ULTRASOUND SCREENING OF PATELLAR TENDINOPATHY IN FEMALE FIELD HOCKEY ATHLETES
ULTRAZVUKOVÝ SKRÍNING PATELÁRNEJ TENDINOPATIE U HRÁČIEK POZEMNÉHO HOKEJA

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ABSTRAKT

Úvod: Dlhé obdobie rekonvalescencie a značné finančné náklady na rehabilitáciu a liečbu poukazujú na dôležitosť implementácie moderných stratégií prevencie športových úrazov kolenného kĺbu, jednou z ktorých je včasná diagnostika a identifikácia rizikovej skupiny.

Ciele: Zdôvodniť možnosť a účelnosť využitia ultrazvukového skríningu na včasnú detekciu patelárnej tendinopatie u športovcov.

Výskumná vzorka a metóda: Vyhľadávanie vedeckých zdrojov bolo realizované podľa výskumnej otázky vo formáte RISO. Štúdie sa zúčastnilo 16 vysokokvalifikovaných hráčiek pozemného hokeja. Ultrazvukový skríning kolenného kĺbu bol vykonaný na prístroji „Siemens Acuson 2000“ expertnej triedy pomocou dopplerografie.

Výsledky: Spomedzi vyšetrených športovcov boli príznaky patelárnej tendinopatie zistené u 6 osôb (37,5 % vyšetrených), z toho: 2 mali sťažnosti na bolesť lokalizovanú na dolnom póle pately a 4 boli bez bolesti. Medzi príznakmi patelárnej tendinopatie boli zistené: zhrubnutie patelárneho väziva a heterogenita jeho štruktúry. Pri skríningu stavu kolenného kĺbu u hráčiek hokejovej reprezentácie sme identifikovali rizikovú skupinu pre vznik patelárnej tendinopatie, ktorá predstavovala 25 % z počtu vyšetrených. To potvrdzuje údaje iných vedcov, že pomocou ultrazvukového vyšetrenia je možné zistiť ultrazvukové abnormality patelárnej šľachy u asymptomatických športovcov.

Závery: U vysokokvalifikovaných športovcov považujeme za účelné vykonať ultrazvukový skríning patelárnej tendinopatie. Výhoda takéhoto skríningu oproti iným vizuálnym metódam spočíva v jeho nízkej cene, rýchlosti vyšetrenia a možnosti výskumu v miestach tréningu športovcov.

Kľúčové slová: Kolenný kĺb, Patelárne väzivo, Úraz, Prevencia, Ultrazvukové vyšetrenie.

ABSTRACT

Theoretical background: A long recovery period and significant financial costs for rehabilitation and treatment indicate the importance of implementing modern strategies for the prevention of sports-related knee injuries, one of which is timely diagnosis and identification of the risk group.

Objectives: To substantiate the possibility and feasibility of using ultrasound screening for the timely detection of patellar tendinopathy in athletes.

Research sample and method: The search for scientific sources was carried out according to the research question in the PICO format. The study involved 16 highly skilled field hockey players. Ultrasound screening of the knee joint was performed on an expert-class «Siemens Acuson 2000» device with the use of Doppler.

Results: Among the examined athletes, signs of patellar tendinopathy were detected in 6 people (37.5% of the number of subjects), of whom: 2 had complaints of pain in the lower pole of the patella, 4 had no pain. The following signs of patellar tendinopathy were found: thickening of the patellar ligament and heterogeneity of its structure.

During the screening of the knee joint among the players of the hockey team, we identified a risk group for the development of patellar tendinopathy, which amounted to 25 % of the number of subjects. This confirms the data of other scientists that ultrasound examination can detect ultrasound abnormalities of the patellar tendon among asymptomatic sports players.

Conclusions: We consider it advisable to conduct ultrasound screening for patellar tendinopathy in highly skilled athletes. The advantage of such screening compared to other visual methods is its low cost, speed of examination and the possibility of research in places of training of athletes.

Key words: Knee joint, Patellar ligament, Injury, Prevention, Ultrasound examination.

INTRODUCTION

Tendinopathy as a condition of the musculoskeletal system is characterized by degenerative changes, often combined with pain during movement and a general decrease in motor function. Tendinopathy is mainly diagnosed in the ankle, knee, hip, shoulder and elbow joints. Patellar tendinopathy (PT) is a source of pain in the lower pole of the patella. The pain increases with exertion of the knee extensor muscles, especially during sports activities that store and release energy in the patellar tendon (Aicale et al., 2020; Swinton et al., 2023). Patellar tendinopathy occurs primarily in athletes aged 15 – 30 years, especially men who play sports such as basketball, volleyball, track and field, tennis, and soccer. The prevalence of this disease among elite

volleyball and basketball players has been found to exceed 40 % (Emery et al., 2019; Nutarelli et al., 2023).

The majority of athletes with patellar tendinopathy present to doctors with a complaint of pain localized to the anterior part of the knee, which often increases during exercise or sometimes due to prolonged knee flexion. But, in many cases, the pain can start unexpectedly and patients often associate the pain with a period of increased sports activity and do not seek medical attention (Malliaras et al., 2013). It should be noted that even severe tendinopathies can be asymptomatic (without pain and motor dysfunction) for a long period of time before clinical signs appear. This leads to the progression of tendinopathy, which is accompanied by a decrease in sports performance and an increase in the number of injuries in athletes. In addition, untimely diagnosis and late treatment increases both the duration and financial costs of treatment and rehabilitation (Abat et al., 2017; Burton, 2021).

High rates of injury, long recovery periods, and significant financial costs for rehabilitation and treatment indicate the importance of implementing modern strategies to prevent knee injuries, one of which is timely diagnosis and identification of the risk group. Among the methods of examination, one can distinguish both questionnaires (Visentini et al., 1998; Yezhova et al., 2021) and instrumental research methods (Malliaras et al., 2015). Due to the fact that questionnaires are more based on pain, which may be absent in the early stages of tendinopathies, visual methods of examination are of practical interest.

AIM

To substantiate the possibility and feasibility of using ultrasound screening for the timely detection of patellar tendinopathy in athletes.

RESEARCH SAMPLE

The inclusion criteria for ultrasound screening were: same sex, same playing sport, high level of sports training, age 18 – 25 years, sports experience of at least 8 years, significant physical activity during the last year, training loads should be the same in volume and intensity. These criteria were met by players who train together as a team, which limits the possible number of participants in the study.

The study was conducted in October 2023. The study involved 16 players of the women's field hockey team. The average age of the players was 20.8 years, with 11.2 years of sports experience. All players had high physical activity during the year (daily training for 2 – 2.5 hours, one day off per week, during 4 training camps per year – twice a day).

All participants provided informed consent (form of primary accounting documentation No. 003-6/o) for the study in accordance with the international principles of the Helsinki Declaration of the World Medical Association (2013) and the Law of Ukraine «Fundamentals of Ukrainian Health Care Legislation» (1992).

METHODOLOGY

To conduct the study, a research question was posed in the PICO format: the population (P) of the study is athletes, the interventions (I) consist of methods for diagnosing patellar tendinopathy, the method of ultrasound examination was chosen for comparison (C), and the result (R) is the diagnostic signs of patellar tendinopathy (Höhne E. et al., 2022). Thus, the formulated research question is: «Is it possible to detect signs of patellar tendinopathy in athletes using ultrasound?»

The search for scientific sources was carried out in the Scopus database for the last 10 years (2014 – 2024). In accordance with the PICO format, the leading search term was «tendinopathy», and 5095 documents were found. When the search was refined with the term «diagnostics» – 1375 sources, «ultrasound method» – 320, «athletes» – 35.

To narrow down the search field, we selected full-text articles that are freely available and are related to systematic reviews and meta-analysis (Filters applied: Free full text, Meta-Analysis, Systematic Review, in the last 5 years). A list of 27 scientific sources was obtained, which were analyzed to justify the start of the study and to discuss the results.

Ultrasound screening of the knee joint was performed on an expert-class «Siemens Acuson 2000» apparatus with the use of Dopplerography. The examination and description of the results was carried out by a ultrasound technician. The conclusion was discussed by an ultrasound specialist, orthopedist and a physical therapist.

Data in the tables are presented as Mean ± Standard Error of the Mean (SEM). The significance of the difference was assessed using the Wilcoxon-Mann-Whitney test. The level of statistical signifi-

Table 1 Baseline characteristics of participants

Characteristic	Baseline±SEM n = 16	G1 Baseline±SEM n = 10	G2 Baseline±SEM n = 6	Wilcoxon-Mann-Whitney test
Age, years	20,8 ± 0,34	20,72 ± 0,42	21,17 ± 1,05	0,3; p≥0,05
Sports experience, years	11,2 ± 0,99	10,83 ± 0,42	12,33 ± 0,42	2,51; p≤0,05
Height, cm	164,6 ± 5,60	163,61 ± 1,07	167,67 ± 1,96	1,57; p≥0,05
Weight, kg	61,5 ± 14,40	59,39 ± 1,11	67,67 ± 1,59	2,96; p≤0,05
Body Mass Index	22,7 ± 0,40	22,22 ± 0,46	24,10 ± 0,55	2,17; p≤0,05

Table 2 Ultrasound parameters of two groups of field hockey athletes

Characteristic	G1 Baseline±SEM n = 10	G2 Baseline±SEM n = 6	Δ value
Ultrasound tendon thickness, mm	4,8 ± 0,26	6,5 ± 0,34	1,7
Presence of hyperechogenic inclusions	–	+	

cance was set at $p \leq 0.05$. Statistical analysis was performed using STATISTICA 6.0.

RESEARCH RESULTS

An ultrasound examination revealed 6 female field hockey athletes with signs of patellar tendinopathy. Therefore, we formed 2 groups of female athletes: Group 1 (G1) – no signs of patellar tendinopathy, Group 2 (G2) – signs of patellar tendinopathy. The characteristics of the study participants are shown in Table 1.

The analysis of the main characteristics of the two study groups suggests that female field hockey athletes with signs of patellar tendinopathy (G2) have significantly higher body weight and, accordingly, Body Mass Index (BMI) compared to athletes from G1. In addition, athletes from G2 have a longer sports experience (Table 1).

Among the examined athletes, ultrasound revealed signs of patellar tendinopathy in 6 people (37.5 % of the number of subjects), of whom 2 had complaints of pain in the lower pole of the patella, and 4 had no pain.

The main characteristics of visual changes in patellar tendinopathy are shown in Table 2.

Among the leading morphological signs of patellar tendinopathy, we found an increase in the thickness of the patellar ligament (on average by 1,7 mm) and the appearance of hyperechogenic inclusions by ultrasound (Table 2). Due to the fact that pain was detected only in 33.3 % of female athletes of group 2, the average values of pain during physical activity can be disregarded. For the rehabilitation of female athletes of this group, it is necessary to apply a patient-oriented approach and develop individual physical therapy programmes.

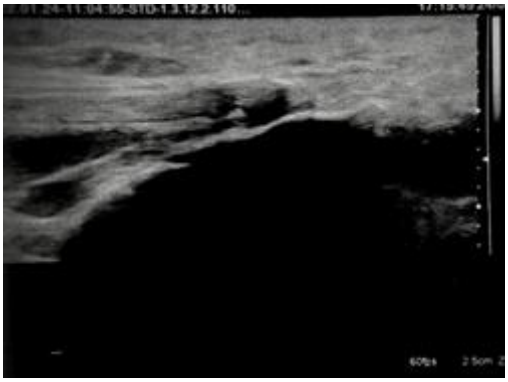

Figure 1 Localized tendinitis of the patellar tendon

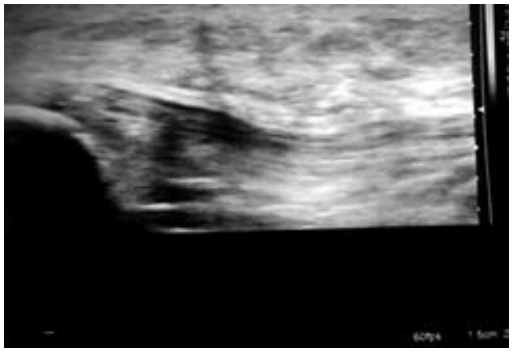

Figure 2 Enthesopathy of the patella's own ligament

Figure 3 Signs of patellar tendinopathy in an asymptomatic case

For example, we present the results of ultrasound screening of the knee joint in female athletes with pain (Fig. 1, 2) and without pain (Fig. 3), which was performed on an expert-class «Siemens Acuson 2000» apparatus using Dopplerography.

In the case of Fig. 1, the athlete complained of moderate pain after exercise and during the ultrasound examination, pain appeared when compressed by the transducer. The examination revealed a thickening of the patellar ligament up to 7 mm, edema; in a 20 mm long section closer to the site of attachment to the tibia, a heterogeneous structure of the ligament was found due to the presence of single anechogenic inclusions up to 1.3 mm in diameter. The patellar ligament itself is hypervascularized. There are hyperechogenic inclusions up to 2.8 mm along the upper contour of the patella, with smooth and clear contours, the integrity of the patella is not impaired.

Figure 2 shows a case with severe pain. There is a heterogeneous structure of the patellar ligament due to hyperechogenic inclusions up to 1.3 mm, the integrity of the ligament is not compromised. At the site of attachment to the patella, there are larger hyperechogenic inclusions up to 2.1x1.8 mm. The integrity of the patella is not impaired; its position is normal.

In the asymptomatic patellar tendinopathy (Fig. 3), a heterogeneous structure of the patellar ligament due to hyperechogenic inclusions up to 1.6 mm was also found closer to the site of attachment to the tibia. The integrity of the patella and ligament is not compromised. Despite the absence of complaints from the athlete, the ultrasound revealed one of the signs of patellar tendinopathy, which allows him to be included in the risk group.

The analysis of the results of ultrasound screening suggests that one of the main signs of patellar tendinopathy in asymptomatic athletes is the heterogeneity of the structure of the patellar ligament due to hyperechogenic inclusions of various sizes.

It should be noted that, according to anthropometric indicators, athletes of group 2 have higher weight and body mass index (BMI) (Table 1). In addition, they also have a longer sports experience.

DISCUSSION

In our study, female field hockey athletes from G2 have higher values in terms of sports experience, body weight and BMI. Similar data have been obtained by different researchers (Crossley et al., 2004; Zhang et al., 2017), but there are also opposite data. Thus, studies of the relationship between BMI and knee tendinopathy in athletes are quite controversial. As noted by Deng et al. (2022) in their systematic review and meta-analysis, there are studies that have found a link between BMI and patellar tendinopathy, but these studies are of varying levels of evidence. Therefore, additional studies are needed to demonstrate conclusive evidence of this relationship.

The study was conducted to identify a risk group for sports-related knee injuries and to take further preventive measures. The significant differences in body weight, BMI and sports experience between G1 and G2 athletes suggest that these indicators can be considered as criteria for including an athlete in the risk group for the development of PT. In this case, it is possible to selectively examine female athletes in the risk group to prevent the development of patellar tendinopathy.

However, there are few studies that focus on preventing the development of patellar tendinopathy. In addition, there is no generally accepted system for diagnosing ligament and tendon pathology (Knapik et al., 2020). Analysis of scientific studies suggests that the VISA-P questionnaire, functional tests, and instrumental visual methods such as radiography, magnetic resonance imaging (MRI), computed tomography (CT), and ultrasound are most commonly used to diagnose tendinopathy. MRI is considered a more accurate diagnostic method than conventional radiography or CT. Some scientists believe that ultrasound is the most accurate method for diagnosing tendinopathies (Albano et al., 2021; Sharif et al., 2023). This method can detect thickening of the ligament/tendon. Some prefer MRI, due to the fact that MRI data can determine the presence of other joint diseases (Brushøj et al., 2006).

According to scientific sources, ultrasound can detect ultrasound abnormalities of the patellar ligament among asymptomatic athletes in playing sports, as well as athletes (Sánchez Romero et al., 2020; Burton, 2021). Indeed, when screening the knee joint among players of a hockey team, we identified a risk group for the development of tendinopathy among athletes, which amounted to 25% of the number of subjects.

Ultrasound examination is the most common examination of ligaments/tendons and, as noted Cook et al., 2016, reveals three main features of the tendon in tendinopathy:

- increased ligament/tendon thickness due to changes in the number and type of ligament/tendon tissue cells
- hypoechogenicity of tendon tissue due to a change in the type of collagen fibers from type I in healthy ligaments/tendons to type II and III in pathological ligaments/tendons.
- neovascularization is associated with areas of hypoechogenicity and is an increase in blood vessels in the area near the ligament/tendon.

Thickening of the tendon provokes an increase in synovial fluid, which subsequently leads to an increase in the size of the tendons. According to some authors, ligament/tendon thickness is indeed moderately correlated with pain, so it is considered an indirect indicator of treatment outcome (McNeilly et al., 1996; Swinton et al., 2023). Hypoechoic tendon tissue is caused by disorganization of collagen fibers. The initial stage of tendinopathy presents small focal areas of hypoechogenicity interrupted by normal ligament/tendon tissue, while in the worst cases, entire ligament/tendon areas have this type of change. Neovascularization is identified using color or energy Doppler. These techniques show a greater number of blood vessels in the case of tendon tissue changes (Del Baño-Aledo et al., 2017).

Thus, the detected structural disorganization of the ligament/tendon may not be associated with pain symptoms, but it allows to identify a risk group for the development and implementation of preventive programs.

Musculoskeletal ultrasound is increasingly being used in rehabilitation services to assess soft tissue structures in both research and clinical settings to inform rehabilitation decisions. The advantage is that it can be performed quickly, non-invasively, the ultrasound machine can be portable and relatively inexpensive, and it is easy to use for routine assessment of tendinopathy in clinical practice. It should be noted that atrophy, decreased strength, improper foot placement, insufficient flexibility of the thigh and hamstring muscles, and decreased rear flexion of the foot may also be associated with patellar tendinopathy, and the detection of these signs strengthens the evidence for the onset of patellar tendinopathy and the need for urgent prevention to stabilize and improve the condition of the knee joint.

CONCLUSIONS

Given the results of our study, we consider it appropriate to conduct ultrasound screening for patellar tendinopathy in female athletes who have been playing field hockey for more than 11 – 12 years and have a body mass index of more than 23. The advantage of ultrasound for screening compared to other visual methods is its low cost, speed of examination and the possibility of examination in the places of training of athletes.

Individual physical therapy programmes have been developed for athletes with patellar tendinopathy, and a preventive programme for the field hockey team to prevent knee injuries. Since patellar tendinopathy is caused by a combination of factors, the prevention programme is based on the control of specific exercises and movements by coaches, the inclusion of recommended therapeutic exercises, especially strength exercises, and the correct selection of sports shoes. Further studies are planned to investigate the results of the implementation of this prevention programme.

REFERENCES

ABAT F., ALFREDSON H., CUCCHIARINI M. et al. Current trends in tendinopathy: consensus of the ESSKA basic science committee. Part I: biology, biomechanics, anatomy and an exercise-based approach. *J Exp Orthop.* 2017; 4 (1): 18.

AICALE R., OLIVIERO A., MAFFULLI N. Management of Achilles and patellar tendinopathy: what we know, what we can do. *J Foot Ankle Res*. 2020;13 (1): 59.

ALBANO D., COPPOLA A., GITTO S. et al. Imaging of calcific tendinopathy around the shoulder: usual and unusual presentations and common pitfalls. *Radiol Med*. 2021; 126 (4): 608-619.

BRUSHØJ C., HENRIKSEN B.M., ALBRECHT-BESTE E. et al. Reproducibility of ultrasound and magnetic resonance imaging measurements of tendon size. *Acta Radiol*. 2006; 47 (9): 954-959.

BURTON I. Autoregulation in Resistance Training for Lower Limb Tendinopathy: A Potential Method for Addressing Individual Factors, Intervention Issues, and Inadequate Outcomes. *Front Physiol*. 2021; 12: 704306.

COOK J.L., RIO E., PURDAM C.R. et al. Revisiting the continuum model of tendon pathology:

what is its merit in clinical practice and research? *Br J Sports Med*. 2016; 50 (19): 1187-1191.

CROSSLEY K.M., BENNELL K.L., COWAN S.M. et al. Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? *Arch Phys Med Rehabil*. 2004; 85 (5): 815-822.

DEL BAÑO-ALEDO M.E., MARTÍNEZ-PAYÁ J. J., RÍOS-DÍAZ J. et al. Ultrasound measures of tendon thickness: Intra-rater, Inter-rater and Inter-machine reliability. *Muscles Ligaments Tendons J*. 2017; 7 (1): 192-199.

DENG M., MANSFIELD M. Association between Body Weight and Body Mass Index and Patellar Tendinopathy in Elite Basketball and Volleyball Players, a Systematic Review and Meta-Analysis. *Healthcare (Basel)*. 2022; 10 (10): 1928.

EMERY C.A., PASANEN K. Current trends in sport injury prevention. *Best Pract Res Clin Rheumatol*. 2019; 33 (1): 3-15.

HÖHNE E., RECKER F., DIETRICH C.F. et al. Assessment Methods in Medical Ultrasound Education. *Front Med (Lausanne).* 2022; 9: 871957.

KNAPIK J.J., POPE R. Achilles Tendinopathy: Pathophysiology, Epidemiology, Diagnosis, Treatment, Prevention, and Screening. *J Spec Oper Med*. 2020; 20 (1): 125-140.

LAW OF UKRAINE. Fundamentals of the Legislation of Ukraine on Health Care. No. 2801-XII [Internet], November 19. 1992 [cited May 17, 2024] (Ukraine). Available at: https://zakon.rada.gov.ua/laws/show/2801-12#Text.

MALLIARAS P., BARTON C.J., REEVES N.D. et al. Achilles and patellar tendinopathy loading programmes: a systematic review comparing clinical outcomes and identifying potential mechanisms for effectiveness. *Sports Med*. 2013; 43 (4): 267-286.

MALLIARAS P., COOK J., PURDAM C. et al. Patellar Tendinopathy: Clinical Diagnosis, Load Management, and Advice for Challenging Case Presentations. *J Orthop Sports Phys Ther*. 2015; 45 (11): 887-898.

McNEILLY C.M., BANES A.J., BENJAMIN M. et al. Tendon cells in vivo form a three dimensional network of cell processes linked by gap junctions [published correction appears in J Anat 1997 Apr;190(Pt 3):477-8]. *J Anat*. 1996; 189 (Pt 3): 593-600.

NUTARELLI S., da LODI C.M.T., COOK J.L. Epidemiology of Patellar Tendinopathy in Athletes and the General Population: A Systematic Review and Meta-analysis. *Orthop J Sports Med*. 2023; 11 (6): 23259671231173659.

SÁNCHEZ ROMERO E.A., POLLET J., MARTÍN PÉREZ S. et al. Lower Limb Tendinopathy Tissue Changes Assessed through Ultrasound: A Narrative Review. *Medicina (Kaunas)*. 2020; 56 (8): 378.

SHARIF F., AHMAD A., SHABBIR A. Does the ultrasound imaging predict lower limb tendinopathy in athletes: a systematic review. *BMC Med Imaging*. 2023; 23 (1): 217.

SWINTON P.A., SHIM J.S.C., PAVLOVA A.V. et al. What are small, medium and large effect sizes for exercise treatments of tendinopathy. A systematic review and meta-analysis. *BMJ Open Sport & Exercise Medicine*. 2023; 9 (1) : e001389.

VISENTINI P.J., KHAN K.M., COOK J.L. et al. The VISA score: an index of severity of symptoms in patients with jumper's knee (patellar tendinosis). Victorian Institute of Sport Tendon Study Group. *J Sci Med Sport*. 1998; 1 (1): 22-28.

WORLD MEDICAL ASSOCIATION. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*. 2013; 310 (20): 2191-2194.

YEZHOVA O., STEPANENKO O., BUIVALO V. et al. Adaptation of the VISA-P Scale for Ukrainian-speaking Patients with Patellar Tendinopathy and Its Reliability. *Physical Education, Sport and Health Culture in Modern Society*. 2021; 2 (54): 120-125.

ZHANG Z.J., NG G.Y.F., LEE W.C., FU S.N. Increase in passive muscle tension of the quadriceps muscle heads in jumping athletes with patellar tendinopathy. *Scand J Med Sci Sports*. 2017; 27 (10): 1099-1104.