Evaluating the Roles of Sporting Activity and Biomechanical Risk Factors of the Lower Extremity in the Etiology of the Patellofemoral Pain Syndrome

Tállay András

Academic Supervisor:
Anikó Barabás PhD

Semmelweis University, PhD School
Sporttudományi és Neveléstudományi Doktori Iskola

1. Introduction

When selecting my doctoral thesis, the following viewpoints were taken into account. The most frequent patients attending my consultation at the Sports Surgery Ambulatory Clinic of the National Institute of Sports Medicine are adolescents with overuse injuries. The diagnosis is patellofemoral pain syndrome (hereinafter PFPS) in most of the cases. In the event that a clinical pattern is established, it often becomes a chronic problem that may entail a considerable reduction in or even discontinuation of sports activities. It is particularly important to consider that adolescence, the age examined by us, is the period when students may really come to love sports for their lives.

The patellofemoral pain syndrome is the most frequent but perhaps the most mysterious sports overuse injury produced in the adolescent population. PFPS used to be identified with the diagnosis of "chondromalacia patellae" for decades. There is no publication on PFPS in the Hungarian literature; the most recent articles on "chondromalacia patellae" disorders date back to the early 80s. The most important symptom in the clinical pattern is pain, which may lead to the total suspension of sports activities. In order to understand the significance of the syndrome, some basic concepts are required to be familiarised with. Therefore I intend to provide an overview of the main extrinsic (as related to sports activities) and intrinsic (biomechanical discrepancies) risk factors affecting the development of the clinical pattern, as well as of PFPS epidemiology, diagnostics, and prevention possibilities.

In spite of the fact that the authors involved with this clinical pattern provide many different interpretations of it, a clear and obvious definition of PFPS is contained by international literature. Therefore, the diagnosis of PFPS was set up on the basis of the following conditions:

- Typical complaints for over six weeks (retropatellar pain during and after running, after sitting with the flexed knees for a longer time, during squatting, during walking on stairs, and / or when jumping).
- Besides subjective complaints, at least two of the criteria listed below should be complied with during the physical examination:
  - pain at direct pressure on the patella opposite to the condylus in the state of total extension;
  - sensitivity to pressure at the articular surface of the patella;
  - pain reaction to extension against resistance;
  - pain in the case of isometric quadriceps contraction against suprapatellar resistance at 15° flexion (Zohlen test)
- Another condition is that the examination of each ligament and meniscus test, bursa, synovial plica, Hoffa’s fat body, iliotibial ligament, quadriceps, and patellar tendons and the origins thereof should yield negative results.

Besides the primary form of PFPS, a secondary form – also very frequent – should also be specified, the formal background of which contains pathology in all cases (e.g. knee joint instability, post-meniscectomial states, femorotibial arthrosis).

In my experience as regards Hungary today, neither professional nor recreational-level sportsmen pay sufficient attention to prevent sports accidents and overuse injuries; the long-term interests of top sportsmen and competitors are not represented by sports management. Therefore I deemed it necessary to introduce a proprioceptive training, stretching, and strengthening programme to prevent injuries, non-existent in Hungary so far. In my opinion, our initial experiences and results with the prevention programme were extremely favourable with first-league athletes; consequently, possibilities for more wide-spread divulgence should be examined in the near future.
2. Objectives

In my assumption, cross-sectional examination of a representative group of adolescents may yield a number of data which, by way of functional anatomical and biomechanical analysis, provide an accurate picture of PFPS epidemiology, etiology, biomechanical correlations, as well as the relation between pain and functional reduction.

? I aimed at providing a standardised and accurate definition of PFPS.

? The primary objective of my study was to define PFPS epidemiology.

? One of my objectives was to explore the roles of sex and age in the prevalence of the clinical pattern.

? Another objective of my study was to disclose further intrinsic and extrinsic risk factors in the development of PFPS.

? I aim at presenting a diagnostic algorithm which is widely applicable in the knowledge of the factors playing a significant role in the occurrence of PFPS.

? Finally, my main objective is to elaborate PFPS prevention opportunities in the knowledge of risk factors.

3. Material and method

In the course of our surveys, biomechanical, othopaedic, and anthropometric cross-sectional screening was performed on the secondary school age group - between 13 and 19 years of age - most highly affected by the patellofemoral pain syndrome. Before commencing sampling, we contacted the National Office for Statistics (NOS). NOS officials proposed sampling from as many regions of Hungary as possible, from a population of at least 500 persons, as a condition for the epidemiological survey. However, due to high levels of instrumentation and cost savings, we randomly selected six secondary boarding schools from various regions of Hungary for national sampling, in conjunction with NOS. After preliminary coordination by phone with the schools randomly selected, we sent standardised letters to the the directors thereof requesting them to consent to the tests. In order for randomisation, we requested every third student in the roll of each form to perform the test. Students of the forms having a P.E. class on the day of our visit were examined in each case. Visits were performed on a day of the week randomly drawn beforehand. Declarations of consent as approved by TUKEB were received by every third student in the roll of the form concerned; surveys were completed only for those students who delivered a signed declaration of consent to us. Tests were performed on the basis of logical considerations – as it is favourable to wear sports clothing for physical tests, the Hop test, strength measurements, and anthropometric tests –, as well as in the period of P.E. classes; measurements were performed in the gymnasiums. Tests were realised by establishing stations, to the pattern of a "circular training". I compiled a two-page data sheet for data collection.

In the course of test design, we analysed five adolescent patients treated for patellofemoral pain syndrome as clinical case studies at the Sports Surgery Ambulatory Clinic of the National Institute of Sports Health (NISH). Measurement results were compared with similar results in literature. Measurement technology tests and verifications were performed on 10 students at Budapest St. Angela Grammar School - the venue of the site visit - in the course of epidemiological tests, done by two orthopaedists independently from each other in order to estimate measurement errors.

Height and weight measurements were performed with the assistance of P.E. teachers and our administrator. A short guided patient history was taken before the tests, inquiring about deformations and injuries of the knee, the leg, and the hip, as well as about any treatment
thereof and present complaints. A 10 cm visual analog scale (VAS) was used for examining and coding pain, with students’ pain levels recorded at four different states (at rest; during running; when walking on stairs; during and after a long period spent sitting, with the knees flexed). Students filled in the first page of the personal questionnaire themselves as regards questions on patient history data.

No further questions were posed at other places of measurement, therefore doctors performed the tests "blind", without knowing the students’ patient history.

The answer slots for the 45 questions on the second page of the data sheet were completed by the doctors who performed the tests. Each physical test was performed by the same orthopaedist. Leg tests and dynamic walk analysis were performed by a competent medical student and P.E. teacher in each case; anthropometric measurements were made by an orthopedic resident. Each parameter examined was recorded in SI units of measurement on the respective data sheets.

Physical hip, knee, and ankle joint examinations were performed for each student. Physical tests were made in supine position on a portable examination bed. In order to disclose the biomechanical characteristics of the lower limb, anthropometric measurements were made including hip width [SIAS distance], length of the lower limb (LL), intermalleolar [IM] and intercondylar [IC] distances, as well as Q angle, leg-heel (LH) angle, and tibia torsion both at relaxed and contracted quadriceps muscles. Depending on the alignment of the lower limb, either the two internal ankles or the two medial tibia condylus are in contact in an upright position. For students with the two internal ankles in contact, the distance between the medial tibial condyles was measured (genu varum). In the event that tibia medial condyleses are in contact, the distance between the two internal ankles are measured (genu valgum). In the event that the distance between both the condyleses and the internal ankles was less than 1 cm, the axis of the lower limb was considered to be normal. The leg-heel angle was assessed using the method applied by Hyvarinen and Karhu. Measurements were performed standing in an standing position, with the lower limb muscles relaxed and patellas boking ahead. Campbell Calipers were used for measurements. According to orthopaedic practice, the length of the lower limb was measured between SIAS and the internal ankles in supine position. In order to determine the axis of the patellofemoral joint, static Q angle measurements were performed using a manual goniometer. The Q angle was specified between the SIAS, the centre of the patella, and the centre of the tuberculum tibiae. In the course of measurement, students were in supine position; measurements were performed first with relaxed and then with tense quadriceps muscles. Tests for general joint laxity, flexibility, and KT-1000 arthrometer tests were also performed in supine position. In accordance with Beighton’s recommendations, general joint laxity was examined by the thumb-lower arm, elbow, knee, shoulder, and small finger hyperextension. The Ely test was applied for examining the flexibility of the quadriceps femoris muscle. Dynamic foot structure tests were performed using the Adidas footscan system. Measurements were performed in standardised conditions as described in the company’s specifications. The students were running along a 10 m long, straight, slide-proof run track at medium speed. The sensor pad was loaded first by their right and then by their left leg. After two trials, the results of the third measurement were processed.

The parameters specified in the personal data sheet were used for establishing a PC-based Microsoft Access database. The distribution of different variables was analysed by generally accepted descriptive statistical methods. The constant variable parameters of students suffering and not suffering from PFPS, respectively, were compared using a Student-type t-test applied for independent variables. A khi-square test was used for analysing the discrete variables of the two groups; its significance level was determined with the Yates method for contingency tables containing values below 10 and with Pearson’s method for any other
cases. The variance analysis method (ANOVA) was used for comparing more than two groups set up on the basis of different variables. In each case, significance was determined as \( p=0.05 \).

4. Results

In the course of our epidemiology survey, we examined a total of 1172 knee joints and lower limb characteristics of 586 students in various regions of Hungary. Distribution by the sexes is nearly identical: there were 294 (50.17%) boys and 292 (49.83%) girls. The average age of students was 16.05 ± 1.45 years (13 to 19); their average weight was 60.73 ± 10.89 kg (39 to 105); their height was 172.16 ± 8.83 cm (148 to 202); their body mass index (BMI) was 20.41 \( \pm \) 2.79 kg/m\(^2\) (13.87 to 31.35). When analysing various levels of sports activity, hobby sports came up most frequently with both girls (45.9%) and boys (59.5%). Unfortunately, 39.7% of girls – as opposed to 17% of boys – can be classified as not practising any sports. Significant discrepancies were found between the basic data for the anthropometric and sports activity levels of the two sexes, therefore the data for girls and boys should be handled separately hereinafter in the course of the study.

A total of 129 cases out of the adolescents featuring in our survey presented anterior knee pain complaints sustained for over 6 weeks. In two cases, surgical intervention was performed earlier on. For six students, some other reasons for anterior knee pain were diagnosed on the basis of the physical test. In the case of the thus remaining 121 students, the PFPS diagnosis was set up (PFPS group). The remaining 465 students were assigned as the control group. Clinical pattern prevalence was found to be 20.65% subject to the criteria of inclusion and exclusion accepted by us. The distribution of PFPS by sexes was nearly equal (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>control N=465</th>
<th>PFPS N=121</th>
<th>Total N=586</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>234 (50.32%)</td>
<td>60 (49.59%)</td>
<td>294 (50.17%)</td>
</tr>
<tr>
<td>Girls</td>
<td>231 (49.68%)</td>
<td>61 (50.41%)</td>
<td>292 (49.83%)</td>
</tr>
<tr>
<td>Total</td>
<td>465 (79.35%)</td>
<td>121 (20.65%)</td>
<td>586 (100.00%)</td>
</tr>
</tbody>
</table>

On the basis of age analysis it is revealed that adolescent boys suffering from PFPS are 0.36 years younger than their counterparts without any complaint; while girls with complaints are 0.84 years older than girls with no complaints.

In order to examine the impact of sports load, we analysed the respective roles of the branches of sport, sports activity levels, sports age, and the frequency of practising sports (hours/week). Based on the results, it can be obviously shown that PFPS is more frequent with students practising competitive sports and leisure sports than in the group not practising any sports. As regards the population not practising any sports, our survey did not indicate any differences between boys and girls in the PFPS group in terms of the prevalence of the clinical pattern (P=0.8662).

In the course of our survey, the highest levels of pain were indicated by patients when walking on stairs (4.68 cm) from among the four states monitored by VAS. Pain levels for sitting with the knees flexed for a longer period as well as during and after running were found to be somewhat lower. 15 students out of the 121 patients diagnosed with PFPS had unilateral complaints: 7 cases on the right (5.78%) and 8 cases on the left side (6.61%). We found bilateral complaints in most of the cases – with 106 students (87.61%).
Besides patellofemoral pain in the PFPS group, students (as regards 227 PFPS knees) complained about crepitation in 62.11%; a subjective giving-way feeling in 10.57%; swelling in 13.66%; and locking in 14.98%. Members of the control group complained about crepitation in 26.98%; a subjective giving-way feeling in 3.07%; swelling in 3.17%; and locking in 3.07%. Significant differences were found between the occurrences of the subjective symptoms of the two groups (p<0.0001).

In the course of the physical examination of the 586 students, patella instability tests were found to be positive in 26 cases. No significant correlation was found between patella instability and PFPS (p>0.05). Earlier dislocation occurred in two cases; they were referred to the control group in accordance with our modified exclusion criteria.

In the course of the physical examination, similar test findings were disclosed for 219 students, including pain by direct pressure on the patella, and pain at knee extension against resistance (Zohlen sign). Besides the 129 students suffering from anterior knee pain, the remaining 90 students (41.1%) had positive physical examination findings but did not report on complaints sustained for a period below six weeks or reported no complaints at all.

In the course of analysing the significance of the Q angle, the average values of the figures measured were calculated with a view to distribution by sexes on the basis of our surveys completed first with a relaxed and then with a tense quadriceps muscle. As there is a highly significant difference between both types of Q angle values of healthy girls and healthy boys (p<0.0001), therefore it is reasonable to specify the normal values of the two measurement types separately.

In the case of adolescent boys, the Q-angle values measured at both the relaxed and tense states of the quadriceps are considerably higher in the PFPS group as opposed to girls (Table 2.)

<table>
<thead>
<tr>
<th></th>
<th>TOTAL</th>
<th>PFPS</th>
<th>P</th>
<th>TOTAL</th>
<th>PFPS</th>
<th>P</th>
<th>TOTAL</th>
<th>PFPS</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q angle (relaxed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>control</td>
<td>12.5</td>
<td>13.2</td>
<td>0.0121</td>
<td>13.9</td>
<td>14.6</td>
<td>0.1627</td>
<td>11.0</td>
<td>11.8</td>
<td>0.0162</td>
</tr>
<tr>
<td>PFPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q angle (tense)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>control</td>
<td>9.9</td>
<td>10.5</td>
<td>0.0173</td>
<td>11.3</td>
<td>11.6</td>
<td>0.2952</td>
<td>8.6</td>
<td>9.4</td>
<td>0.0083</td>
</tr>
<tr>
<td>PFPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q angle (relaxed-tense)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>control</td>
<td>2.6</td>
<td>2.7</td>
<td>0.1735</td>
<td>2.7</td>
<td>2.9</td>
<td>0.1216</td>
<td>2.4</td>
<td>2.4</td>
<td>0.6902</td>
</tr>
<tr>
<td>PFPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In summary, it can be stated that if the two sexes are examined together, higher Q angles are coupled with significantly larger occurrences of PFPS. In the course of analysis by sexes, statistically significant differences were evidenced only with males.

In the course of statistical analyses, we did not manage to reveal significant discrepancies between the PFPS and the control groups at either sex on the basis of LL length difference. Information on the varus / valgus alignment can be obtained by calculating differences between the IM-IC distances measured. The occurrence of PFPS at normal alignment is significantly lower than malalignments (p=0.0119). At girls, increased varus alignment occurred as a significant risk factor of PFPS (p=0.0049). At the same time, valgus alignment do not represent significant risk factors. In the course of statistical analyses, significant differences can be indicated between the two sexes when examining the leg-thigh angle providing information on tibial rotation; however, no correlations have been found in terms of PFPS. When examining the ratio referring to femur anteversion, no significant differences were found between the PFPS and the control group, neither with girls, nor with boys. On the
basis of KT-1000 stability tests – based on the results of the maximum manual strength test – the knee joints of the control group were found to be looser, contrary to expectations. The leg-heel (LH) angle allows us to draw inferences on leg pronation. There was a significant difference between the female PFPS and control groups (0.038), with the control group producing higher values. In the course of processing leg-related subjective complaints, the PFPS group presented a significantly higher frequency of pain in the heel (p=0.0106) and the dorsum of the foot (p=0.0015), sole spasms (p=0.0126), and rapid sole exhaustion (p=0.0002). Wearing of arch support also shows significantly higher frequency in case of PFPS (p=0.0001). In the course of the tests performed using the Adidas footscan system, we found considerable deformations in students’ foot structure both in the PFPS and the control group. Based on the dynamic tests of the arch of the foot, ideal load conditions were specified in a total of 23 students at both sides and in 70 cases at one side. This may be the reason for the fact that we were not able to provide evidence for significant differences between the PFPS and the control group as 98.04% of the students were to be classified into groups of abnormal leg structure. Based on the leg length, leg width, and leg length – leg width indices, significant differences were found between the PFPS and the control group of girls (p=0.0025). The ratio of leg length without load / leg length under load refers to collapse of the arch of the foot. Its value was found to be higher with the control group.

In the course of evaluating the results of isokinetic strength measurements and the Hop test, we took into account the ratio of the values of the complaint side / both sides. The results of both measurements show significantly lower values at the PFPS side in the case of girls. According to the Brighton scale, we were able to set up a diagnosis of generalised hyperlaxcity only in one case out of the total number of patients diagnosed with PFPS. As regards flexibility tests, the rate of occurrence is significantly higher in the female PFPS group as opposed to the control group (p=0.0336). Based on the results of the 586 students examined, the average ranges of movements of the hip, knee, and ankle (upper and lower ankle joints) were specified for the students of 13 to 19 years of age participating in the survey. The results of the two groups were compared, but no significant discrepancies were found.

The students involved in our survey practise 37 branches of sport on a regular basis. Different branches of sport exert a different impact on the development of PFPS. The most frequent competitive and hobby sports include football and basketball for boys and handball and aerobics for girls. We registered the material of the sports track cover. Unfortunately, P.E. classes are held in the open air, on a concrete or asphalt track in most cases at each of the schools surveyed by us. The most frequently used shoes are the cheap linen gym shoes that used to be compulsory earlier, with rubber sole and no proper arch support.

Table 3. shows our short-term results achieved by proprioceptive prevention training completed as a pilot study.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Number of complaints+injuries / pers. N=20</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFPS</td>
<td>1</td>
</tr>
<tr>
<td>Secondary PFPS</td>
<td>1</td>
</tr>
<tr>
<td>LCA rupture</td>
<td>1</td>
</tr>
<tr>
<td>Ankle ligament injury</td>
<td>5</td>
</tr>
<tr>
<td>Instability of the talocrural articulation</td>
<td>1</td>
</tr>
</tbody>
</table>
Due to the low number of cases, it is not worth drawing far-reaching consequences from the results of the short-term follow-up examination; however, the improvement tendency is positive in terms of all diagnoses studied, with initial experiences proving to be highly favourable.

5. Discussion

The most frequent musculoskeletal complaint of adolescent athlete is non-traumatic pain in the knee. Although the patellofemoral pain syndrome occurs highly frequently, the actual role played by the factors promoting its development is unknown. Anterior knee pain complaints may be caused by arthrosis, dislocation, synovitis, chondromalacia, and a number of other eliciting factors, therefore differentiated PFPS diagnostics presents a challenge even for experienced professionals. PFPS is still used as a collective "waste basket" concept by many people, so it is difficult to compare the results of various studies. It is essential that the term PFPS be used in a standardised manner in the future, otherwise the epidemiology, etiology, and treatment of this clinical pattern will continue to be controversial.

It is a problem that the statistical representativity of the population examined is questionable or unsuitable in all epidemiological studies published so far. Having learnt from the mistakes of surveys by authors involved in PFPS earlier on, we looked up and took over the most accurate PFPS definition to be found in literature – as used by Witvrouw. Deficiencies related to the standardised use of the definition are properly characterized by the fact that even Thomeé et al. formulated different criteria in their various articles. Patellofemoral instability as a factor of exclusion was not applied consistently, either, and the start of symptoms was not specified. A synoptic article by Crossley et al. reveals that certain authors recommend to set up a PFPS diagnosis only in case of chondromalacia evidenced by arthroscopic tests and others only over 6º of foot-heel angle. Exclusion criteria also include a number of rarely mentioned factors, some of them worthy to be considered, such as systemic disease, pregnancy, medication, earlier physiotherapy, or wearing of orthosis.

It can be established that the definitions applied, the examination methods, and the population examined were not standardised in the four epidemiological surveys so far, therefore the prevalence values of the epidemiological test performed by us are not worth comparing with similar data in literature. The reason for this is that all authors but Witvrouw et al. used a definition different from the one applied by us - not even referring to PFPS (!). However, while Witvrouw et al. measured the incidence of the clinical pattern among the students of a single school in the course of a two-year longitudinal survey, we obtained information on the prevalence of the clinical pattern on the basis of a cross-sectional study. Whereas there is no other longitudinal study similar to the work of Witvrouw et al., based on an accurate definition, there is no cross-sectional study similar to ours, either. Therefore they can be considered as authoritative before other similar works are completed. Distribution by sexes was nearly identical in three studies.

In my survey I reviewed the impact of various selections of the time factor on the results of epidemiological studies. It was managed to be proved by comparative analysis that the requirement of complaints prevailing for at least six weeks was realistic in the definition provided by Witvrouw et al.

In our survey, there were significant discrepancies by sex between students’ main anatomical and biomechanical parameters, therefore differentiation by sex was applied further on. Girls with PFPS are older than the ones without any complaints, and there was a higher prevalence of PFPS with more active girls. Greater proportions of adolescent girls of a higher
age in the PFPS group is also probably interrelated with increased BMI as their height stagnates but their body weight continues to increase in this period.

Although the clinical pattern of PFPS is bilateral in most cases, we also came across unilateral manifestations in our material for research. Therefore it is justified to draw statistical conclusions for certain parameters on the number of knees rather than the number of students. In their works, Witvrouw, Thomée, and Fairbank et al. opted for a similar bilateral analysis. In our investigation, the proportion of bilateral complaints is higher than the measurements by both Thomée et al. and Witvrouw et al. (68.6%, 45.6%).

It was established as an unfortunate fact that nearly 40% of girls do not play any sports. The results indicated an obvious correlation between higher levels of sports activity and more frequent occurrences of PFPS, regardless of sex. This difference was most conspicuous in terms of students pursuing competitive sports and leisure sports, and students pursuing competitive sports and not pursuing any sports, respectively. Almost all of those completing epidemiological surveys on subjects of similar age recognise the role of overload; however, they still provide superficial information on the sports habits of students.

Besides patellofemoral pain in the PFPS group, students (as regards 227 PFPS knees) complained about crepitation in 62.11%; a subjective giving-way feeling in 10.57%; swelling in 13.66%; and stoppage in 14.98%. Significant differences were found between the results specified by other authors.

All in all, it can be established that if we come across pain localised to the anterior part of the knee without any injury, coupled with crepitation and symptoms have been present for at least 6 weeks, most probably a PFPS diagnosis can be established.

The 10 cm VAS measurements performed by us yielded results similar to those of Crossley. In the course of our survey, patients indicated the highest pain levels during walking on stairs from among the four monitored states. In his survey, Thomée found that the average pain level was somewhat higher than the levels measured by us.

The diagnostic criteria of PFPS often do not exclude the fact that patients with patellofemoral instability also be classified into the PFPS group. In my opinion, the deficiency of the PFPS definition used by Witvrouw is that patellofemoral instability and earlier patellar dislocation are not considered to be reasons for exclusion – although this did not appear as a significant problem in our survey. According to Dubs, surgical treatment of patellofemoral instabilities is effective, whereas that of PFPS is much less effective. Therefore the pain syndrome should be more sharply separated from patellofemoral instabilities, and the number of unjustified surgical interventions could be decreased on the basis of correct standardised diagnosis. Consequently, I classified patellar dislocation included in patient history among criteria for exclusion.

In the course of the physical examination, pain by direct pressure on the patella, and pain at knee extension against resistance (Zohlen sign) were disclosed for a total of 219 students. In his book, Strobel states that the Zohlen test in itself is not specific enough in terms of PFPS diagnostics. Similarly to Strobel, the conclusion can be drawn on the basis of our results that the Zohlen test is not suitable in itself for examining the patellofemoral joint due to significant pseudo-positivity.

One of the most important aims of our survey was to disclose any possible correlations between the axial discrepancies of the lower limb and PFPS. The results of our measurement methods are intended to be compared with similar values in literature.

Most authors have examined the role of the Q angle with regard to anterior knee pain. There are a number of methods known for measuring the Q angle: the person examined may stand or lie, the quadriceps muscle may be in tense or relaxed state, and the knee may be bent to different degrees. Based on our comparative measurement results yielded by two versions, it can be taken as proven that the circumstances of measuring the Q angle may influence the
results considerably, therefore the method of examination should always be indicated when describing the results. Examining the two sexes together, the occurrence of PFPS was found to be significantly greater at higher Q angles. In the course of analysis by sexes, a statistically significant difference was evidenced among boys only.

When examining lower limb asymmetry, a number of authors were able to provide evidence for sports injuries by overload. Similarly to the results of Milgrom et al. and Kannus et al., our examinations did not prove any statistically significant correlation between discrepancies of lower limb length and PFPS prevalence.

The alignment of the lower limb can only be accurately measured on the basis of standing X-ray shots recorded on long film. By calculating differences between the IM-IC distances measured, information can be obtained about the varus/valgus alignment. We followed the recommendation of Witvrouw et al. in the course of evaluation. If the IM-IC value exceeds 10 mm, there is a valgus alignment, and if the IC-IM value exceeds 10 mm, there is a varus alignment. In our survey, varus alignment with girls occurred as a significant PFPS risk factor. However, Neely describes it logically in his article that in the case of a varus alignment, the overstrain of the lateral retinaculum may lead to pains.

The influence of increased tibial rotation emerges in relation with sports injuries by overload. In the course of our measurements, our experience was that it was difficult to perform the examination; perhaps this is the reason why we did not find any similar measurement methods when reviewing the literature of PFPS. Consequently, we could not perform a comparative evaluation of our results due to the lack of similar data.

When examining the ratio referring to femur anteversion by age group, we did not find any significant differences between the PFPS and the control group, neither with girls, nor with boys.

As regards international PFPS literature, it is only Bergstrom who performed KT-1000 measurements on adolescents in the course of examining connections between knee complaints related to load and the associated pain. Similarly to us, he could not provide evidence for any correlations based on measurements on 45 students.

The foot-heel angle (LH angle) allows us to make inferences on foot pronation. Some authors assume, some of them discard the role of increased pronation in sports injuries by overload. We dismissed increased heel pronation as a risk factor in the population examined.

There are several measurement procedures for revealing main foot characteristics. One of the potential measurable parameters is the podogram, the instep index. Bruckner et al. used the foot length–width index in the course of their work, examining the structure of the foot in the function of age and body weight in case of women; they inferred to foot structure insufficiencies from the post-load increase of foot length – width values. Foot structure discrepancies are mentioned as a possible reason for knee pain in various research works. Our examination did not yield any evidence on significant differences between the two groups.

The Adidas footscan system was used for dynamic tests of foot structure. There are a number of tests in literature on measuring the dynamic characteristics of the knee joints of PFPS patients and on examining correlations of walk analysis results; however, none of the tests applied the Adidas footscan system for measurements. The results of our measurements indicated no difference whatsoever between patient and control groups in terms of the results of dynamic sole pressure measurements. Nevertheless, the measurements obviously indicate that the problem of deformities in the arch of the foot (pes planus, planovalgus, "flat foot") affects a considerable proportion of students.

While we could not disclose significant differences between the PFPS and the control group with instrumental tests, the foot structure of both groups being similarly bad, in the case of students suffering from PFPS we could see the development of localised pains on various parts of the foot (heel, dorsum of foot) more frequently. Similar results were yielded by
answers to the questions related to rapid exhaustion and spasm of the sole as well. Having
reviewed international literature, we did not find any similar detailed surveys to analyse PFPS
and subjective foot complaints. Nevertheless, the results yielded favourably correlate with
clinical experience, that is, the number of complaints localised to both the foot and the
anterior part of the knee can be decreased by applying proper arch support.

In the literature of PFPS, Alaca et al. published data on results of Hop tests performed
parallelly with isokinetic force measurements. While they concluded that the results of the
two measurements did not correlate, we experienced in the course of our examination that the
ratios of PFPS limb / both limbs assumed significantly lower values than the healthy limb / both limbs ratio during the Hop test and isokinetic measurements as well.

General hyperlaxity is frequently mentioned as a possible reason for strains and dislocations
and a lack of muscular flexibility as a potential reason for strains. Applying the Beighton-
score system, only one student was diagnosed with general hyperlaxity in our survey. Neither
Kannus et al. nor Nyttymaki found any correlations in the efficiency of the conservative
treatment of competitive and top sportsmen suffering from PFPS.

The Ely test was used for examining the flexibility of quadriceps femoris muscle. Girls in the
PFPS group presented significantly higher rates of occurrence as opposed to the control
group. According to Smith et al., the most frequent flexibility problem is posed by tied
quadriceps muscles, which can act as a predisposition factor for patellofemoral pain as well as
the saltatory and Osgood–Schlatter diseases. Jones et al. described both too tied and too lax
muscles as injury risk factors; Witvrouw et al. did not confirm this in their survey.

According to a number of studies, reduction of the movement range of the hip, the knee, and
the ankle, particularly the restriction of the dorsal flexion of the talocrural articulation may
lead to sports injuries by overload. Similarly to Thomeé’s research, our measurements did not
indicate differences in the movement ranges of the PFPS group and the control group, except
for external hip rotation.

In the schools surveyed by us, P.E. classes are generally held at open-air sports tracks.
Unfortunately, each of the sports tracks were covered by concrete or asphalt. A quarter of
students still use cheap, unhealthy gym shoes that used to be compulsory earlier, with thin
rubber sole and no proper support. The role of interaction between the cover of the sports
track and the shoes is frequently studied in relation with sports injuries by overload. In spite
of the controversial results of various studies, PFPS patients often report that a pair of new
high-quality shoes totally eliminated knee joint complaints. In Hungary today, school sports
tracks are not provided with modern plastic cover of proper quality, primarily for financial
reasons in my opinion. I deem it important to call the attention of competent officials at
national level that bodily exercise performed on non-compliant sports tracks may lead to long-
term knee joint complaints of as many as one third of students.

Handball is one of the popular and successful sports of our days. As general physician of the
women’s national handball team, I had the opportunity to observe that the nature of the game
has considerably changed over the past decade, having become quicker and more dynamic. As
a consequence, handball players present a massive number of knee complaints, including both
sports injuries and overload. At present, sportsmen do not afford sufficient time and energy to
maintain their muscular system, to maintain muscular balance, and do not perform proper
stretching and strengthening exercises. In my experience, proprioceptive training combined
with stretching may prevent sports accidents and may also be effective in the prevention of
sports injuries by overload.

A method taken over from Norwegian physiotherapist Mycklebust was introduced at the
women’s handball team of FTC-Herz one and a half years ago after modifications for
adaptation. In terms of introduction, the most difficult task was to convince the sports
management. However, our short-term experiences did away with nearly everybody’s doubts at the club. The number of lower limb injuries and overload cases has decreased to the minimum over the past one and a half years. In the history of the team, it was the first occasion in 8 years that there was no anterior cross ligament rupture for an entire handball season and the number of exterior heel injuries became negligible. In the team, the number of patellofemoral complaints was also reduced considerably as 70% of the knee joints of the sportswomen had been operated earlier on, therefore only a secondary PFPS diagnosis can be stated in their case. As the risk factors of primary PFPS include proprioceptive and muscular balance disorders as well as flexibility problems, the method introduced for top sportsmen may be beneficial for students as well. Due to positive experiences and minimum cost demands, I hereby propose to introduce this method, applied to a school environment, integrated to the material of P.E. classes - as the most effective opportunity for prevention known today.

6. CONCLUSION

After processing the data of 586 students, I arrived at the following conclusions based on the statements in my dissertation.

I. In the course of my research, it was proved that each epidemiological publication in international literature so far took as a basis a different definition of PFPS. Consequently, the results of these publications specify PFPS prevalence and incidence within a wide range. For all these reasons, their results are incomparable.

? The epidemiological data of studies so far were specified between 3.3 and 30%. Comparisons are made even more difficult by the fact that some studies focus on PFPS prevalence (cross-sectional studies), while others on PFPS incidence (longitudinal studies).

? In case of epidemiology-type surveys in literature, the authors used a different definition in each case. I stated that the diagnostic criteria of the clinical pattern were not standardised: even the same author used a different definition in two publications.

? There is an accurate description the PFPS diagnosis in literature. Earlier on, it was proven by scientific methods that the diagnosis described by Witvrouw et al. was properly specific and sensitive.

II. Besides a properly specified definition, it was possible to obviously decide on each member of the population examined whether they comply with PFPS diagnostics criteria. Due to this fact and the representativity of the sample, it became possible to determine PFPS prevalence in Hungarian adolescents between 13 and 19 years of age, amounting to 20.65%.

? When decreasing the time of continuance in the diagnostic criteria applied in my research, the value of PFPS prevalence produced a significant increase. Having raised the time of continuance to over six weeks, there was no longer any significant drop in prevalence levels.

? The 20.65% prevalence value indicates that I managed to explore the realistic occurrence of a considerable problem.

? The prevalence value used by me, arrived at by an extended definition, differs from those in earlier studies published in literature. Due to insufficient definitions applied earlier, the comparision of results cannot be interpreted.
III. Based on the study examining PFPS prevalence performed by me, being the first in international terms, I was the first to prove that PFPS occurs in equal proportions between girls and boys.

? I discarded the theory of PFPS as a dominantly female disease. I found the proportion of girls and boys to be nearly identical. PFPS prevalence is 20.41% for males and 20.89% for women.

? When examined in an age distribution, the age of girls suffering from PFPS is significantly higher.

IV. I proved that as regards girls, intrinsic risk factors include increased varus alignment, reduced quadriceps muscle strength, and a lack of flexibility (tied muscles) as the most important risk factors. As regards girls, greater body weight and increased sports activity levels jointly represent a significant risk factor. I demonstrated with my measurements that in the case of boys, increased Q angle and greater hip width represent significant intrinsic risk factors.

In the case of boys, I discarded the role of increased sports activities as a predisposition for PFPS. Regardless of sex, I found sports track cover to be the most significant factor of extrinsic risk factor.

? I proved that increased sports activity levels make girls and boys susceptible to PFPS.

? I did not find any significant differences between the PFPS and the control group – neither for girls, nor for boys – in terms of height, body weight, and the body mass index.

? Malalignments of the lower limb differ by sex as a PFPS risk factor. Girls were characterised by increased varus alignment, and boys by an increased Q angle.

? Complaints related to various forms of foot deformation are significantly more frequent in the PFPS group than in the control group for both sexes.

? Correlation between muscle imbalance disorders and PFPS was possible to prove only with girls. The Hop index, the quadriceps index, and the lack of flexibility (tied muscles) were all significantly lower in the PFPS group.

? I proved that only few of the risk factors of adolescent girls and boys form a common set. A common intrinsic risk factor is plaintive, pathological foot structure and a common extrinsic one is increased sports activity.

V. Varus alignment, a risk factor established for girls, can be evidenced by IM-IC measurements, even using a simple slide-gauge. The Ely test, a manual examination was used for flexibility. A simple tape-measure is required for completing the Hop test. For boys, the Q angle was measured by manual goniometer. I hereby state that the main risk factors can be surveyed with instruments of minimal cost demand.

? The Zohlen test – as a test applied in the course of patellofemoral pains – is not sufficiently specific; I found the proportion of pseudo-positive cases to be 16.7%.

? The examinations listed in section V should be performed to screen the risk factors evidenced by me. These simple, cheap, and reproducible measurements are suitable for screening tests and may play a role in primary PFPS prevention.

VI. I proved that the proprioceptive training programme modified by stretching exercises, earlier used for the prevention of LCA injuries, was effective for women handball players in terms of both primary and secondary PFPS prevalence.

? The preventive training program modified with our physiotherapists was introduced by me, never existed in Hungary before.
The method introduced and promoted by me has proved to be effective in PFPS prevention in the course of the past 18 months.

In the course of my epidemiology survey, having documented the recorded and measured parameters of the 586 students, I obtained a total of 86728 data. Such a large database provides almost “unlimited” opportunities for statistical analysis. It required thorough consideration and detailed studies of current literature to decide which parameters should be included in comparative analysis to obtain really valuable and new information. Naturally, I am aware of the fact that I could perform a number of further valuable statistical analyses using my database. As further analyses extend beyond the scope of my dissertation, they will be the subject of further scientific studies and articles.

6.1. Recommendation

Based on the result of my study, I propose that the modified, supplemented diagnostics criteria be used in a standardised manner.

Being aware of the high prevalence of PFPS, let me call the attention of P.E. teachers, trainers, and sports physicians involved with adolescents – and adolescents actively practising sports – that they should first think about the patellofemoral pain syndrome in case of non-injury based anterior knee pain.

I propose that risk factors specified by sex should increasingly be taken into consideration for the purposes of prevention, setting up an accurate diagnosis, and the introduction of proper treatment.

The risk factors evidenced by me can be easily measured; they are applicable in screening tests for primary prevention.

Being aware of the risk factors, I propose that thigh muscles should be regularly strengthened and stretched, and a muscular balance should be established, even among people not suffering from or not susceptible to PFPS.

The stretching proprioceptive training introduced by me and applied at top sportsmen is deemed to be suitable for the prevention of acute sports injuries and PFPS as well on the basis of favourable experiences; I recommend to include it in the curriculum.

7. SUMMARY

Most adolescent knee complaints are produced around the patella, the most frequent clinical pattern being the patellofemoral pain syndrome (PFPS). Our cross-sectional epidemiological study performed on 586 secondary school students was aimed to explore the prevalence of the patellofemoral pain syndrome. In order to improve the primary prevention of PFPS, its major intrinsic and extrinsic risk factors were disclosed. In a pilot study completed on top athletes, the impact of proprioceptive prevention training was analysed with regard to the incidence of PFPS and other injuries.

In the course of the epidemiological study completed on 586 students selected randomly – a study without any precedent in international terms and representative from the statistical point of view –, students were surveyed by various anthropometric, knee stability, and foot structure measurements besides taking physical tests and recording patient history. Data were entered in a previously prepared registration system and then analysed by parametric statistical methods.

In the course of statistical analysis, no discrepancies between the sexes could be shown in terms of PFPS prevalence. PFPS prevalence was (N=60) 20.41% for males and (N=61) 20.89% for females, representing 20.65% for the entire age group. Our study confirms the role of overload: significant correlations between PFPS prevalence and various levels of sports activity were proven by evidence. As regards intrinsic risk factors, evidence could be
provided on increased Q angles for males; and higher age, increased varus alignment, muscle balance disorders (extension/weakness of the quadriceps muscle), and higher levels of sports activity coupled with larger weight for females. Among intrinsic risk factors, only complaints related to foot deformities indicated significant correlations with higher PFPS prevalence in both sexes. Extrinsic risk factors included hard sports track cover in each case. All these facts support the theory that the establishment of clinical patterns is of multifactorial origin. Furthermore, perhaps the most important perception of the study is that the majority of these risk factors are non-specific.

Based on our survey experience and a review of literature, it is proposed in the case of PFPS that students should not overload their problematic joints and should avoid sitting for long periods of time triggering pain – e.g. with the knee flexed –, walking on stairs, and squatting. In agreement with Thomeé’s opinion, we see no reason for totally prohibiting PFPS patients from practising sports. Sports loads on the students with the risk factors differing by sex – as explored by us – may require training modifications. A well-designed customized training programme lead by a physiotherapist may form an important part of treatment besides modified sports activities.

As regards PFPS prevention, all attempts so far have been made to apply various arch supports, heel raisers, and patella fixers. Besides the treatment of various static deformations, our attempts were made to correct proprioceptive disorders as described in the literature, the intrinsic risk factor explored by us as well, and the lack of flexibility. A stretching proprioceptive prevention training method was introduced for a first-class women’s handball team 1.5 years ago. Earlier injuries were registered retrospectively; new injuries were recorded prospectively. Our initial short-term experiences are highly favourable: the injury prevention training method proved to be extremely effective in the prevention of LCA injuries, external ankle ligament injuries, and PFPS.

In our opinion, there is still a long way to go to fully understand the PFPS clinical pattern; further prospective, long-term follow-up examinations as well as basic research activities are required for collecting further information.
CONGRESS ORAL PRESENTATIONS

1. Tállay A.: Compart ment szindróma - sportolóknál, Fiatal Orvosok Fóruma, Agárd 1996
7. Tállay A., Halasi T., Pavlik A.: Foot Arch Deformities and Their Effect on the Knee Joint, PhD Hallgatók Nemzetközi Konferenciája, Miskolc 1999

CONGRESS ORAL PRESENTATIONS (as Co-Author)


POSTERS


Megjegyzés: Volt egy poszterdam dal FPFS-rol is tavaly Kecskeméten!!!
PUBLICATIONS


PUBLICATIONS (as Co-Author)