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Hamstring length in patellofemoral pain syndrome

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Abstract

Objectives To investigate whether there was a difference in hamstring length between patients with patellofemoral pain syndrome and healthy asymptomatic controls aged 18 to 35 years.
Design A cross-sectional observational study measuring hamstring length in patients and asymptomatic controls.
Setting Hospital physiotherapy department.
Participants Two groups were tested; one group diagnosed with patellofemoral pain syndrome (mean age 27 years, $n = 11$, six males, five females) and one group of asymptomatic controls (mean age 25 years, $n = 25$, 13 males, 12 females).
Main outcome measures Hamstring length was evaluated using the passive knee extension method to measure popliteal angle.
Results The mean (standard deviation) values for hamstring length were 145.6 (8.7)° for patients with patellofemoral pain syndrome and 153.7 (10.1)° for the asymptomatic controls. The mean (95% confidence interval) difference between the groups was 8.0 (0.8 to 15.1)°, and analysis with a *t*-test revealed that this was statistically significant ($P < 0.05$).
Conclusions This study found that patients with patellofemoral pain had shorter hamstring muscles than asymptomatic controls. It is not clear whether this is a cause or effect of the condition. Further research is suggested to study how hamstring length changes with rehabilitation, and the relationship with pain.

Keywords: Knee; Patellofemoral pain syndrome; Joint flexibility; Muscle stretching exercises

Introduction

Patellofemoral pain syndrome (PFPS) is a common condition, especially prevalent in adolescents and young adults, and particularly those who play sport. The prevalence is higher in females than males [1,2], although data for the UK are lacking [3]. PFPS can be treated conservatively by physiotherapy, orthotic devices and exercise [2,4,5], particularly quadriceps strengthening exercises [6]. However, the exact causes of PFPS remain unclear [7]. Various factors have been implicated in the aetiology, including lower extremity malalignment, insufficient flexibility and quadriceps deficits, particularly that of vastus medialis which stabilises the patella [7]. Quadriceps deficits, and therapy to alleviate these deficits, remain the focus of much research, with other aspects receiving far less attention.

Muscle tightness or shortness is frequently described as an objective sign in PFPS patients, and represents a target for treatment. Indeed, this is a common clinical observation that physiotherapy aims to alleviate. However, a review of the literature carried out by the authors revealed that the evidence for specific hamstring shortness in PFPS is not unequivocally supported by primary research. Although literature reviews often mention hamstring length as a putative factor [8], reviews often group together flexibility of the iliotibial band, quadriceps and hamstrings, rather than documenting them specifically and separately. To the authors' knowledge, only three previous studies have measured hamstring length in the area of PFPS, with conflicting results. Smith *et al.* [9] reported that hamstring length was correlated with patellofemoral pain in a longitudinal study of figure skaters, but no actual raw data on hamstring length were presented. In a cross-sectional observational study, Piva *et al.*

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[10] reported that hamstring length was significantly shorter in patients with PFPS than controls, by an average of 9° [95% confidence interval (95% CI) 4 to 15°]. In contrast, Witvrouw *et al.* [11] carried out a 2-year prospective study of 282 students, 24 of whom developed PFPS over the period, but found that hamstring length did not differ significantly between students who did and students who did not develop PFPS. Therefore, it is unclear whether hamstring muscles are shorter in PFPS patients than asymptomatic subjects. The lack of scientific information regarding the impact of muscle length on PFPS and the effect of physiotherapy to improve this has been noted by researchers [11]. Data on the normal range of hamstring lengths are limited and comparisons are difficult because of differing methodologies.

Both Piva *et al.* [10] and Witvrouw *et al.* [11] used the straight leg raise method to measure hamstring length. It has been argued that the knee extension method of measuring popliteal angle is superior, as it has the advantage of immobilising the hip joint [12], but data are not available for PFPS patients using this method. Therefore, the purpose of this study was to compare hamstring muscle length in PFPS patients and healthy asymptomatic controls using the popliteal angle method and hand-held goniometry [13]. As hamstring shortness is often mentioned in PFPS literature reviews and is commonly observed in these patients, the hypothesis of the present study was that PFPS patients would have shorter hamstring muscles than asymptomatic controls.

Methods

This was a cross-sectional observational study to investigate whether hamstring length differed between a group of patients with PFPS and a group of healthy asymptomatic controls. This was measured indirectly by the popliteal angle method [12–16].

Participants

Ethical approval was granted by the South Tees Local Research Ethics Committee. Before taking part, each participant read an information sheet about the study and gave informed consent. All subjects completed a Knee and Osteoarthritis Outcome Score (KOOS) [17] and a visual analogue scale (VAS) for usual pain [18].

Thirty-one asymptomatic participants were recruited from hospital staff via staff bulletins requesting volunteers for the study. To be included, asymptomatic participants had to be aged between 18 and 35 years, and they were excluded if they had any lower limb pathology, spinal pathology, neuropathology or any history of previous knee pathology or knee pain. Six participants reported pain on either the KOOS or VAS; these subjects were excluded, leaving 25 asymptomatic participants.

PFPS patients aged between 18 and 35 years were recruited via an acute hospital orthopaedic outpatient clinic.

Table 1
Descriptive characteristics of participants, mean (standard deviation) values

	PFPS ($n = 11$)	Control ($n = 25$)
Age (years)	27.0 (5.2)	25.2 (3.8)
Height (m)	1.71 (0.09)	1.75 (0.09)
Weight (kg)	77.7 (20.5)	74.3 (21.4)
KOOS pain	65.2 (21.1)	100 (0)
KOOS symptoms	65.8 (20.2)	97.6 (3.1)
KOOS ADL	75.6 (20.0)	100 (0)
KOOS sport/rec	63.6 (23.1)	99.8 (1.0)
KOOS QOL	48.9 (21.1)	99.5 (2.4)
VAS score	3.1 (2.5)	0 (0)

PFPS, patellofemoral pain syndrome; KOOS, Knee Injury and Osteoarthritis Outcome Score; ADL, activities of daily living; sport/rec, sport and recreation function; QOL, knee-related quality of life; VAS, visual analogue scale.

All patients who were referred to physiotherapy by an orthopaedic consultant, with a diagnosis of anterior knee pain or PFPS, were invited to participate in the study. To be included, PFPS patients had to present with non-specific pain over the anterior aspect of the knee during or after activities such as ascending or descending stairs, running, squatting and sitting with their knees flexed [19]. In addition, they had to describe no history of trauma, no abnormality on X-ray, and no positive clinical findings on ligament or meniscal testing. Patients with a clinical diagnosis of Osgood-Schlatters disease or Sindig-Larsen disease were excluded because they would have bony abnormality. Patients with patellar tendonitis were also excluded as they had specific pain which was outside the scope of this study. Data were collected over a 1-year period from August 2006 to July 2007. No patients declined to take part, resulting in a PFPS group with 11 subjects. Demographic details of participants (including age, height and weight) were recorded prior to testing and are shown in Table 1.

Instrumentation

A stabilisation board similar to that used by Rakos *et al.* [12] and Hopper *et al.* [14] was constructed. This apparatus was designed to ensure that the hip position would be maintained at 90° of flexion during the measurement and returned to the same point for each measurement. The apparatus consisted of two vertical bars on either side of the board, connected by a horizontal bar at a height of 45 cm. The board was placed on to a physiotherapy treatment plinth. An inextensible fabric strap was used to stabilise and eliminate hip flexion of the contralateral limb during testing. This has been reported to be a highly reliable method [12,14,15].

A universal goniometer was used to measure the popliteal angle. The increments were masked by a disc of card [15], so that the centre of the dial was visible to allow correct placement but the peripheries were occluded.

Procedure

Several studies have measured popliteal angle, using the passive knee extension test, as a measure of hamstring length, and have reported excellent reliability [13,14,16]. In the present study, the measurement was carried out in a standardised manner by three examiners, with each examiner assigned the same role each time, as in the study by Corkery *et al.* [15]. Examiners 1 and 2 were senior physiotherapists with a minimum of 9 years of clinical experience, who performed popliteal angle measurement on a daily basis as part of their clinical duties. Examiner 3 was a physiotherapy assistant with 11 years of relevant clinical experience.

Data were collected from the symptomatic leg of the PFPS patients, and the dominant limb of the controls (all were right dominant). Each participant was instructed to lie supine on the stabilisation board. Examiner 1 positioned the patient so that the thigh rested on the cross bar when the hip was flexed to 90°. The asymptomatic or non-dominant leg was strapped to the bed using one inextensible fabric strap across the mid thigh and fastened under the plinth. The leg to be measured was then positioned with the hip flexed to 90° and the thigh resting on the cross bar. Examiner 1 then extended the knee passively to the point of firm resistance to movement [13,20]. This was standard clinical practice, and the normal method for these experienced examiners. No participants described pain during the procedure. Examiner 2 placed the centre of the goniometer over the lateral femoral condyle, and aligned the two goniometer arms with the lateral malleolus at the ankle and the greater trochanter at the hip. While Examiner 2 held the goniometer in position, Examiner 3 read and recorded the popliteal angle. This procedure took less than 5 seconds, and the leg was then rested on the plinth for 10 seconds with the hip in a neutral position and the knee extended. The measurement was repeated two further times. It was not possible to blind the examiners to participant group; however, Examiners 1 and 2 were blinded to the goniometer reading [15]. Goniometry measurements of knee joint range of motion have been shown to be extremely reliable, with intrarater reliability being superior to inter-rater reliability [13].

To allow evaluation of between-session repeatability, nine asymptomatic participants were remeasured at a subsequent session an average of 2 weeks later using an identical protocol.

Statistical analysis

Statistical analysis was performed using Statistical Package for the Social Sciences Version 13 (SPSS Inc., Chicago, IL, USA). Differences between the groups were tested for statistical significance using an independent *t*-test, as the data did not breach the assumptions of normality (Shapiro Wilk test, $P > 0.05$). Alpha was set at 0.05. Differences were also evaluated using mean [standard deviation (SD)] values and mean (95% CI) differences. Due to the small sample size in the patient group, the influence of gender was not evaluated using statistical tests, but was explored using mean (95% CI) differences.

Repeatability of the measurements was addressed by analysis of the three within-session measurements, and by analysis of the average values of Session 1 and the average values of Session 2. To assess relative repeatability, intraclass correlation coefficients (ICCs) of the three within-session measurements (ICC 3,3) and between-session measurements (ICC 3,1) were calculated. To assess the precision or measurement error, the typical error was calculated by taking the square root of the ANOVA error variance [21,22] for both the within-session and between-session data. This value is also known as the standard error of the measurement or the within-subject SD.

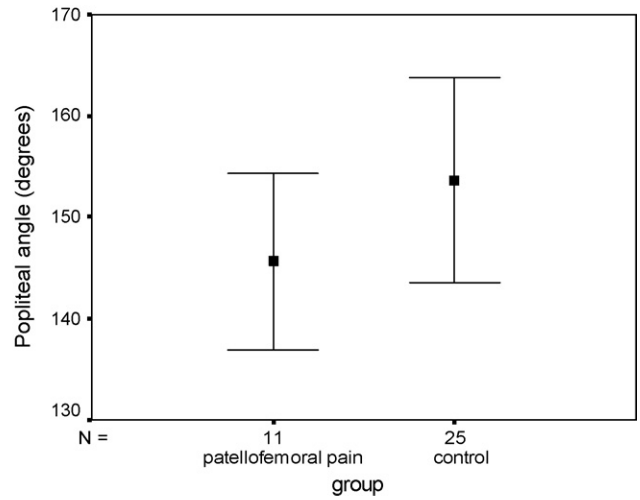

Fig. 1. Hamstring length measured by popliteal angle method. Values are mean standard deviation.

Results

The demographic characteristics of the groups (Table 1) show that the two groups were similar in age, height and weight. The mean (SD) values for hamstring length were 145.6 (8.7)° for the PFPS patients and 153.7 (10.1)° for the asymptomatic controls. These data are shown in Fig. 1. The mean (95% CI) difference between the groups was 8.0 (0.8 to 15.1)°. Analysis with a *t*-test revealed that this difference was statistically significant ($P < 0.05$). When converted to an effect-sized standardised difference [23], a dimensionless value obtained by dividing the difference by the mean SD, this value was approximately 1, indicating a large difference [23]. When the influence of gender was explored descriptively (Table 2), the popliteal angle data showed trends for

Table 2
Popliteal angle grouped by gender (°)

Group	Mean (SD) value		Mean (95% CI) difference
	Male	Female	
PFPS	140.6 (10.2)	151.8 (7.0)	11.2 (−1.0 to 23.4)
Control	150.5 (7.2)	157.1 (11.9)	6.6 (−1.5 to 14.6)

PFPS, patellofemoral pain syndrome; SD, standard deviation; CI, confidence interval.

lower flexibility in males compared with females in both groups, with a distinct asymmetry about the zero value in the CIs for the differences.

For within-session repeatability, the ICC (3,3) analysis revealed a mean (95% CI) ICC value of 0.96 (0.92 to 0.98), indicating excellent repeatability for the within-session measurements. Assessing within-session precision or measurement error, the typical error was 3.7°; this is the variation one would expect to see in a participant from measurement to measurement [21,22].

For between-session repeatability, the data for the nine subjects who returned for retesting produced a mean (95% CI) ICC (3,1) value of 0.97 (0.88 to 0.99), indicating good repeatability. When between-session precision or measurement error was assessed, the typical error was 2.7°.

Discussion

The aim of this study was to determine if there was a difference in hamstring length between patients with PFPS and asymptomatic controls. The results indicate that the hamstring muscle was significantly shorter in patients with PFPS, by an average of 8°; this between-group difference was classed as large and indicates markedly lower flexibility.

The PFPS patient sample appears to be representative of the PFPS population. The mean patient VAS score of 3.1 is similar to mean pain scores reported by Piva *et al.* [10] and McClinton *et al.* [24] (3.9 and 3.1, respectively) after stair ascent on a 32-cm-high step. The VAS has been shown to be a valid and reliable measure of pain [19]. The KOOS ADL score for the patients in the present study is also fairly similar to that reported by Piva *et al.* (75.6% vs. 64.5%, respectively) [10]. The present repeatability data are comparable with those of Hopper *et al.* [14], who reported an ICC of 0.89 and typical error of 5.0°, indicating that the present methods have similar robustness as previously published studies. In agreement with Piva *et al.* [10] and Smith *et al.* [9], the present study found that hamstring muscles are shorter in patients with PFPS than in asymptomatic controls. The mean difference found in the present study is very similar to that found by Piva *et al.* [10] (8° vs. 9°, respectively). Interestingly, this contrasts with the findings of Witvrouw *et al.* [11] who observed no statistically significant difference in hamstring length between participants who developed PFPS and those who did not. As the latter study was longitudinal, it is possible that hamstring tightness is actually an effect of PFPS, rather than a cause. Also, in the study by Witvrouw *et al.* [11], the group was younger (aged 17 to 21 years) than in the current study (18 to 35 years), so direct comparisons cannot be drawn.

It has been argued that reduced flexibility in the hamstrings is clinically relevant as it can elicit more knee flexion than normal during activities, which can produce increased patellofemoral joint reaction forces [10,25,26]. Hamstring stretching is commonly prescribed for this pathology [26]. The current study does not provide evidence to help ascertain whether this tightness is a cause or effect of PFPS. It does, however, have clinical implications for assessment, diagnosis and management. As a relationship has been demonstrated between hamstring length and PFPS, consideration should be given by clinicians to hamstring length on assessment of patients who present with PFPS. The present study also noted a trend for differences between the genders in both the PFPS patient group and the control group, with females having a greater mean popliteal angle than males, and the CIs indicating that this is probably a true difference. Although the generalisability of these results is limited by the small sample size, this finding concurs with previous research in healthy adults supporting gender differences in flexibility [13,15]. This is interesting because, notwithstanding the observation that males have tighter hamstrings, the prevalence of PFPS is actually higher in females, and this therefore shows the multifactorial nature of the condition. These data therefore concur with the suggestion by Youdas *et al.* [13] that gender clearly affects any threshold for classifying the hamstrings as tight. It may be that hamstring tightness is an indicator for PFPS, but confirmation of this would require an in-depth study with long-term follow-up. Further research is needed in this area, with assessment of hamstring length in a larger population. It would also be appropriate to analyse the effects of improving hamstring length on PFPS symptoms.

Limitations to the study

There are some limitations to this study. As in other research in this area [10], the examiners were not blinded to group status of the participants. This may have caused subconscious experimenter bias during the testing. However, Examiners 1 and 2 were blinded to the goniometer readings, with the aim of reducing any bias this may have caused. The study did not take into account the duration of symptoms in the PFPS patient group, and as some authors propose that tightness may be as a result of PFPS [10], it may be affected by duration of symptoms. Diagnosis and classification of PFPS is difficult, and as criteria can also differ between studies, this may affect the generalisability of these results. The subjects were measured without warm-up or pre-stretching, and this may have affected flexibility. However, as this was standardised, any effect would be spread across all participants. Finally, the study was limited by a small sample size in the PFPS patient group and therefore the results should be interpreted with caution. Recruitment was markedly lower than anticipated because of reductions in referrals into the hospital from the local primary care trust.

Conclusion

This study found that patients with patellofemoral pain had shorter hamstring muscles than asymptomatic controls. It is not clear whether this is a cause or effect of the condition.

Further research is suggested to study how hamstring length changes with rehabilitation, and the relationship with pain.

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Conflict of interest: None.

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