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Investigating Achilles and patellar tendinopathy prevalence in elite athletics

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ABSTRACT

Although injury surveillance in athletics is routinely conducted, discipline-specific Achilles and patellar tendinopathy prevalence remains unknown. The purpose of this study was to explore discipline-specific tendinopathy prevalence and identify whether injury-specific risk factors differed in athletes. Elite athletes were recruited and provided information on their sport training including Achilles and patellar tendon pain history. In order to ascertain whether between-discipline differences existed, data were categorized into discipline groups. Middle-distance athletes reported the highest prevalence of Achilles tendinopathy and the combined athletes reported the highest patellar tendinopathy prevalence. Greater calf stiffness was reported in athletes who experienced Achilles tendinopathy compared to those who did not. A substantial portion of athletes believed their performance decreased as a result of their tendon pain. In order to develop discipline-specific evidence-based injury prevention programmes, further discipline-specific research is required to quantify the mechanism for Achilles and patellar tendinopathy development in elite athletics.

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KEYWORDS

Risk factors; Achilles tendinitis; injury prevention

Introduction

Achilles and patellar tendinopathy are the most common lower-limb tendinopathies that may have the potential to end sport careers (Kettunen, Kvist, Alanen, & Kujala, 2002). Management of these tendinopathies is challenging and has led to research into the prevalence and risk factors of these injuries for various sports (Lian, Engebretsen, & Bahr, 2005; van der Worp et al., 2011; Zwerver, Bredeweg, & van den Akker-Scheek, 2011). Achilles tendinopathy is most commonly found in middle and long distance runners with up to 29% sustaining the injury (Knobloch, Yoon, & Vogt, 2008; Kujala, Sarna, & Kaprio, 2005). The presence of patellar tendinopathy has been found to be high in explosive sports characterized by high demands on speed and power of the leg extensors such as elite volleyball (45%), basketball (32%), athletics (track and field) (23%), handball (15%), and soccer (13%) (Lian et al., 2005; van der Worp et al., 2011; Zwerver et al., 2011).
Various risk factors have been found to be associated with developing Achilles and/or patellar tendinopathy, indicating the development of these insidious injuries to be multi-factorial (Maffulli, 1996). An increased risk of developing tendinopathies has been associated with being male (Lian et al., 2005; Zwerver et al., 2011), elite (Lian et al., 2005; Zwerver et al., 2011), increased body mass (van der Worp et al., 2011), lower foot arch height (van der Worp et al., 2011), high volume of training (Visnes & Bahr, 2012), and decreased flexibility (Jarvinen et al., 2001; Malliaras, Cook, & Kent, 2006; van der Worp et al., 2011). In the review paper by van der Worp et al. (2011), more than 40 potential patellar tendinopathy risk factors were investigated and only 9 revealed some evidence (and none showed strong or moderate evidence) supporting the notion that identifying specific risk factors for patellar tendinopathy development is challenging. In addition, the different participant groups, subgroups, and statistical analysis in previous studies have led to conflicting results. For example, weight training was found to be associated with patellar tendinopathy in volleyball players in one study (Lian, Engebretsen, Ovrebo, & Bahr, 1996), but was not in another study by the same research group (Lian, Refsnes, Engebretsen, & Bahr, 2003). Similarly, smaller ankle dorsiflexion range was found in volleyball players with patellar tendinopathy (Malliaras et al., 2006) but this was not supported in other studies (Mendonça et al., 2016).

Athletics is a sport with multiple disciplines where athlete’s anthropometrics and training programmes may vary based upon the characteristics of the discipline. For example, throwers may have greater body mass and perform more strength training than middle-distance runners. As a result, distinctive tendinopathy risk factors may be associated with these disciplines and, therefore, potentially have different tendinopathy prevalence (van der Worp et al., 2011: Visnes & Bahr, 2012). Previous researchers have quantified tendinopathy prevalence in masters athletes and found no significant effect of Achilles tendinopathy on the discipline (Longo et al., 2009). In another study investigating patellar tendinopathy prevalence in elite athletes, male sprinters and high jumpers were grouped together and compared to other sports (Lian et al., 2005). Although 23% of these elite male athletes were found to suffer from patellar tendinopathy, other disciplines were not collected. In fact, to date no known study has fully compared the prevalence of Achilles and patellar tendinopathy in elite athletics.

In order to better understand the injury incidence in elite athletics, injury surveillance at international competitions are routinely conducted (Alonso et al., 2010; Engebretsen et al., 2013; Junge et al., 2009). These studies have revealed that up to 59% of the reported injuries to be overuse with the highest prevalence reported in the combined events (decathlon and heptathlon) and middle- and long-distance events. A limitation when collecting injury surveillance at a competition is that athletes who were unable to compete as a result of injury would not be present and may lead to an under-representation of the injury. In addition, as athletes are often able to continue competing when suffering from Achilles or patellar tendinopathy, it is likely that the prevalence of these injuries in elite athletics is underestimated (Clarsen, Myklebust, & Bahr, 2013). These studies, however, did not differentiate between the types of overuse injuries per competition discipline and, therefore, it remains unknown how the prevalence of Achilles or patellar tendinopathy is distributed within elite athletics.

To assess the severity of patellar tendon pain, function and sports participation, the Victorian Institute of Sport Assessment-Patella (VISA-P) questionnaire (Visentini et al.,
1998) was developed and is now a component of the clinical assessment. The use of an online questionnaire, such as the VISA-P, may allow for data from a large group of (international) participants to be collected as clinical assessments may be time consuming and expensive. To assess the validity of this questionnaire for accurate clinical diagnosis, Morton et al. (2015) compared participants’ responses to patellar tendinopathy severity measures and risk factors with clinical assessment of the participants. Depending upon the variable measured, moderate-to-strong correlations (0.60–0.90) were found between results from the online questionnaire and the clinical assessment. A similar questionnaire to assess the severity of Achilles tendon pain (Victorian Institute of Sport Assessment-Achilles (VISA-A) (Robinson et al., 2001)), to our knowledge, has not yet been validated as an online tool. The favourable results of the VISA-P questionnaire, however, have allowed for researchers to confidently utilize online questionnaires with proper visual aids in order to gather injury-prevalence data.

The van Mechelen’s injury prevention model (1992) states that prior to preventive measures being introduced, the problem first needs to be identified. As it remains unknown whether and what the prevalence of lower limb tendinopathy is in elite athletics, how this varies per discipline, and which risk factors are associated with these athletes, this first needs to be quantified in order to develop sport-specific prevention strategies. With the assistance of an online questionnaire, the aims of this study were to (a) explore discipline-specific Achilles and patellar tendinopathy prevalence in elite athletics, and (b) to identify whether athletes who did and did not sustain an injury were exposed to different risk factors.

**Methods**

Athletes who competed in their National Athletics Championship in 2014 or 2015 were invited to participate in an online questionnaire. In order to exclude athletes with knee pathologies such as Osgood–Schlatter disease, Sinding-Larsen-Johansson syndrome, or osteoarthritis, an age restriction of 18–35 years old was used (Mendonça et al., 2016; van der Worp, van Ark, Zwerver, & van den Akker-Scheek, 2012). At the start of the questionnaire, all participants gave their informed consent. A local ethics committee evaluated the study and concluded it did not require further Medical Research Involving Human Subject Act clearance.

An online questionnaire was designed and sent out between April and May 2015 to collect 6 months of retrospective training and injury information, previously shown to be a valid time for collecting injury history (Gabbe, Finch, Bennell, & Wajswelner, 2003), in the following categories:

1. **Respondent characteristics**: Gender, date of birth, height, body mass, foot type based on a picture (Figure 1(a)), and whether they wore orthotics in their training shoes.
2. **Training history**: Competition discipline/event, number of years competing at the senior national championships, total training hours, strength training hours, and flexibility training hours per week, self-reported muscle flexibility of the quadriceps, hamstrings, and calves were reported as feeling normal, stiff, or flexible (Morton et al. 2015).
Achilles tendon pain: Whether they currently had Achilles pain, whether they had Achilles pain in the last 6 months, or whether they have previously been diagnosed with Achilles tendinopathy, duration and location of the pain (insertional or mid-portion tendinopathy; see Figure 1(b)), which leg was affected, and whether a physiotherapist or physician had diagnosed Achilles tendinopathy. Subjective answers regarding which movement caused the most pain, whether the pain affected their performance, or whether the pain increased during heavy training weeks were also collected. Participants were classified as having Achilles tendinopathy if they indicated having Achilles pain and/or if they reported being

Figure 1. Pictorial representations of (a) Foot type, (b) Location of the Achilles pain, and (c) Location of the knee pain. Participants selected one picture of each section to describe their footedness and location of their pain.
diagnosed as such by a physiotherapist or physician. Participants with current Achilles pain or who had experienced Achilles pain in the last 6 months completed the VISA-A questionnaire (Robinson et al., 2001) to indicate the severity of the Achilles pain, function and sports participation (score 0–100; 0 = most severe complaints, 100 = no complaints).

(4) Patellar tendon pain: Whether they currently had knee pain, whether they had knee pain in the last 6 months, or whether they have previously been diagnosed with patellar tendinopathy, duration and location of the pain on a self-administered pain map (see Figure 1(c) (van der Worp et al., 2012)) which leg was affected, and whether a physiotherapist or physician had diagnosed patellar tendinopathy. Participants also answered questions regarding which movement caused the most pain, whether the pain affected their performance, or whether the pain increased during heavy training weeks. Participants were classified as having patellar tendinopathy if they indicated having pain on the inferior or superior poles of the patella (Figure 1(c), parts E,F)) and/or if they were diagnosed as such by a physiotherapist or physician. Participants with current patellar tendinopathy or who sustained patellar tendinopathy in the last 6 months completed the VISA-P questionnaire (Visentini et al., 1998) (score 0–100; 0 = most severe complaints, 100 = no complaints).

Following data collection, respondents were categorized into seven discipline groups for analysis: sprints (100, 200, 400 m), middle distance (800, 1500 m), long distance (5, 10, 3 km steeplechase, marathon), jumps (long jump, triple jump, pole vault, high jump), throws (shot put, javelin, discus, hammer), combined (decathlon, heptathlon), and hurdles (100, 110, 400 m) (Alonso et al., 2010). In order to ascertain whether discipline-specific respondent characteristics existed, Kruskal–Wallis tests were conducted with Mann–Whitney U post hoc test to identify which discipline groups were different.

To ascertain whether injury prevalence differed between disciplines, a Fisher’s Exact Test (7 × 2) was conducted combining the responses from all three groups: athletes who indicated they currently had Achilles or patellar tendon pain, had tendon pain in the last 6 months, or those who had previously received a clinical diagnosis of either Achilles or patellar tendinopathy. When between-discipline significance was found, post hoc Fisher’s Exact tests (2 × 2) were conducted to ascertain which groups were different.

Chi-square tests were then performed separately to identify whether previously identified Achilles and patellar tendinopathy risk factors were associated with athletes who currently had tendon pain and who had tendon pain the last 6 months. Statistical significance was set at $P < 0.05$ and all statistics were performed using statistical software (IBM SPSS Statistics 21.0.0; Somers, New York, USA). An adjustment to the alpha level was not made due to the exploratory nature of our study (Perneger, 1998).

**Results**

A total of 125 athletes from eight different countries (The Netherlands, Belgium, Denmark, Canada, New Zealand, Australia, South Africa, and Great Britain) completed the questionnaire. Upon inspection of the data, six were excluded from analysis due to unsuitable ages leaving a total of 119 respondents with 64% male and 36% female
Significant differences in discipline-specific respondent characteristics were found in height ($P = 0.027$), body mass ($P < 0.001$), and the amount of strength ($P < 0.001$) and flexibility ($P = 0.031$) training performed. Throwers were found to be the tallest and heaviest and performed the most amount of strength training, whereas the hurdlers performed the most flexibility training. No between-group differences in age ($P = 0.689$), number of years competing at the national level ($P = 0.152$), or total training hours per week ($P = 0.064$) were found.

Significant differences in Achilles tendinopathy ($P = 0.030$) and patellar tendinopathy prevalence were found ($P = 0.024$) between the disciplines. Higher prevalence of Achilles tendinopathy was found in the middle-distance runners compared to the sprint, throws, jumps, and combined events (Table 2). Of those with Achilles tendon pain, 78% reported pain in the mid-portion of the tendon. Foot type revealed that 75% of these athletes considered themselves to have a “normal foot” while 18% had flat feet and the remaining 14% had high arches. Significantly higher patellar tendinopathy prevalence was found in the combined athletes compared to the long distance, jumps, hurdles, and sprint disciplines. Of those with current patellar tendinopathy or that within the last 6 months, 92% identified pain localized to the inferior pole of the patellar (Figure 1(c, part E)), and the rest localized the pain to the quadriceps tendon insertion (Figure 1(c, part F)). Athletes who reported ever receiving a diagnosis of patellar tendinopathy were not questioned on the location of the pain. A total of 15 athletes (13% of the respondents) reported developing both Achilles and patellar tendinopathy although no between-discipline differences were found ($P = 0.521$).

When exploring whether Achilles and patellar tendinopathy risk factors differed between athletes who sustained an injury, those who developed Achilles tendon pain reported greater calf muscle stiffness than athletes who did not ($P = 0.021$). Athletes who developed patellar tendinopathy were significantly taller ($P = 0.026$), heavier ($P = 0.019$), conducted more total training hours ($P = 0.040$), and were more likely to be male ($P = 0.010$).

On average, 75% of the injured athletes reported pain in one limb where 25% reported developing pain bilaterally (Table 3). The pain lasted an average of 10–12 months with a VISA-A or -P score of 73. Athletes who suffered from Achilles tendon injuries reported the most pain during takeoff and accelerating while athletes with patellar tendinopathy reported pain in the takeoff and landing. On average, more than half of the respondents believed that their pain affected their performance and that the pain increased during heavy training weeks.

**Discussion**

Although lower limb tendinopathy prevalence has been quantified for several sports, it remains unknown whether between-discipline differences exists in elite athletics. This is the first known study to demonstrate significant between-discipline differences in Achilles and patellar tendinopathy prevalence. The implications of these findings are discussed below.

In support of previous research (Knobloch et al., 2008), the highest Achilles tendinopathy prevalence was found in the middle- and long-distance athletes. Self-reported stiffness of the calf muscles was found to be a risk factor associated with athletes who...
Table 1. Mean ± standard deviation values for respondent characteristics (n = 119) per grouped discipline.

<table>
<thead>
<tr>
<th></th>
<th>Sprint</th>
<th>Middle distance</th>
<th>Long distance</th>
<th>Jumps</th>
<th>Throws</th>
<th>Combined</th>
<th>Hurdles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total respondents (n)</td>
<td>21</td>
<td>12</td>
<td>19</td>
<td>28</td>
<td>15</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Male/Female (n)</td>
<td>11/10</td>
<td>8/4</td>
<td>15/4</td>
<td>14/14</td>
<td>10/5</td>
<td>10/1</td>
<td>8/5</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>24.0 ± 4.2</td>
<td>23.7 ± 2.9</td>
<td>23.1 ± 4.1</td>
<td>23.2 ± 3.1</td>
<td>25.3 ± 4.1</td>
<td>23.4 ± 3.9</td>
<td>24.9 ± 4.8</td>
</tr>
<tr>
<td>Height (m)*</td>
<td>1.77 ± 0.02</td>
<td>1.79 ± 0.88</td>
<td>1.79 ± 8.0</td>
<td>1.82 ± 9.6</td>
<td>1.86 ± 7.1</td>
<td>1.84 ± 7.4</td>
<td>1.79 ± 8.5</td>
</tr>
<tr>
<td>Body mass (kg)*</td>
<td>66.9 ± 7.4</td>
<td>65.4 ± 9.8</td>
<td>61.8 ± 8.5</td>
<td>69.8 ± 7.9</td>
<td>98.9 ± 16.3</td>
<td>77.9 ± 9.1</td>
<td>68.3 ± 9.5</td>
</tr>
<tr>
<td>Yrs at Nat’l champs</td>
<td>3.6 ± 3.2</td>
<td>5.7 ± 2.9</td>
<td>3.7 ± 4.0</td>
<td>5.0 ± 3.1</td>
<td>5.7 ± 4.1</td>
<td>5.0 ± 4.1</td>
<td>6.8 ± 4.9</td>
</tr>
<tr>
<td>Total training/week (hrs)</td>
<td>11.4 ± 3.7</td>
<td>12.7 ± 5.7</td>
<td>14.1 ± 4.5</td>
<td>12.5 ± 4.1</td>
<td>17.1 ± 7.0</td>
<td>14.6 ± 5.1</td>
<td>13.2 ± 5.0</td>
</tr>
<tr>
<td>Strength training/week (hrs)*</td>
<td>3.3 ± 1.6</td>
<td>2.1 ± 1.6</td>
<td>1.8 ± 1.1</td>
<td>3.6 ± 1.6</td>
<td>6.9 ± 3.8</td>
<td>2.5 ± 1.4</td>
<td>3.4 ± 1.9</td>
</tr>
<tr>
<td>Flexibility training/week (hrs)*</td>
<td>1.4 ± 1.1</td>
<td>1.3 ± 1.1</td>
<td>1.0 ± 0.9</td>
<td>1.3 ± 0.9</td>
<td>1.8 ± 1.5</td>
<td>1.1 ± 1.2</td>
<td>2.5 ± 2.0</td>
</tr>
</tbody>
</table>

Significant between-group differences (*) were found in height, body mass, strength training and flexibility training hours per week.
developed Achilles tendinopathy. However, the cross-sectional nature of this study makes it impossible to determine a causal link between the two factors. Several studies, including a recent prospective study (Rabin, Kozol, & Finestone, 2014), have identified decreased ankle range of motion as a risk factor for Achilles tendinopathy development (Kaufman, Brodine, Shaffer, Johnson, & Cullison, 1999) and, more recently, patellofemoral pain in young dancers (Steinberg, Tenenbaum, Hershkovitz, Zeev, & Siev-Ner, 2017).

Alternatively, in a prospective cohort study of male military recruits, increased ankle dorsiflexion range of motion was a significant predictor of Achilles tendinopathy (Mahieu, Witvrouw, Stevens, Van Tiggelen, & Roget, 2006). In the current study, no significant differences were found in any other risk factors, supporting previous research

### Table 2.
The number of athletes who reported developing Achilles tendinopathy (n = 51), patellar tendinopathy (n = 34), and both (n = 15) classified by competition discipline. Significant between-discipline differences were found for Achilles (*) and patellar (**) tendinopathy.

<table>
<thead>
<tr>
<th></th>
<th>Achilles tendinopathy (*)</th>
<th>Patellar tendinopathy (**)</th>
<th>Achilles and Patellar tendinopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprint (n = 21)</td>
<td>43% (9)</td>
<td>14% (3)</td>
<td>5% (1)</td>
</tr>
<tr>
<td>Middle Distance (n = 12)</td>
<td>83% (10)</td>
<td>33% (4)</td>
<td>25% (3)</td>
</tr>
<tr>
<td>Long distance (n = 19)</td>
<td>53% (9)</td>
<td>26% (5)</td>
<td>12% (2)</td>
</tr>
<tr>
<td>Jumps (n = 28)</td>
<td>29% (8)</td>
<td>21% (6)</td>
<td>7% (2)</td>
</tr>
<tr>
<td>Throws (n = 15)</td>
<td>40% (6)</td>
<td>40% (6)</td>
<td>20% (3)</td>
</tr>
<tr>
<td>Combined (n = 11)</td>
<td>18% (2)</td>
<td>73% (8)</td>
<td>18% (2)</td>
</tr>
<tr>
<td>Hurdles (n = 13)</td>
<td>47% (7)</td>
<td>15% (2)</td>
<td>13% (2)</td>
</tr>
</tbody>
</table>

Results are presented as percentage (%) of the total respondents and the number of athletes (n).

### Table 3.
Descriptive responses for athletes who currently had Achilles and patellar tendinopathy, had pain in the last 6 months, or previous a diagnosis of Achilles or patellar tendinopathy.

<table>
<thead>
<tr>
<th></th>
<th>Achilles tendinopathy</th>
<th>Patellar tendinopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral/bilateral tendinopathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current pain (%)</td>
<td>n;</td>
</tr>
<tr>
<td></td>
<td>65% (13)/35% (7)</td>
<td>75% (12)/25% (4)</td>
</tr>
<tr>
<td></td>
<td>Pain last 6 months (%)</td>
<td>n;</td>
</tr>
<tr>
<td></td>
<td>71% (12)/29% (5)</td>
<td>80% (8)/20% (2)</td>
</tr>
<tr>
<td></td>
<td>Previous diagnosis (%)</td>
<td>n;</td>
</tr>
<tr>
<td></td>
<td>79% (11)/21% (3)</td>
<td>75% (6)/25% (2)</td>
</tr>
<tr>
<td>Duration of pain (months)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current pain</td>
<td>12 ± 19</td>
</tr>
<tr>
<td></td>
<td>Pain last 6 months</td>
<td>2 ± 2</td>
</tr>
<tr>
<td></td>
<td>Previous diagnosis</td>
<td>6 ± 6</td>
</tr>
<tr>
<td>VISA score</td>
<td>Current pain</td>
<td>74 ± 15</td>
</tr>
<tr>
<td></td>
<td>Pain last 6 months</td>
<td>73 ± 23</td>
</tr>
<tr>
<td>Movement which caused the most pain</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current pain</td>
<td>Takeoff: 35%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Landing: 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accelerating: 30%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other: 10%</td>
</tr>
<tr>
<td></td>
<td>Pain last 6 months</td>
<td>Takeoff: 24%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Landing: 6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accelerating: 59%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other: 12%</td>
</tr>
<tr>
<td>Pain affected performance (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current pain</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>Pain last 6 months</td>
<td>59%</td>
</tr>
<tr>
<td>Pain increase during heavy training weeks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current pain</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>Pain last 6 months</td>
<td>59%</td>
</tr>
</tbody>
</table>

Severity of the injury (VISA score) was quantified for athletes with current pain or in the last 6 months.
results of no-effect risk factors such as age, gender, body mass, or body height on the prevalence of Achilles tendinopathy in masters athletics athletes (Longo et al., 2009).

On average, Achilles tendon pain lasted for 12 months and currently injured athletes scored 74 points on the VISA-A questions. Interestingly, athletes who reported that they had been injured in the last 6 months also reported an average score of 73, suggesting they still experienced pain and/or limited function or sports participation. 18% (3/17) of these athletes reported they had stiffness when first getting up, felt pain when doing single-leg heel raises, and could do minimal pain-free single-leg hops. Why these athletes reported not being currently injured with such high pain remains unclear, although it is speculated that these athletes may have considered themselves “uninjured” if they were able to complete their sport training. It can be suggested, however, that residual pain, stiffness, and limited function remain when returning to the sport, confirming the chronic nature and impact of Achilles tendinopathy.

The highest patellar tendinopathy prevalence was found in the combined athletes (73%), the athletes that have also been shown to be the most injured during competition (Alonso et al., 2012). No known research has investigated the reason for a high lower-limb overuse injury prevalence in combined athletes. In the current study, however, as no difference in training hours were found between the groups, it is likely that the content and variation of the training, including the type and frequency of jumps, may explain the injury prevalence discrepancy. More detailed information on the type of training athletes performed, such as sprinting, interval training, or plyometric training would provide more insights into this difference. This, however, was not collected in the current study and it is suggested that future research consider the influence of training type. Further research should quantify the training load and magnitude of patellar tendon loading in activities that are typically included in training sessions for elite combined athletes in order to provide evidence upon which training programmes can be structured to reduce the risk of patellar tendinopathy.

The second highest patellar tendinopathy prevalence group was found to be the throwing athletes. As mentioned above, patellar tendinopathy development is thought to have a multifactorial aetiology. Throwers were significantly taller, heavier, and conducted more strength training, risk factors which by some researchers have been related to patellar tendinopathy development (Lian et al., 1996). In particular, Lian and colleagues (1996) reported that volleyball players with patellar tendinopathy were capable of generating greater eccentric quadriceps strength, and greater eccentric quadriceps strength has also been identified as a predictor of patellar tendon loading during landing (Janssen, Steele, Munro, & Brown, 2013). Although the magnitude of patellar tendon force during elite sport has been quantified in sports such as volleyball (Janssen et al., 2013), no known studies have quantified patellar tendon force in any athletics disciplines. In the current study, 69% of the athletes who developed patellar tendinopathy reported that their pain affected their performance, and they experienced pain for, on average, 11 months. Recently, de Vries et al. (2017) reported that 55% of athletes who developed patellar tendinopathy reported reduced sports performance. Combined, these studies demonstrate the impact of this injury on elite athletics athletes and its need to be further investigated.

Although our study is the first known to quantify the prevalence of lower limb tendinopathy in elite athletics, due to the study’s preliminary nature and methodological
limitations, these results should be interpreted with caution. First, it is likely that a responder bias exists where athletes with an injury were more likely to respond than those who have never had an injury. As a result, it is possible that there is an overestimation of Achilles and patellar tendinopathy prevalence; however, this is likely to be evenly distributed per discipline. For these reasons, in order to quantify the Achilles and patellar prevalence at any one time, it is suggested that similar research be conducted on all elite athletes who compete at a large international competition. Conducting such research at a competition, and incorporating data from the medical and coaching staff, may reduce the potential recall errors on injury and training history which may occur as a result of the retrospective nature of the current study. Another limitation of using an online survey may be the use of a self-reported pain map to classify athletes as suffering from Achilles or patellar tendinopathy. Similar visual aids, however, were used with previous research reporting that 95% of patients correctly identified their injury (van der Worp et al., 2012) indicating that it is a suitable method for the diagnosis of patellar tendinopathy.

In conclusion, significant between-discipline difference in Achilles and patellar tendinopathy prevalence was found in elite athletics. The differences in respondent characteristics and training strategies may influence the prevalence of these injuries. Subjective analyses also revealed that a substantial portion of the athletes believed that their performance decreased as a result of their tendon pain. These results together with the long pain duration and lower VISA scores demonstrate the impact of these injuries. For this reason, research into discipline-specific training load and magnitude of Achilles and patellar tendon loading in elite athletics is recommended in order to develop injury prevention programmes to reduce the development of these complicated injuries.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

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