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Original paper

The ultrasound appearance of the patellar tendon attachment to the tibia in young athletes is conditional on gender and pubertal stage

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Abstract

This cross-sectional study investigated the imaging appearance of the patellar tendon attachment to the tibia in young male and female tennis players of different ages and pubertal status. Forty-four competitive young players, who had been playing tennis at least for 2 years, were recruited from a tennis school and local tennis clubs. All subjects had bilateral ultrasound imaging of the patellar tendon attachment to the tibia. Standard anthropometric measurements, pubertal status and injury history were recorded. Ultrasound appearance of the patellar tendon attachment was categorised into three stages: cartilage attachment, insertional cartilage and mature attachment. Cartilage attachment was more prevalent in boys (32%) and extended further into puberty (until Tanner stage 4) compared to girls (6% and Tanner stage 1). Tendons with Osgood–Schlatter Disease symptoms ($n = 3$) did not have a cartilage attachment. Imaging appearance commonly seen in young active athletes, consistent with a clinical diagnosis of OSD, was more common in boys and in the pre- and peri-pubertal stages.

Keywords: Patellar tendon; Puberty; Tennis; Osgood–Schlatter disease; Growth spurt; Ultrasonography

1. Introduction

The patellar tendon attachment to the tibia can cause pain that restricts physical activity in active adolescents (Osgood–Schlatter disease (OSD)). Imaging techniques (X-rays, ultrasound, magnetic resonance imaging (MRI) and computed tomography) have been used to assess the clinical presentation of OSD. Changes defined as abnormal have been documented radiographically to transition from irregularity of the apophysis to fragmentation in the later stages.[1] Sonographically and on MRI, structural differences between those with and without OSD have been reported.[2]

Longitudinal studies have categorised the stages of both normal development and OSD. Hirano et al. staged (five stages) the progress of OSD on MRI from normal through to terminal and then healing.[3] The presence of separated ossicles has been reported to be both indicative of OSD[4] and to be part of the normal developmental process.[5]

To investigate whether the imaging appearance is indicative of OSD or normal tendon development, we examined the patellar tendon attachment in a group of young athletes at various stages of puberty. This study aimed to report the relationship between the imaging appearance and age and gender. This study may lead to a better understanding of the appearance of the patellar tendon attachment in young athletes.

2. Methods

Students in the tennis program at a specialist sports school and from local tennis clubs were enrolled in the study and

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Table 1
Age, height and weight (mean ± S.E. (range)) and pubertal status of boys and girls.

	Boys ($n = 28$)		
	Pre-pubertal ($n = 4$)	Peri-pubertal ($n = 21$)	Post-pubertal ($n = 3$)
Age (years)	12.2 ± 0.5 (10.9–13.1)	13.9 ± 0.3 (11.3–15.7)	16.7 ± 1.0 (14.7–18.2)
Height (cm)	144.1 ± 3.5 (135.5–152.4)	162.2 ± 2.1 (144.8–177.0)	179.0 ± 3.3 (174.3–185.4)
Weight (kg)	32.6 ± 1.5 (29.3–36.1)	51.8 ± 2.3 (35.1–76.0)	67.6 ± 3.7 (60.4–72.7)
	Girls ($n = 16$)		
	Pre-pubertal ($n = 2$)	Peri-pubertal ($n = 8$)	Post-pubertal ($n = 6$)
Age (years)	10.9 ± 0.3 (10.6–11.2)	12.7 ± 0.5[a] (10.6–14.9)	14.3 ± 0.5[a] (12.1–15.3)
Height (cm)	143.6 ± 4.7 (138.9–148.4)	157.6 ± 4.6 (143.2–179.8)	163.7 ± 4.1[a] (152.8–177.9)
Weight (kg)	31.8 ± 0.4 (31.4–32.3)	49.6 ± 3.0 (36.0–60.2)	56.2 ± 3.8 (46.4–70.4)

[a] Different from boys, $p < 0.05$.

underwent ultrasound evaluation of their patellar tendons. This group was chosen as they expose their patellar tendon to high loads through puberty. All participants' parents or guardians gave informed consent. The study was approved by the Deakin University ethics committee. The experiments conformed to the Statement of Human Experimentation by the National Health and Medical Research Council of Australia.

Standard demographic and anthropometric measures were taken. Body weight was measured to the nearest 0.1 kg with an electronic scale and standing and sitting heights were measured to the nearest 0.1 cm with a stadiometer.

Maturity was established by self-assessed Tanner staging (pubic hair and breast and testes development).[6] Pre-puberty was defined as Tanner stage 1, peri-puberty as Tanner stages 2–4 and post-puberty as Tanner stage 5. Girls who were in Tanner stage 4 and postmenarcheal were considered post-pubertal.

In addition to Tanner stages, an estimation of the age at peak height velocity (PHV) was obtained. This estimation is based on the fact that the acceleration in appendicular growth precedes the accelerated growth of the trunk that is concomitant to the growth spurt (or PHV). For each subject, a maturity offset indicating the number of years before or after his/her predicted age at PHV was calculated.[7]

The patellar tendon was imaged by an experienced musculoskeletal sonographer, blind to documented age and pubertal status. Images were obtained at both the proximal and distal insertions using a Philips ATL 5000 ultrasound machine with a 13 MHz linear probe (Philips Medical Systems, Bothell, WA). Each image was stored and then categorised on a three point scale, similar to that proposed by Grechenig et al.[8]: cartilage attachment (Fig. 1A and B), insertional cartilage (Fig. 1C) and mature attachment (Fig. 1D). Colour Doppler was used to assess vascularity in those with large hypoechogenic areas and/or ossification within the tendon.

History of knee pain and specific history of Osgood–Schlatter disease were recorded. Each participant was also examined by an experienced musculoskeletal physiotherapist to confirm the diagnosis. Injury history was not available for four participants.

One-way ANOVA was used to compare the age and maturity offset in tendons with different attachment sites (and Kruskal–Wallis for non-parametric data). Fisher's exact test examined the frequency of injury in each of the tendon categories.

3. Results

Twenty-eight boys and 16 girls aged between 10.6 and 18.2 years were included in the study (Table 1). The median starting age of playing was 7.5 years in boys and 6.7 years in girls (range: 4.0–13.3 years). All subjects had been playing

Table 2
Tendon attachment (no. with Osgood–Schlatter Disease symptoms) and pubertal status in boys and girls.

	Boys ($n = 28$)		
	Pre-pubertal ($n = 4$)	Peri-pubertal ($n = 21$)	Post-pubertal ($n = 3$)
Cartilage	3	6	0
Insertional cartilage	1	12 (2)	1
Mature attachment	0	3	2
	Girls ($n = 16$)		
	Pre-pubertal ($n = 2$)	Peri-pubertal ($n = 8$)	Post-pubertal ($n = 6$)
Cartilage	1	0	0
Insertional cartilage	1	6 (1)	1
Mature attachment	0	2	5