2019

Low Prevalence of Patellar Tendon Abnormality and Low Incidence of Patellar Tendinopathy in Female Collegiate Volleyball Players

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ABSTRACT

The prevalence of patellar tendinopathy has been reported to be as high as 50% in elite male volleyball (VB) players; however, the rate of injury in female collegiate VB athletes is unknown. The purpose of this study was to 1) identify the prevalence of ultrasonographic evidence of patellar tendon abnormality at the start of the preseason in female collegiate VB players; 2) report the incidence of tendinopathy during the season; and 3) determine if the preseason presence of tendon abnormality is associated with onset of disease. One hundred and six female collegiate VB players had both patellar tendons imaged. Incidence of patellar tendinopathy was tracked during the course of the 4-month season. Twenty-two athletes presented with ultrasonographic evidence of patellar tendon abnormality in at least one knee at the start of the preseason. The incidence of time-loss patellar tendinopathy was 0.26 (95% CI: 0.04, 0.85) per 1000 athletic exposures. This study was unable to determine if preseason presence of tendon abnormality was associated with a greater risk of tendinopathy due to power. The prevalence of tendon abnormality in the preseason and the incidence of patellar tendinopathy in female collegiate VB players are lower than that observed in other populations.

ARTICLE HISTORY
Received 21 March 2019
Accepted 18 October 2019

KEYWORDS
College; jumper's knee; knee; patella; tendon abnormality; tendinopathy; ultrasound

Introduction

Patellar tendinopathy is an overuse injury marked by histopathological changes in the portion of the tendon between the inferior pole of the patella and its insertion on the tibial tubercle (Cook, Khan, Kiss, Purdam, & Griffiths, 2001a; Gisslen & Alfredson, 2005; Malliaras, Cook, Purdam, & Rio, 2015; Mendonca et al., 2016; Peers & Lysens, 2005). Patellar tendinopathy, commonly referred to as jumper's knee, is primarily experienced by athletes [age range 14–30s; Note: Lian, Engebretsen, and Bahr (2005) reported tendinopathy in male volleyball (VB) athletes with a mean age of 26.8 ± 4.2 years] especially those who play VB and basketball (Cook, Khan, Kiss, & Griffiths, 2000b; Cook, Khan, Kiss, Purdam, & Griffiths, 2000a; Gisslen & Alfredson, 2005; Ito, Iwamoto, Azuma, & Matsumoto, 2014; Janssen, van der Worp,

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Hensing, & Zwerver, 2018; Lian et al., 2005; Witvrouw, Bellemans, Lysens, Danneels, & Cambier, 2001). Prevalence of patellar tendinopathy in VB players has been reported between 14.4% in Dutch community-based clubs or student teams (mean age 22.9 y ± 2.7) to over 50% in high-level male volleyball players (elite division players from Norwegian teams; age range not provided) (Lian et al., 2005; Lian, Holen, Engebretsen, & Bahr, 1996).

In the United States, VB is a popular sport with over 27,000 women competing at the collegiate level (O'Rourke, 2018). Incidence of injury in women's VB at the collegiate level has been reported for many common conditions; however, specific rates for patellar tendinopathy have not been reported (Agel, Palmieri-Smith, Dick, Wojtys, & Marshall, 2007). Reported rates for "patella or patella tendon injury" range from 0.10 (95% CI: 0.07, 0.13) per 1000 athletic exposures (AE) during games to 0.15 (95% CI: 0.13, 0.17) during practices (Agel et al., 2007). The prevalence of this condition in female collegiate volleyball players is also unknown. This condition is challenging to treat with many athletes experiencing loss of time from sport and/or having to retire prematurely from competition (Cook et al., 1997; Kettunen, Kvist, Alanen, & Kujala, 2002).

Identifying athletes at risk for developing patellar tendinopathy is warranted. In the United States, there are several levels of competition at the collegiate level [e.g. National Collegiate Athletic Association (NCAA) and National Association of Intercollegiate Athletics (NAIA)]. Most athletes, except for those competing at the NCAA Division I level report to their team in August after having been off-campus for the summer months. Coaches and sports medicine professionals have a limited number of weeks to prepare their athletes for their first competition (National Collegiate Athletic Association, 2019). Screening athletes when they return back to campus may help identify athletes at risk for injury. Diagnostic ultrasound imaging of the patellar tendon may be used as a screening tool to identify athletes who present with a patellar tendon abnormality (Figure 1(a,b)). The presence of a patellar tendon abnormality is not always associated with symptoms; however, there is evidence that the presence of an abnormality increases the risk of developing symptomatic patellar tendinopathy (Cook et al., 2000a). Cook et al. reported a 4.2 times greater risk of elite basketball players (age range 14–18 y) developing symptoms when they presented at baseline testing with an asymptomatic patellar tendon abnormality (i.e., presence of a hypoechoic region) (Cook et al., 2000a). Subsequent studies supported the aforementioned association between symptom onset and tendon imaging at the start of the season (Gisslen, Gyulai, Nordstrom, & Alfredson, 2007; Visnes, Tegnander, & Bahr, 2015). Visnes et al. (2015) reported the presence of a hypoechoic region in an asymptomatic male or female elite teenage VB at baseline was associated with a 3.3 times greater risk of developing patellar tendinopathy. The risk of developing patellar tendinopathy was low in junior VB players (n = 22; mean age 16 y) who started the season with normal clinical and diagnostic ultrasound findings (Gisslen et al., 2007).

The prevalence of patellar tendon abnormality is unknown in female collegiate VB players. Also, unknown is if the presence of a tendon abnormality increases the risk of one developing symptomatic patellar tendinopathy. There are three purposes to this study. The first purpose of this study is to identify the prevalence of patellar tendon abnormality in a population of female collegiate VB athletes at the start of the preseason. It was hypothesized that these characteristics would be associated with a greater odds of having patellar tendon abnormality at the start of the preseason: older age, taller/heavier/higher body mass index (BMI), positions that require more jumping (e.g., outside hitter, middle blocker,

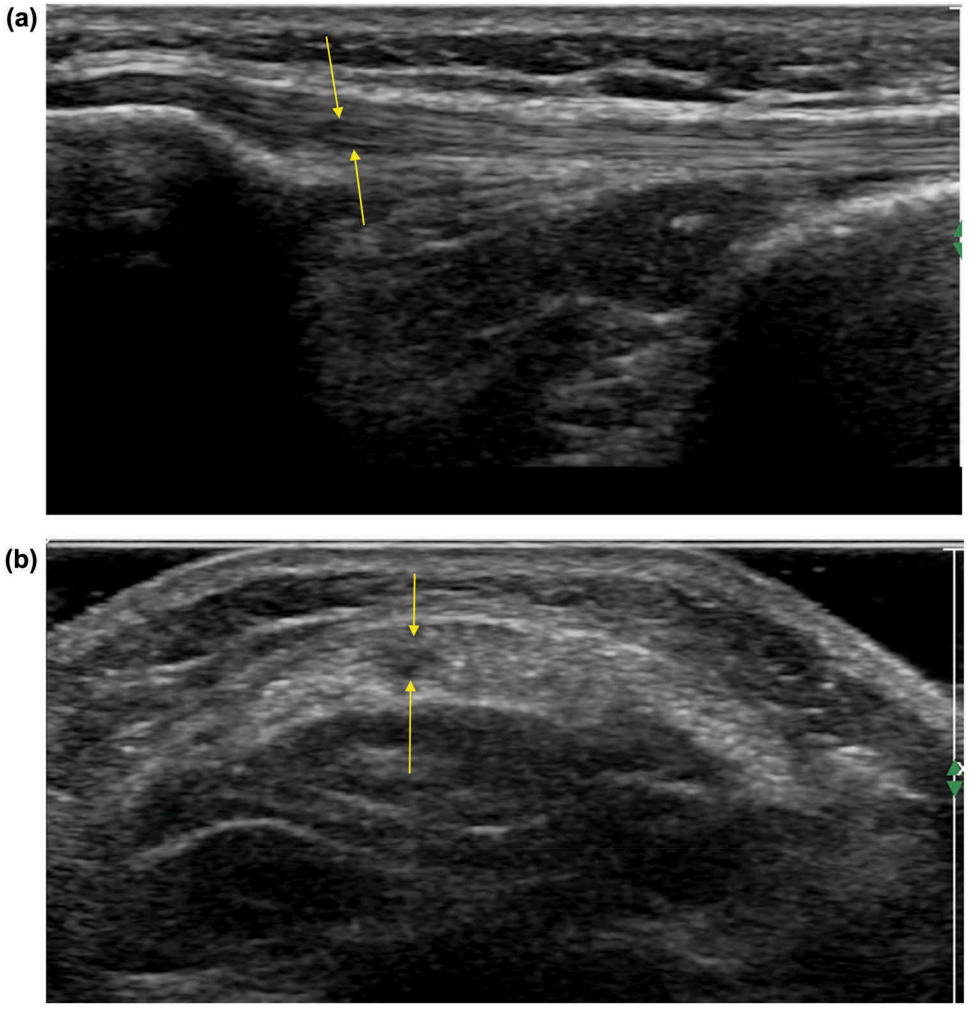

Figure 1. A) Hypoechoic region in a right patellar tendon from an 18-year-old national collegiate athletic association division III volleyball player (longitudinal view). B) Cross-sectional view depicting hypoechoic region.

opposite hitter), athletes who devoted less time to off-season training, starters, and athletes who played for institutions that offer athletic scholarships. The second purpose of this study was to report the incidence density of patellar tendinopathy in this population. It was hypothesized that female collegiate VB players would have an incidence of patellar tendinopathy lower than 0.10 per 1000 AEs. The third purpose of this study was to determine if the preseason presence of a patellar tendon abnormality is associated with a greater risk of developing a diagnosis of patellar tendinopathy resulting in time-loss from sport.

Methods

A total of 106 female collegiate VB players (mean age 19.3 ± 1.1 years) representing 7 teams participated in this study. Teams were recruited from the Portland, OR and the

Azusa, CA regions. The population sample consisted of VB players representing National Collegiate Athletic Association (NCAA) D II (n = 32), NCAA D III (n = 49), and National Association of Intercollegiate Athletes (NAIA) (n = 25) levels of competition. An athlete was excluded from study participation if she was restricted from sport participation by the team physician or the team's certified athletic trainer due to injury, or was unable to participate fully in practice, or was unable to complete a drop vertical jump from 30.48 cm, or was under the age of 18 at the time of testing. The 30.48 cm drop vertical jump was included in the preseason testing battery as a part of a larger study. The Institutional Review Boards of George Fox University (Newberg, OR) and Azusa Pacific University (Azusa, CA) approved this study. Informed consent was collected from each subject prior to study participation.

Testing protocol

Demographic information, anthropometric measures, and diagnostic ultrasound imaging were collected during the athletes' off-season period during the week prior to the official start of their collegiate preseason. Demographic information was collected from each athlete prior to imaging. Age was obtained from the athlete when she completed the informed consent. Athletes reported the average time devoted per week for the 6-week period prior to the start of the official preseason for the following training categories: weight lifting, plyometric training, and scrimmaging. Height was collected using a cloth tape affixed to a wall. Weight was collected when the athlete stood on a force plate (BP 600600 force plate, ATMI, Watertown, MA). BMI was calculated from height and weight measures (BMI = kg/m^2). Player position and starter/non-starter status were determined by reviewing each team's roster and season statistics.

Diagnostic ultrasound protocol

Ultrasonography (US) was performed by two researchers at George Fox University (MKH: 27 years of clinical experience and 6 years of US experience; TC: 26 years of clinical experience and 6 years of US experience) and one researcher at Azusa Pacific University (CP: 13 years of clinical experience and 3 years of US experience). Inter-rater reliability between different sonographers for collecting diagnostic ultrasound images for the patellar tendon has proven to be excellent (Black, Cook, Kiss, & Smith, 2004; Del Bano-Aledo et al., 2017; Gellhorn & Carlson, 2013).

Athletes were positioned in supine on a treatment plinth with knees flexed to approximately 110 degrees. Four ultrasound images, a longitudinal view and three transverse views were captured for each of the athlete's patellar tendons. For the longitudinal view, the captured image consisted of the tendon from the distal pole of patella to its insertion at the tibial tuberosity. Transverse views were captured at the proximal (near the apex of the patella) and distal insertion (near the tibial tuberosity) points, and midpoint between these structures (a total of three images per tendon). Affinity 50G ultrasound machine (Phillips Healthcare; Andover, MA) fitted with a 50 mm linear array probe (53 Hz) was used at a depth of 2.5 cm for all images.

All ultrasound images were reviewed for the presence of patellar tendon abnormality by MKH. MKH has previously reported a kappa statistic of 0.828 when evaluating patellar

tendons (Keefer Hutchison, Houck, Cuddeford, Dorociak, & Brumitt, 2019). A tendon was identified as having a patellar tendon abnormality based on the presence of a hypoechoic region (Figure 2). Individuals diagnosed with patellar tendinopathy frequently demonstrate tendon abnormality in the form of a hypoechoic region and a thickened tendon. None of the athletes at the start of the study were classified as having patellar tendinopathy. Rather, imaging was performed to identify abnormality, in particular, a hypoechoic region, and to evaluate this finding as a potential risk factor for the onset of symptoms during the season. The discussion section will discuss why tendon thickening was not evaluated as a risk factor. Individuals were categorized as either having patellar tendon abnormality in the right patellar tendon only, tendon abnormality in the left patellar tendon only, tendon abnormality in both patellar tendons, or as having no presence of patellar tendon abnormality in either tendon.

Injury Surveillance

Injury information and athletic exposures were collected from each team's athletic trainer on a weekly basis over the course of the 4-month season. The athletic trainers reported the number of athletes participating in each event (i.e., practice or game) and each injury resulting in time-loss. Athletic trainers were instructed to diagnose an athlete with patellar tendinopathy if she presented with complaints of pain to the patellar tendon during jumping or landing during sport, had pain with palpation to the patellar tendon, and pain during a single-leg squat (Cook et al., 2000a; Malliaras et al., 2015; Ramos et al., 2009; Visnes et al., 2015). For this study, only athletes diagnosed with patellar tendinopathy resulting from a noncontact mechanism were analysed.

Statistical analysis

An a priori sample size estimation was calculated using the proportions of individuals who had developed patellar tendinopathy reported in Cook et al. (2000a). In that study, 30% of athletes with asymptomatic patellar tendon abnormality (i.e., presence of a hypoechoic

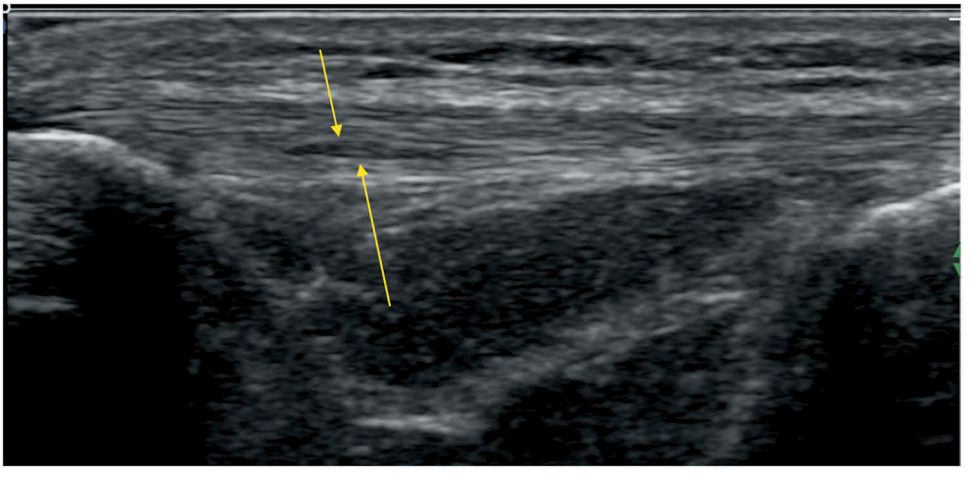

Figure 2. A) Hypoechoic region in a left patellar tendon from an 18-year-old national collegiate athletic association division III volleyball player (longitudinal view).

region) developed patellar tendinopathy whereas only 7% had developed in the control group. For the prospective cohort component of this study the alpha level was set at 0.05, power of 0.80, and using the aforementioned proportions a sample size of 90 subjects was estimated.

Descriptive statistics (mean ± SD) were calculated for athlete's age, height, weight, BMI, and off-season training habits. Comparisons between VB players for demographic measures and reported off-season training habits were calculated by performing independent t-tests. An athlete was categorized as having a patellar tendon abnormality if she had sonographic evidence (i.e., a hypoechoic region) of tendon abnormality. Logistic regression was performed to calculate prevalence odds ratios (OR) for potential risk factors. Ten risk factors analysed in this study were: age, height, weight, BMI, player position (e.g., jumping dominant positions: outside hitter [OH], middle blocker [MB], opposite side hitter [OPP] vs. setter [S], libero [L], defensive specialist [DS]), starter status, level of competition (programs that can offer athletic scholarships: NCAA D II and NAIA vs. NCAA DIII), and the three off-season training categories: weight lifting, plyometric training, and scrimmaging. Each factor was dichotomized into an "at risk" and a "lesser risk" (i.e., reference) group. Receiver operator characteristic (ROC) curves were constructed for each continuous variable; however, none of the ROC curves depicted a potential cut-off score that maximize sensitivity and specificity. Age was dichotomized based on mean scores from this sample: the reference group consisted of athletes 19 years or younger whereas the at risk group consisted of athletes 20 years of age and older. Taller, heavier, and athletes with a larger BMI were categorized as at risk whereas shorter, lighter, and normal weight (BMI) athletes served as the reference groups. Prior reports have suggested that age, weight, and BMI may be risk factors for tendinopathy (Crossley et al., 2007; Franeschi et al., 2014; Lian et al., 2005). Player position was dichotomized by positions that require frequent episodes of jumping (e.g., OH, MB, OPP) or by positions that require a lower frequency of vertical jumping (e.g., S, L, DS). Athletes in the "jumping" group (e.g., OH, MB, OPP) were categorized as at risk; setters, liberos, and defensive specialists served as the reference group. It was hypothesized that athletes who perform more jumps during sport would be at a greater risk of having a tendon abnormality. Starters were identified from season statistics as the players who started a majority of games for their team. Starters were categorized as at risk whereas non-starters served as the reference group. It was hypothesized that starters may be at a greater risk because they may have more exposure (i.e., time spent on the court during practices and games) than their non-starter counterparts. Athletes were dichotomized into two groups based on the level of competition: NCAA D II and NAIA athletes were categorized as at risk whereas NCAA D III athletes served as the reference group. This dichotomization was made based on programmes that can offer athletic scholarships (e.g., NCAA D II, NAIA) and those that cannot (NCAA D III). Mean scores for off-season training habits were used to dichotomize athletes into at risk and lesser risk groups. There is evidence that athletes who devote less time to off-season training are at a greater risk for a noncontact time-loss injury (Brumitt et al., 2017; Rauh, 2014).

Incidence density was calculated by dividing the number of cases of patellar tendinopathy resulting in time-loss from sport by the total number of athletic exposures (1 AE = 1

practice or 1 game). Relative risk was calculated to determine the risk of developing patellar tendinopathy based on preseason presence of a patellar tendon abnormality (Peers & Lysens, 2005). Open Epi was used to calculate the sample size. SPSS 25 was used for all statistical calculations (Chicago, IL).

Results

Twenty-two subjects (20.8% of the population) presented with patellar tendon abnormality (i.e., sonographic evidence of a hypoechoic region) in at least one knee during preseason testing. Of the 212 tendons evaluated there were a total of 28 tendons (13.2% of all tendons) with an abnormality: 16 cases of a unilateral presentation (eight cases of tendon abnormality on the right side, eight cases of tendon abnormality on the left) and six individuals that had bilateral presentation (n = 12). There was no difference in demographic measures, anthropometric measures, or reported off-season training habits between those with tendon abnormality and those without (Table 1; all p-values > 0.05).

The odds of presenting with a patellar tendon abnormality based on demographics, anthropometric measures, off-season training habits, and sport-specific measures (e.g. player position, starter status, level of competition) are presented in Table 2. There were no significant associations between the aforementioned characteristics and the presence of tendon abnormality.

There were only two time-loss patellar tendinopathy cases that occurred during the course of this study. A total of 7746 athletic exposures occurred during the course of the study. The incidence density for time-loss patellar tendinopathy was 0.26 (95% CI: 0.04, 0.85) per 1000 AEs. Athletes who presented with a hypoechoic region were no more likely to develop symptomatic patellar tendinopathy during the season than athletes without tendon abnormality (relative risk = 1.0 [95% CI: 0.0, 20.4]; p-value = 0.516) (Table 3).

Table 1. Comparison of demographic information, anthropometric measures, and reported off-season training habits between female collegiate volleyball players with patellar tendon abnormality (PTA) or without at the start of the preseason.

Characteristic	All Subjects (n = 106)	Subjects with PTA (n = 22)	Subjects without PTA (n = 84)	p-value‡
Age (y)	19.3 (1.1)	19.1 (1.0)	19.4 (1.1)	0.408
Years in School (y)	2.2 (1.1)	2.2 (1.1)	2.2 (1.1)	0.974
Age Starting Sport (y)	11.7 (2.2)	11.7 (2.1)	11.7 (2.2)	0.977
Off-Season Training Habits (hr./wk.):				
Weight lifting	4.7 (2.9)	4.6 (3.5)	4.7 (2.8)	0.863
Plyometric training	2.5 (1.9)	2.1 (1.3)	2.6 (2.1)	0.294
Scrimmaging	3.9 (6.2)	3.8 (6.5)	4.0 (6.1)	0.898
Height (m)	1.74 (0.08)	1.74 (0.07)	1.74 (0.08)	0.925
Weight (kg)	71.2 (9.6)	71.9 (10.2)	71.0 (9.5)	0.702
Body Mass Index	23.5 (2.7)	23.6 (2.3)	23.5 (2.8)	0.825

aReported off-season training habits during the 6-week period prior to the start the official preseason.
‡Comparison between subjects with PTA versus subjects without PTA

Table 2. Relationships between age, anthropometric measures, and sport-related demographics with the presence of patellar tendon abnormality.

Characteristic	*N* per category	Patellar tendon abnormality *N* (%)	Odds ratio (95% CI)	*p*-value
Age (years)				
19 or younger	60	9 (15.0)	Reference	0.792
20 or older	46	13 (28.3)	0.9 (0.3, 2.3)	
Height (m)				
1.73 or less	51	10 (19.6)	Reference	0.779
1.74 or more	55	12 (21.8)	1.1 (0.4, 2.9)	
Weight (kg)				
71.19 kg or less	48	11 (22.9)	Reference	0.618
71.20 kg or more	58	11 (19.0)	0.8 (0.3, 2.0)	
BMI (kg/m^2)				
23.49 or less	50	10 (20.0)	Reference	0.856
23.50 or more	56	12 (21.4)	1.1 (0.4, 2.8)	
Position				
S, L, DS	39	7 (17.8)	Reference	0.587
OH, MB, OPP	67	15 (22.4)	1.3 (0.5, 3.6)	
Starter Status				
Non-Starter	66	13 (19.7)	Reference	0.730
Starter	40	9 (22.5)	0.8 (0.3, 2.2)	
Level of Competition§				
NCAA DIII	49	13 (26.5)	Reference	0.519
NCAA DII/NAIA	57	9 (15.8)	0.5 (0.2, 1.3)	
Off-Season Training Habits (hr./wk.):				
Weight lifting				
4.7 hr. or more	47	9 (19.2)	Reference	0.716
<4.7 hr.	59	13 (22.0)	1.2 (0.5, 3.1)	
Plyometric training				
2.5 hr. or more	36	6 (22.9)	Reference	0.458
< 2.5 hr.	70	16 (16.7)	1.5 (0.5, 4.2)	
Scrimmaging				
3.9 hr. or more	34	7 (20.6)	Reference	0.977
<3.9 hr.	72	15 (20.8)	1.0 (0.4, 2.7)	

NCAA = National Collegiate Athletic Association; NAIA = National Association of Intercollegiate Athletics; D II = Division II; D III = Division III

§ – Dichotomization based on competition levels eligible to offer athletic scholarships

Table 3. Relative risk of developing patellar tendinopathy based on the presence of patellar tendon abnormality.

Category	Subjects per category	Cases of PT (%)	Relative risk (95% CI)	*p*-value
Patellar Tendon Abnormality				
Yes	22	0 (0)a	1.0 (0.0, 20.4)	0.516
No	84	2 (2.4)	Reference	

aTo account for zero subjects 0.5 was entered into the 2 × 2 contingency table

Discussion

To our knowledge, this is the first study to report the prevalence of patellar tendon abnormality and the incidence of time-loss patellar tendinopathy in female collegiate volleyball players. The results of this study indicate that over 20% of athletes started the season with a hypoechoic region in at least one of their patellar tendons. However, there was no association between tendon abnormality and the potential risk factors explored in this study. This study also presented the incidence of time-loss patellar tendinopathy. The

presence of patellar tendon abnormality at the start of the preseason was not associated with the onset of the condition during the season.

The first purpose of this study was to report the prevalence of patellar tendon abnormality in a population of female collegiate volleyball players and to determine if there are characteristics associated with a greater odds of presenting with patellar tendon abnormality. The presence of a hypoechoic region represents a failed repair response to loading (Cook, Khan, Kiss, Coleman, & Griffiths, 2001b; Kaux, Forthomme, Le Goff, Crielaard, & Croisier, 2011; Ker, 2002; Malliaras, Cook, Ptasznik, & Thomas, 2006; Shepherd & Screen, 2013). The prevalence of patellar tendon abnormality (20.8% of the population) in this study is consistent, albeit a bit lower, with the proportions reported in prior studies: 26% in elite teenage basketball players, 36% in elite junior volleyball players, 26.6% in adult volleyball players, and 33.7% in male collegiate basketball players (Cook et al., 2000b; Gisslen et al., 2007; Keefer Hutchison et al., 2019; Malliaras et al., 2006). It is important to recognize that the presence of a hypoechoic region does not mean that one is symptomatic. In this study, the athletes were able to participate fully in sport and were currently not under the care of a physician or an athletic trainer.

Associations between demographic information, training habits, anthropometric measures, or sports specific characteristics and the presence of patellar tendon abnormality during the preseason were evaluated. None of the explored variables were associated with a greater risk of presenting with a hypoechoic region in the patellar tendon. This finding is consistent with a recent report that found no relationship between tendon abnormality and demographic information, anthropometrics, player position, and competition level in male collegiate basketball players (Keefer Hutchison et al., 2019). However, in that study the authors reported non-starters were 3.5 times more likely to present with ultrasonic evidence of tendon abnormality at the start of the preseason (Keefer Hutchison et al., 2019).

The second purpose of this study was to report the incidence density of time-loss patellar tendinopathy in a population of female collegiate VB players. The incidence of patellar tendinopathy was higher than what was hypothesized [0.26 (95% CI: 0.04, 0.85) per 1000 AEs]. This incidence rate is important and warrants discussion. First, the aforementioned rate is higher than what has been previously reported. A prior multi-year epidemiological study reported a rate of 0.15 patella or patella tendon injuries per 1000 AEs (during practices) and a rate of 0.10 patella or patella tendon injuries per 1000 AEs (during games) (Agel et al., 2007). This rate included athletes from all levels of collegiate competition and all diagnoses related to the patella. It is possible that athletes who participate at higher levels of competition (e.g., NCAA Division I [none evaluated in this study] and/or those who are competing for scholarship-granting programmes (e.g., NCAA D II, NAIA) may be monitored or trained differently than athletes who compete at the NCAA D III level. This is only speculative, but in this study, the two cases of patellar tendinopathy were diagnosed in athletes from the NCAA D III level. Of the 22 athletes who presented with a patellar tendon abnormality during testing a majority were from the NCAA D III level: 13 (59.1%) were NCAA D III athletes, 5 (22.7%) were NCAA D II athletes, and 4 (18.2%) were NAIA athletes. Second, because the incidence reported in this study included a larger percentage of athletes from the NCAA D III level (46% of total population) this rate should be viewed with caution. Future studies are warranted to identify

preseason prevalence rates for patellar tendon abnormality and in-season incidence rates for patellar tendinopathy for individual levels of competition.

The third purpose of this study was to determine if preseason presence of patellar tendon abnormality was associated with a greater risk of developing time-loss patellar tendinopathy. In this study preseason presence of a hypoechoic region was not associated with the onset of symptomatic patellar tendinopathy. As previously mentioned Cook et al. (2000a) and Visnes et al. (2015) reported the presence of a patellar tendon abnormality in the form a hypoechoic region in elite teenage athletes who were asymptomatic was associated with a 3 to 4-fold increased risk of developing symptomatic patellar tendinopathy. It is important to highlight that a thickened tendon is also an abnormality observed on an ultrasound image; however, thickening of the tendon is typically associated with symptomatic cases (Malliaras et al., 2015; Visnes et al., 2015). In this study, a thickened tendon in conjunction with the presence of a hypoechoic region was not evaluated as a potential risk factor. Visnes et al. (2015) previously reported that a thickened tendon was not a risk factor in elite female VB players.

There are a few potential reasons for the difference between this study and prior studies regarding tendon abnormality as a risk factor for the onset of symptomatic patellar tendinopathy. First, the athletes evaluated in prior studies were younger than the sample investigated in this study (Cook et al., 2000a; Visnes et al., 2015). It could be speculated that younger athletes may be at a greater risk for symptomatic patellar tendinopathy; however, the prevalence of this condition appears to be higher in adult athletes (Cook et al., 2000b; Gisslen et al., 2007; Lian et al., 2005, 1996; Malliaras et al., 2006). Rather, the greater incidence of patellar tendinopathy in Cook et al. (2000a) and Visnes et al. (2015) when compared to the athletes in this study may be due to the duration of their season. Elite teenage athletes (Cook et al., 2000a; Visnes et al., 2015) may be at a greater risk of injury due to participating in a longer season than the approximately 4-month collegiate volleyball season in the United States. Second, there may be differences in injury rates between genders. This study only evaluated female volleyball players whereas Cook et al. (2000a) assessed male and female basketball players and Visnes et al. (2015) assessed male and female volleyball players. It is important to note that in both studies the male players had a higher injury rate. Also, risk of patellar tendinopathy onset was based on combining genders; it is possible that analysis of risk per gender may not have been significant. It is important to note that this is only speculative and would require future study. Third, the surveillance period differed between studies may have been a factor. Cook et al. (2000a) followed the basketball players for a 16-month period and Visnes et al. (2015) followed the VB players for a 4-year period. In this current study athletes were only followed during the course of the 4-month season. The chance of developing patellar tendinopathy may be greater in the aforementioned studies because those athletes may have had more exposure (e.g., training sessions, total jumps performed) than athletes in this current study. However, it is important to highlight that the finding in this study is important for sports medicine professionals who work with VB at the collegiate level in the United States. It would be inappropriate to apply the findings from Cook et al. (2000a) or Visnes et al. (2015) to this population. Finally, even though we recruited more athletes than our sample size calculation we may have been underpowered due to the total cases occurring during the season.

There are several strengths to this study. First, diagnostic ultrasound images were collected prospectively by experienced physiotherapists. Second, investigators collected injury information and athletic exposures on a weekly basis to ensure accurate data collection from each team. Third, several novel risk factors were evaluated to determine if athletes were at a greater odds of presenting with a tendon abnormality based on demographic factors, anthropometric measures, training habits, and sports specific characteristics. Fourth, this study investigated prevalence of tendon abnormality and incidence of patellar tendinopathy in a population that had not yet been investigated.

There are limitations associated with this study. First, as previously mentioned, this study may have been underpowered to determine if preseason tendon abnormality is associated with a greater risk of developing patellar tendinopathy. To address these future investigations should evaluate athletes per level of competition and recruit a larger sample size. Even though in this study we recruited more athletes than our sample size calculation, that calculation was based on proportions from a study consisting of teenage basketball players. Second, future investigations should consider monitoring athletes over the course of several years. A relatively short 4-month surveillance period in this study only produced two cases of patellar tendinopathy. Only two cases out of 106 athletes are a relatively small incidence of the disease; however, other studies have recognized the prevalence of this condition to be as high as 50% (Lian et al., 1996). Visnes et al. (2015) reported that the average time to disease onset was 0.9 years from the start of the study. A future study assessing collegiate athletes in the United States should evaluate all incoming freshmen following them for the course of their collegiate career.

Conclusion

The prevalence of patellar tendon abnormality in a population of female collegiate VB players was greater than 20%; however, the incidence of patellar tendinopathy during the season was low. The presence of tendon abnormality was not associated with an increased risk of developing patellar tendinopathy; however, future studies are warranted to prospectively evaluate potential risk factors over a longer surveillance period.

Acknowledgments

This study was approved by the Institutional Review Boards of George Fox University and Azusa Pacific University.

Disclosure statement

No potential conflict of interest was reported by the authors.

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