knee flexion, indicating that vascular problems may be involved in the pathogenesis of PFP. Considering the high number of study participants experiencing problems with prolonged sitting, further studies evaluating possible mechanisms are warranted.

Interestingly, participants who reported problems with sitting were also likely to report problems with squatting, but not with running or stair ambulation. Sitting and squatting are bilateral activities that typically involve high degrees of knee and hip flexion that may be sustained for prolonged periods when compared to running and stair ambulation. These physical postures could engender more cumulative compression loading at

TABLE 3 Proportion of Participants Experiencing Problems With Squatting, Running, and Stair Ambulation*

	No Difficulty With Sitting (n = 88)	Pain With Sitting After Exercise (n = 121)	Problems With Prolonged Sitting (n = 249)	*P* Value†
Difficulty squatting (n = 429)	74 (84.1)	112 (92.6)	243 (97.6)	<.001‡§
Difficulty running (n = 416)	78 (88.6)	109 (90.1)	229 (92.0)	.629
Difficulty stair walking (n = 419)	77 (87.5)	108 (89.3)	234 (94.0)	.150

**Values are n (%) unless otherwise indicated.*
†Analysis of variance/Kruskal-Wallis test.
‡Post hoc significant difference between "no difficulty" and "pain after exercise."
§Post hoc significant difference between "no difficulty" and "pain with prolonged sitting."

the patellofemoral joint as a means of increasing intraosseous pressure and contributing to pain. In contrast, the tasks of stair ambulation and running involve more transient, repetitive patellofemoral joint loading at lower degrees of knee flexion.[6,7] Patellofemoral pain also may be expressed differently in the unilateral tasks of stair ambulation and running, conceivably manifesting through frontal and transverse plane mechanics.[13]

Considering the high number of sitting-based occupations and recreational activities, our data suggest that physical therapists and other health practitioners should consider pain with sitting as part of the evaluation and management of people presenting with PFP. Explicit questioning and probing of sitting-related symptoms could be used to inform treatment. Along with increasing patient awareness of pain during prolonged sitting, this may include advice to avoid maintaining large degrees of knee flexion if possible, or integrating regular knee movement into prolonged sitting periods (eg, standing, walking around, or moving the knee repetitively into flexion/extension). Our data support the need for research on the potential mechanisms of sitting pain to facilitate development of effective, targeted interventions.

The consensus statement from the 3rd International Patellofemoral Pain Research Retreat emphasized the need to identify different subgroups of people with PFP.[19] Our data revealed that persons with PFP who experienced pain during prolonged sitting were younger, more likely to be female, and had a lower BMI compared to persons who did not experience sitting problems. This finding may indicate a distinct subgroup of people with PFP who have problems with sitting and provides clinicians with guidance as to patient characteristics that may indicate the need to explore sitting pain during evaluation and management. Due to limited availability of other consistent data across our cohorts, we were unable to further explore potential clinical signs and mechanisms in terms of strength, pain sensitization, and patellar alignment.

It is also important to consider that sitting or sustained knee flexion postures were among 1 of 8 physical postures used in selecting participants in most studies from which our data were sourced (see **TABLE 1**). We were unable to determine the proportion of participants included in the source studies on the basis of sitting or sustained knee-flexed postures. As such, our results may overestimate the prevalence of sitting pain, but not the relationships with other activities and patient characteristics. Nevertheless, this study represents the largest PFP cohort to date with consistent outcome measures, and provides important preliminary data highlighting the need for targeted research to improve understanding of this common problem.

CONCLUSION

Problems with prolonged sitting are evident in more than half of persons with PFP, while another 25% experience pain with prolonged sitting after exercise. Sitting problems tend to affect younger females with a lower BMI, worse knee pain severity, and worse function. Those affected are more likely to report problems with squatting, but not with stair ambulation or running. Findings from this study highlight the need to identify and adequately manage sitting pain in persons with PFP. Further research is warranted to explore mechanisms of sitting pain, identify subgroups of persons with PFP more likely to experience pain with sitting, and evaluate targeted interventions to reduce PFP with prolonged sitting. ◉

KEY POINTS

FINDINGS: Pain with prolonged sitting is reported in more than half of persons with PFP. Persons who report problems with prolonged sitting tend to be younger, female, have a lower BMI, have worse symptoms and function, and also report problems with squatting.

IMPLICATIONS: Musculoskeletal and sports physical therapists should question patients with PFP about pain with prolonged sitting, and incorporate strategies to minimize pain into multimodal treatment programs.

CAUTION: The retrospective nature of the study design means that additional factors may contribute to the subgroup of those with PFP who report problems with sitting.

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