Chapter 5

The impact of physically demanding work of basketball and volleyball players on the risk for patellar tendinopathy and on work limitations

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Abstract
Patellar tendinopathy is a common injury in jumping athletes. Little is known about work-related etiological factors for patellar tendinopathy and related work limitations. The aim of this study was to identify work-related etiological factors for patellar tendinopathy and to determine the relation between patellar tendinopathy and work limitations. Basketball and volleyball players between 18 and 35 years were invited to complete an online-questionnaire concerning knee complaints, etiological risk factors for patellar tendinopathy and related work limitations. A total of 1505 subjects were included in the analysis. Risk factors for patellar tendinopathy were gender and heavy physically demanding work. The odds for having patellar tendinopathy were significantly higher for heavy physically demanding occupations compared to mentally demanding occupations. 30% of subjects with patellar tendinopathy with a physically demanding job reported to be impaired in their work and 17% reported to be less productive. Basketball and volleyball players with heavy physically demanding work seem to have an increased risk for developing patellar tendinopathy. This finding has important clinical relevance in the treatment of this injury. Working activities should be adjusted in order to reduce the total load on the patellar tendon and help prevention and recovery.
Introduction

Patellar tendinopathy (PT) refers to a clinical condition characterized by activity-related anterior knee pain associated with focal patellar tendon tenderness. Its prevalence is high, especially in jumping athletes, where values of 31.9% in elite basketball players and 44.6% in elite volleyball players have been reported. A prevalence of 11.1% has been reported for recreational basketball players. The etiology and histopathology of PT have not been completely elucidated so far. PT is considered to be an ‘overuse injury’ with a failed healing response to repetitive microtrauma. Several risk factors have been described but in a recent review Tiemessen et al. found no studies that looked at occupational risk factors. Knowledge about these risk factors could improve prevention and treatment of PT. Because successful treatment of PT remains challenging, PT often negatively influences an athlete’s career. However, to our knowledge no studies have been published that evaluate the impact of PT on work limitations.

The aim of this study was twofold. First, to identify work-related etiological factors for patellar tendinopathy. Second, to determine the relationship between patellar tendinopathy and work limitations.

Methods

Study population and design

All basketball and volleyball players between 18 and 35 years (n = ± 12000) from the Dutch Basketball Association (NBB) and the Dutch Volleyball Association (NEVOBO) were invited by email to complete an online survey. This was done in cooperation with the NBB and the NEVOBO. The survey was conducted between May and July 2008. A total of 2363 respondents filled out the questionnaire.

Survey

The survey consisted of questions concerning 1) subject characteristics, 2) knee injuries and PT, 3) sports participation, and 4) occupation. In this article the work-related questions will be considered.

1) Subject characteristics: Subjects answered questions about gender and age

2) Knee injuries: Subjects were asked whether they had a knee injury, to indicate the location of pain (indicated on a self-administered pain map (figure 1)) and duration of symptoms. Subjects were classified as having PT if they reported that PT had been diagnosed by a physician or a physical therapist. In addition subjects with pain at the inferior pole of the patella - indicated on the self-administered
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Figure 1. Knee pain map. Subjects selected one picture describing the location of pain most correctly; either A) pain on the medial side of the knee, B) pain on the lateral side of the knee, C) pain on the backside of the knee, D) pain behind and around the patella, E) pain directly under the patella, or F) pain directly above the patella.

Several studies have used self-administered pain maps for the inclusion of subjects with PT. The location of knee pain as indicated on a self-administered pain map corresponds very well with the actual pain location. Subjects who were classified by this method as having PT also completed the Dutch version of the VISA-P questionnaire. This questionnaire asks for pain, function and sports participation in subjects with PT and is an indication of the severity of PT. The score on the VISA-P questionnaire ranges from 0 to 100 points, with 100 points indicating no symptoms.

3) Sports participation: This part consisted of questions concerning the sport sub-
jects were involved in (basketball or volleyball) and hours of practice.
4) Occupation: Subjects were asked for their current job title and how much they performed knee loading movements during their job. The knee loading movements were squatting, kneeling, lifting and jumping. Subjects also answered questions about whether they were impaired in their work, less productive in their work and had job absence due to their knee complaints.

Analysis
Reported occupations were classified by two experts (MF and PK) into four categories according to work demands. The four occupational categories were: Mentally demanding work, Mixed mentally/physically demanding work, Light physically demanding work and Heavy physically demanding work. This final category was divided into two new categories. One category contained all sports-related occupations (professional basketball and volleyball players, sports instructors, professional trainers and physical education teachers) and the other category contained the other non-sports-related occupations. This was done since PT is generally considered a sports injury. Putting sports occupations in the same category with other occupations might obscure the results. Only subjects who had a job were included in the analyses.

Results were analyzed using SPSS version 16. Descriptive statistics of subject characteristics, the VISA-P questionnaire and the knee loading movements, prevalence of PT and impact of PT on work were calculated for each occupational category. Logistic regression analyses with the Enter method were performed with diagnosis of PT (yes/no) as the dependent variable. For calculating the odds ratios (ORs) of the different occupations the category with mentally demanding work was chosen as the reference since occupations in this category are the least physical demanding. Gender, using females as reference, and age were included in the regression analyses as covariates. The same logistic regression analysis was also performed with the number of hours the subjects practiced basketball or volleyball per week as an additional covariate. Jobs within occupational categories that showed to be a risk factor for PT were also analyzed separately.

Results
The response rate for the questionnaire was 20%. Of the 2363 respondents 1505 respondents (421 basketball-players, 1084 volleyball-players) were included in the analysis. People without a job (n=775 (including 749 students)) and incomplete
questionnaires (n=83) were excluded from the analysis. Respondent characteristics for the five occupational categories are shown in Table 1. The prevalence of PT in the total group was 17.8% (basketball 15.0%, volleyball 18.9%). The prevalence was more than twice as high in men compared to women (24.8% vs. 11.9%). The median duration of the PT was 24 (range 1-219) months.

**Work related risk factors**
Logistic regression analysis showed that gender and the two occupational categories with heavy physically demanding jobs were significantly associated with having PT (Table 2). Since there was a difference in training hours between the occupational categories (Table 1), the same analysis was repeated with the hours the subjects practiced basketball or volleyball per week as an additional covariate. This did not change the results. The other significant contributor to the model was gender. Men have a greater risk for PT than women (OR 2.3, 95% CI 1.8 to 3.1). The jobs within the two categories with heavy physically demanding work, for which there were 10 subjects or more, were also analyzed separately. For both food & beverage workers (bartenders, waiters, etc) and for professional basket-

<table>
<thead>
<tr>
<th>Occupational categories</th>
<th>n</th>
<th>Age:</th>
<th>Gender:</th>
<th>Hours of training per week</th>
<th>PT prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentally demanding work</td>
<td>988</td>
<td>30.0 ± 3.8</td>
<td>468</td>
<td>47.4%</td>
<td>3.4 ± 3.1</td>
</tr>
<tr>
<td>Mixed mentally/physically demanding work</td>
<td>251</td>
<td>27.2 ± 4.0</td>
<td>85</td>
<td>33.9%</td>
<td>3.7 ± 3.6</td>
</tr>
<tr>
<td>Light physically demanding work</td>
<td>37</td>
<td>26.1 ± 4.7</td>
<td>11</td>
<td>29.7%</td>
<td>3.9 ± 4.0</td>
</tr>
<tr>
<td>Heavy physically demanding work - non-sports-related</td>
<td>184</td>
<td>24.5 ± 4.4</td>
<td>97</td>
<td>52.7%</td>
<td>4.3 ± 4.5</td>
</tr>
<tr>
<td>Heavy physically demanding work - sports-related</td>
<td>45</td>
<td>25.4 ± 4.1</td>
<td>29</td>
<td>64.4%</td>
<td>8.1 ± 7.7</td>
</tr>
<tr>
<td>Total</td>
<td>1505</td>
<td>27.3 ± 4.1</td>
<td>690</td>
<td>45.8%</td>
<td>3.7 ± 3.7</td>
</tr>
</tbody>
</table>
ball/volleyball players a significant increased risk for PT was found (Table 3). Figure 2 shows the self-reported knee loading for the five occupational categories. Subjects with light and heavy physically demanding jobs performed more knee loading movements compared to the two other categories. In a logistic regression analysis none of these four knee loading movements showed to be an increased risk for PT. However, the professional basketball and volleyball players differed significantly (p<0.001) from all other jobs in number of jumps per day. No differences in self-reported knee loading could be found that accounted for the increased risk in food & beverage workers.

**Impact on work**

The influence of PT on work limitations is shown in Table 4. The VISA-scores for the five occupational categories were comparable ($F_{4,263}=0.332$, p=0.85). More than 25% of the subjects with PT in the occupational categories with physically demanding and mixed mentally/physically demanding jobs were impaired in their work and more than 10% were less productive. People with sports-related jobs were most often impaired and less productive in their work and had the highest job absence due to PT. The median duration of job absence for the 14 subjects who reported job absence was 10 (range 1-120) days with 65% of the job absence lasting less than 15 days. No comparison of job absence duration between occupational groups could be performed because of the low number of subjects that reported job absence.

<table>
<thead>
<tr>
<th>Table 2. Results of the logistic regression analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covariates</td>
</tr>
<tr>
<td>Gender (male)</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Occupational Category</td>
</tr>
<tr>
<td>(ref: mentally demanding work)</td>
</tr>
<tr>
<td>Mixed mentally/physically demanding work,</td>
</tr>
<tr>
<td>Light physically demanding work</td>
</tr>
<tr>
<td>Heavy physically demanding work - non-sports-related</td>
</tr>
<tr>
<td>Heavy physically demanding work - sports-related</td>
</tr>
</tbody>
</table>

**p≤0.01 * p≤0.05**
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Discussion

The main finding of the present study is that heavy physically demanding work seems to be a risk factor for developing PT in people who play basketball or volleyball. Also, PT has a considerable impact on work limitations.

Work related risk factors

As far as we know, this was the first study to investigate the relationship between work related etiological factors and PT. No studies have been published which evaluate occupational risks for developing this specific injury.\textsuperscript{6} We found that heavy physically demanding jobs might increase the risk for developing PT in people who also play basketball or volleyball compared to people with mentally demanding work. Risk increased both for people with non-sports-related heavy physically demanding work as well as for people with sports-related heavy physically demanding work. Including the training hours in the analysis had no effect on the risk for people with non-sports-related heavy demanding work, which indicates that the increased risk is independent of training hours.

The increased risk for professional basketball/volleyball players has been described in the literature and it is also the reason why PT is often referred to as jumper’s knee.\textsuperscript{2, 14} This is also reflected in that professional basketball/volleyball players differed significantly from all other jobs in the number of jumps performed per day. The reason why food & beverage workers show an increased risk for PT is unclear. There is not much literature available on knee injuries in food & beverage workers. One study among hotel restaurant workers reported that 33% had pain in the

\begin{table}
\centering
\caption{Odds ratios (OR’s) for the different jobs within the two heavy physically demanding work categories (OR’s for jobs with n<10 are not shown).}
\begin{tabular}{llll}
\hline
Occupational category & Job title & N & OR (95 % CI) \\
\hline
Heavy physically demanding work - non-sports-related & Automotive repair workers & 11 & 1.6 (0.5-5.8) \\
 & Care givers/Nurses & 76 & 1.5 (0.8-2.8) \\
 & Construction workers & 20 & 0.8 (0.3-2.5) \\
 & Food & Beverage workers & 22 & 3.3** (1.3-8.0) \\
Heavy physically demanding work - sports-related & Physical education teachers & 32 & 1.7 (0.8-3.8) \\
 & Professional basketball/volleyball players & 10 & 7.8** (1.9-31.1) \\
\hline
\end{tabular}
\end{table}

** p<0.01
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knee/thigh region in the previous month, but no information was given on the type of the injury. The finding that physically demanding work increases the risk for developing PT might indicate that subjects with these jobs perform certain movements that increase the risk for this injury. It is clear that people with physically demanding work perform more knee loading movements than subjects with mentally demanding work (figure 2). Yet, except for jumping in professional athletes, none of the specific loading movements (squatting, kneeling, lifting and jumping) could be identified as a risk factor for PT. Further research is needed to gain more specific knowledge of which movements can be considered risk factors.

The present findings have important clinical relevance in the treatment of PT. Kountouris & Cook (2007) described a tendon rehabilitation program consisting of three components. One of these components is managing tendon pain by modifying tendon load. Reducing load will diminish symptoms and makes it possible to perform an exercise program. The present findings indicate that working activities should also be taken into account when adjusting the load to the patellar tendon.

Gender

<table>
<thead>
<tr>
<th>VISA-P score (95% CI)</th>
<th>% of subjects with PT that is impaired in performing their job</th>
<th>% of subjects with PT that is less productive</th>
<th>Job absence in subjects with PT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentally demanding work</td>
<td>67.0 (64.4 - 69.7)</td>
<td>8% (14/167)</td>
<td>4% (6/167)</td>
</tr>
<tr>
<td>Mixed mentally/physically demanding work</td>
<td>67.2 (61.4 – 73.0)</td>
<td>26% (9/35)</td>
<td>11% (4/35)</td>
</tr>
<tr>
<td>Light physically demanding work</td>
<td>75.50#</td>
<td>0% (0/2)</td>
<td>0% (0/2)</td>
</tr>
<tr>
<td>Heavy physically demanding work – non-sports-related</td>
<td>62.4 (56.9 - 68.0)</td>
<td>27% (13/48)</td>
<td>10% (5/48)</td>
</tr>
<tr>
<td>Heavy physically demanding work - sports-related</td>
<td>65.7 (56.5 - 74.9)</td>
<td>50 % (8/16)</td>
<td>31% (5/16)</td>
</tr>
<tr>
<td>Total</td>
<td>66.2 (64.0 - 68.3)</td>
<td>16% (44/268)</td>
<td>8% (20/268)</td>
</tr>
</tbody>
</table>

# No 95% CI is given since only two subjects in this category were diagnosed with PT

Gender

Being male was identified as a risk factor for PT in the logistic regression analy-
sis. The prevalence of PT was about twice as high in men compared to women, which corresponds with a previous study that found the same ratio.\textsuperscript{2} According to the authors of that study this gender difference may be explained by the lower force-generating capacity of the quadriceps in women. Another explanation of this difference may be that estrogen plays a protective role.\textsuperscript{17} Other studies, however, have shown that estrogen inhibits exercise induced collagen synthesis in the human tendon and leads to a lower rate of tendon tissue repair.\textsuperscript{18, 19} Since PT has a multifactorial etiology it is difficult to draw firm conclusions with regard to differences in gender and the role of estrogens.

**Impact on work**

The results show that PT has a considerable impact on work limitations and productivity. A high percentage of subjects, diagnosed with PT, was impaired in their work or less productive. Since the median duration of PT in the studied population was 24 months, this injury has considerable consequences for employers and employees. The percentage of subjects for whom PT interfered with performing the

![Figure 2. Mean and 95% CI for self-reported knee loading during work per day for the five occupational groups.](image)
job is highest in the sports-related category. This is also the only category where job absence is substantial. This is because PT is a sports injury and it therefore has the most influence on sports-related work. Another reason might be that sports participation requires a near maximal performance. Although there was a difference between the occupational groups in the impact that PT has on work limitations, the severity of PT as indicated by VISA-P scores was comparable.

Limitations

One limitation of this study is the low response rate of 20%. Online questionnaires have in general a lower response rate compared to other survey methods (e.g. paper or telephone surveys). Because an advantage of an online questionnaire is that more subjects can be approached, the absolute response rate may be comparable to that of other survey methods. Another reason for the low response may be that subjects without knee complaints were less inclined to complete the survey. This may have resulted in a selection bias and an increased prevalence of PT in this study. The influence of this selection bias on the outcomes of risk factors and work limitations is less clear.

The use of an online diagnostic method may also be a limitation. It however appeared to be quite reliable. From the subjects who were classified having PT, 45 were invited to participate in another study. Before inclusion for that study a clinical examination was performed by an experienced sports medicine physician, and PT was diagnosed in 44 of the 45 subjects.

Another limitation of this study is that the studied population may not be representative for all patients with PT since only volleyball and basketball players were invited to complete the questionnaire. It can therefore not be concluded that heavy physically demanding work is a risk factor for PT in people who do not play basketball or volleyball.

The distribution of subjects over the five occupational categories may also be a limitation. A high percentage (66%) of the respondents had mentally demanding work whereas only a small percentage (15%) had heavy physically demanding work. The distribution over the occupational categories in this study, however, seems to correspond with the distribution of the working population in the Netherlands, where almost 50% of the working people have a job that involves computer work and only 20% of the workers regularly perform heavy physically demanding work.
Conclusions
In conclusion, this study shows that sports-related and non-sports-related heavy physically demanding work in basketball and volleyball players are both risk factors for developing PT. This finding has important clinical relevance for treating this injury, and should be taken into account for training and rehabilitation programs. Furthermore, having PT is related with work limitations.
Acknowledgements
We would like to thank S. Roerink for her help with designing and executing the survey. We also would like to thank the Dutch Basketball Association (NBB) and the Dutch Volleyball Association (NEVOBO) for their cooperation with the execution of the survey.

References
