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Original research

Factors associated with the presence of patellar tendon abnormalities in male athletes

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ABSTRACT

Objectives: To investigate the association between lower limb alignment, range of motion/flexibility and muscle strength with the presence of patellar tendon abnormalities in male athletes.
Design: This was a cross-sectional study.
Methods: Thirty-one male basketball and volleyball athletes were assessed for ankle dorsiflexion range of motion, shank-forefoot alignment, iliotibial band flexibility, hip external rotators and abductors isometric torque, passive hip internal rotation range of motion and frontal plane knee and patellar alignment (McConnell and Arno angles). Ultrasonographic evaluations of hypoechoic areas of the patellar tendons were performed in longitudinal and transverse planes. A receiver operating characteristic curve was used to determine clinically relevant cut-off point for each variable. When the area under the curve was statistically significant, Prevalence Ratio (PR) and 95% confidence intervals were calculated to indicate the strength of the association between the independent variable and the presence of patellar tendon abnormalities.
Results: Receiver operating characteristic curve showed that iliotibial band flexibility ($p = 0.006$), shank-forefoot alignment ($p = 0.013$) and Arno angle ($p = 0.046$) were associated with patellar tendon abnormalities. Cut-off points were established and only the Prevalence Ratio of iliotibial band flexibility (cut-off point = –0.02°/kg; PR = 5.26) and shank-forefoot alignment (cut-off point = 24°; PR = 4.42) were statistically significant.
Conclusions: Athletes with iliotibial band or shank-forefoot alignment above the clinically relevant cut-off point had more chance to have patellar tendon abnormalities compared to athletes under the cut-off point values. These results suggest that such factors could contribute to patellar tendon overload, since patellar tendon abnormalities indicate some level of tissue damage. Both factors might be considered in future prospective studies.

1. Introduction

Sport modalities that include jumping and landing actions may result in overload of the patellar tendon.[1–3] The presence of ultrasonographically identified patellar tendon morphological changes are commonly associated with patellar tendon pain and dysfunction (i.e. injuries or symptoms that required time off from training and/or decreased performance) and have often been found to be indicative of tissue damage.[4–6] Interestingly, Cook et al.[7] reported that 22% of the athletes that had patellar tendon abnormalities (PTA) on ultrasound had no clinical symptoms. Although these athletes have no symptoms, they may still have tissue damage and the potential to develop chronic dysfunction and eventually tendon rupture, especially considering elite athletes with high training load[4,6] Therefore, it is suggested that in the presence of PTA, even in the absence of symptoms, an athlete should receive proper attention by the team's medical staff.[1,3] Thus, lower limb related factors that may affect jumping and running actions and could lead to patellar tendon overloading should be investigated, even in the absence of symptoms.

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Tendon overload depends on the amount of stress applied to the musculoskeletal system and how much stress the musculoskeletal system can tolerate.[8,9] Factors related to landing pattern (i.e. foot alignment, passive hip stiffness) could be involved in the mechanism of development of this condition.[10–12] According to this perspective, landing requires adequate capability of the musculoskeletal system (i.e. proper strength and stiffness) to deal with ground reaction forces.[11,12] The knee, as an intermediate joint in the kinetic chain, depends on the mechanical behavior of hip and ankle to mitigate and properly distribute forces imposed to the lower limbs during landing (specially considering the presence of proper lower limb alignment).[10,13] Forces that act on the knee joint could stress specific portions of the patellar tendon, interfere with the capability of tissue remodeling and promote a degenerative process. Increased varus foot alignment [12–14] and limited ankle dorsiflexion,[15] for example, can promote excessive pronation of the foot in landing and predispose tibial internal rotation and increased patellar tendon tension. Moreover, excessive tibial internal rotation can induce femur internal rotation, enhance patellar and knee misalignment and patellar tendon tension.[14] Adequate hip external rotators strength and proper stiffness could control this excessive lower limb internal rotation and minimize patellar tendon overload.[12] Therefore, factors related to load transfer and dissipation mechanisms during landing could be associated to the development of patellar tendon abnormalities identified via ultrasound (i.e. hypoechoic areas).

Injury prevention in jumping sports requires measures to avoid excessive load of the patellar tendon that, in turn, could interfere with the athletes' performance and compromise their career. Identification of factors associated with the process of tendon damage could support the development of appropriate strategies to prevent such injuries. Thus, the purpose of this study was to investigate the association between lower limb alignment, range of motion/flexibility and muscle strength with patellar tendon morphological abnormalities in male basketball and volleyball athletes.

2. Methods

This cross-sectional study included 18 volleyball and 13 basketball elite male athletes recruited from two sport teams that participated in a preseason assessment. All athletes had to be able to fully participate in their team's activities and could not have history of lower limb surgery and/or undergo to rehabilitation protocol related to other knee problems (assessed by questionnaire applied to the athlete and sports team physical therapist) in the prior 6 months of the assessment. The University's Ethics in Research Committee approved the study's procedures (Approval Report number 0493.0.203.000-09) and all participants signed an informed consent.

Initially, a total of 48 athletes (without another knee injury) were assessed during preseason evaluation and were invited to undergo ultrasound evaluation of the patellar tendon of both lower limbs. Athletes that had signs of knee pathologies not related to the patellar tendon or missed any part of the preseason assessment were excluded from the study. Forty-three athletes attended to ultrasound exam (due to personal problems, five athletes were not available for the US examination and were not included in the study), in which four basketball athletes were identified with Osgood-Schlatter disease and were excluded.[15] Eight athletes were excluded due to incomplete preseason assessment data. VISA-P (*Victoria Institute of Sport Assessment*) questionnaire was collected in all athletes for characterization of patellar tendon pain and dysfunction.[16]

Examiners with at least 5 years of experience in preseason assessments and good results in the reliability analysis of the study's measures performed all the tests. The measures were collected as part of this study and preseason assessments on both legs, in the following sequence: shank-forefoot alignment (SFA), ankle dorsiflexion range of motion (ROM), iliotibial band flexibility, passive hip internal rotation (IR) ROM, frontal plane patellar alignment and frontal plane knee projection angle, hip external rotators (ER) and abductors isometric strength.

SFA was measured with the athlete in prone with the foot off the treatment table. The shank was bisected and a metal rod was placed with a strap on the forefoot for photographic record (Fig. 1a), according to Mendonça et al.[13] Three photos of each foot were taken and the measurement of the intersection between shank bisection and forefoot inclination (represented by the metal rod) were performed in a two-dimensional analysis software (Simi Motion Twinner® – Fig. 1b) to determine the mean angle for SFA (intra-rater Intraclass Correlation Coefficient $(ICC)_{3,3} = 0.93$; Standard Error of Measurement (SEM) = 2.47°; Minimal Detectable Difference (MDD) = 6.82°).[13] Negative values were assigned to valgus SFA and positive values to varus SFA.

To assess ankle dorsiflexion ROM the athlete was positioned facing a wall and was instructed to move the knee toward a vertical line drawn on the wall without removing the heel off the floor as described by Bennell et al.[17] Ankle dorsiflexion was measured using an inclinometer positioned 15 centimeters from the tibial tuberosity (Starrett®). This measure was performed three times on each leg and the average was considered for analysis (intra-rater $ICC_{3,3} = 0.98$; SEM = 0.04°; MDD = 0.11°).

Iliotibial band flexibility was measured with the participant in side lying. The examiner performed the modified Ober test protocol described by Reese and Bandy[18] (Fig. 1c). Measures were taken with an inclinometer (Starrett®) positioned proximal do lateral femoral condyle. The examiner performed passive joint motions to produce tissues' viscoelastic accommodation. Three measures of each leg were obtained (intra-rater $ICC_{3,3} = 0.99$; SEM = 0.0001°/kg; MDD = 0.0004°/kg). The mean was normalized by body mass (degrees/kg). Positive values were assigned to hip abduction (indicative of iliotibial band less flexible) and negative values to hip adduction (indicative of a iliotibial band more flexible).

To assess hip ER and abductors isometric strength the examiner used a handheld dynamometer (microFET2; Hoggan Health Industries, Inc., West Jordan, UT). For hip abductors assessment, the dynamometer was positioned proximal to the knee joint following the protocol described by Bittencourt et al.[12] (intra-rater $ICC_{3,3} = 0.94$; SEM = 0.08 N m/kg; MDD = 0.22 N m/kg). For hip ER strength measurement, the handheld dynamometer was placed proximally to the medial malleolus with the athlete in the prone position and 90° of knee flexion[19] (intra-rater $ICC_{3,3} = 0.98$; SEM = 0.04 N m/kg; MDD = 0.11 N m/kg). The same protocol of abductors test was used, except that we performed a progressive contraction to avoid excessive compensatory movements (i.e. trunk and pelvis rotation, and hip adduction) that could add bias to the test. Muscle torque was calculated as the product between the mean of three strength measures and the distance from the location of the dynamometer to the greater trochanter (for abductors test) and from the femoral condyles (for external rotators test). Torque values were normalized by body mass (N m/kg).

Passive hip IR ROM was assessed with the participant positioned in prone with 90° of knee flexion and the pelvis stabilized by a strap using the protocol described by Carvalhais et al.[20] The passive movement of hip internal rotation, produced by the weight of the leg and foot of the athlete, was allowed until passive structures and hip muscular tension stopped this movement. Therefore, passive hip IR ROM test is inversely related to hip external rotators passive stiffness.[20] Initially, the examiner performed passive joint motions to produce tissue's viscoelastic accommodation. Three measures