Is a jumper's knee work-related? A systematic review to find evidence for a possible case definition

September 28th 2008

Dr. IJH Tiemessen:

Dr. PPFM Kuijer: p.p.kuijer@amc.nl: 0031-20-566 5339

Dr. CTJ Hulshof:

Prof. Dr. MHW Frings-Dresen

Academic Medical Center, Coronel Institute of Occupational Health, Netherlands Center for Occupational Diseases, Meibergdreef 9, 1100 DD, Amsterdam, the Netherlands

Coronel Institute of Occupational Health

Netherlands Center for Occupational Diseases

amc

Content

Summary

Aim The main aim of this project, as formulated by the Danish Working Environment Authority, is developing a reference document summarizing the evidence for a possible case definition for work-related jumper's knee. A case definition consists at least of information how a jumper's knee should be diagnosed and how the work-relatedness should be assessed.

Methods A systematic search of the international scientific literature was performed within the period 25th of March 2008 to 10th of April 2008 in the scientific databases (a) Medline - biomedical literature, (b) Embase (1980-2008) - biomedical and pharmacological literature and (c) SportDiscus (EBSCOhost, including CINAHL plus) – sport-related literature. Specific inclusion criteria were formulated for disease, exposure, causality and individual risk factors. All types of studies were included.

Results The search strategy retrieved 494 hits for disease; after inclusion, 75 studies remained, of which three were reviews. There were 67 hits for exposure; 28 reports were included (0 reviews). There were 11 hits for causality, of which one was included (0 reviews); for individual risk factors, there were 41 hits, fourteen of which were included (0 reviews).

Jumper's knee is diagnosed based on a history (a dull ache in the anterior knee after strenuous activity) and clinical examination (palpation of the knee and provocation tests). Imaging techniques should be used to exclude other disorders of the knee. No studies found described exposure in an occupational setting. Notably, a positive association between jumper's knee and stress exists only in the context of elite sports such as volleyball and basketball. This stress results from both hours of playing and training, as well as hours of weight-bearing activities and playing or training on a hard surface.

Conclusion Jumper's knee is diagnosed based on a history and clinical examination. No criteria could be formulated for the work-relatedness of jumper's knee in an occupational setting, due to a lack of relevant studies. Only for the elite sports volleyball and basketball is there a positive association described with jumper's knee. We recommend varying parameters for analysis of this issue in a context-dependent fashion. If certain occupations or activities are under investigation, future research will require prospective longitudinal cohorts with clear case definitions and exposure criteria in terms of duration, intensity and frequency.

Introduction

Jumper's knee is among the most frequent injuries in sports (Kujala et al., 2005, Lian et al., 2005) and has upset many professional sporting careers. The term "jumper's knee" was first introduced by Blazina et al. (1973): a gradual insidious onset of aching in the knee centered over the infrapatellar or suprapatellar region, especially localized to the superior or inferior poles of the patella. Blazina et al. (1973) described three phases of pain progressively with the development of jumper's knee: (1) pain during activity, (2) pain during and after the activity and finally, (3) pain during and after the activity for a longer time, making it more difficult to perform.

It is generally accepted that jumper's knee is caused by a dynamic overload, mainly eccentric, of the extensor mechanism of the knee joint (Peers & Lysens, 2005, Fredberg et al., 1999, Khan et al., 1998). Clinically, jumper's knee is characterized by activity related to anterior knee pain and focal tenderness. The pathophysiological mechanism is still not clear, though recent studies suggest jumper's knee is a tendinopathy of the tendon, called tendinosis (Khan et al., 2000, Kannus et al., 1997). Tendinosis is clinically described as a focal area of intratendinous degeneration that is initially asymptomatic. Histologically, it is described as the degeneration of affected tendon cells and collagen fibers, as well as the non-collagenous matrix components. Other research also has shown that it is not an inflammatory response of the tendon (called tendinitis), originally thought to represent the pathophysiological mechanism behind jumper's knee (Maffuli et al., 2004, Khan et al., 1996).

Jumper's knee is mainly associated with sports and sporting activities, especially with repetitive activities such as jumping, but also with climbing, kicking or running (Khan et al., 1998, Fredberg et al., 1999, Peers & Luysens, 2005). Therefore, jumper's knee is perhaps a misleading term. Moreover, the term jumper's knee does not indicate the affected tissue and therefore may also denote other conditions such as patellofemoral pain syndrome (Peers & Lysens, 2005).

Not only those engaged in professional sports, but also those in occupational professions might be at risk for developing jumper's knee. The condition could result from exposure during recreational sports and/or physically stressing work, due to similar biomechanical risk factors. Kinsella (2007) wrote that the vast majority of semi-professional athletes performing a variety of occupational professions complain of symptoms similar to jumper's knee as a result of work-related activities, including walking up and down stairs or sitting for extended periods. If occupational professions are indeed at stake, the high rate of recurrence (Khan et al., 1998) and the risk of the condition becoming chronic might result in decreased work ability and increased sick leave. It is

currently unknown, however, if jumper's knee can be empirically related to work and working activities.

This reference document summarizes whether there are possible causalities between physical exposure at work and the development of jumper's knee. Elite sports will be equated with work, as athletes might come within the law of workers compensation for work-related injuries. Moreover, the physical exposure typical in sports might also be present in specific occupations. Of course, we will be prudent in translating sport-related exposure to traditional work-related exposure, due to possible differences in both population characteristics as well as the intensity and duration of exposure.

The aim of this project, as stated by the Danish Working Environment Authority, is the development of a reference document summarizing the evidence for a possible case definition for work-related jumper's knee. A transparent and evidence-based reference document might overcome disagreements between employers, employees and professionals in occupational health regarding whether jumper's knee can be classified as an occupational disease. Evidence regarding exposure and causality is described herein. In addition, evidence regarding the diagnosis of jumper's knee, individual risk factors, pre-existing diseases and/or conditions are given. The specific research questions in this reference document are thus:

1. What are the signs and symptoms of jumper's knee? How are these diagnosed?
2. What is the prevalence and/or incidence of jumper's knee?
3. What are work and non-work related risk factors associated with the onset or worsening of jumper's knee?
4. Is it possible to describe the work-related and non-work-related risk factors with a dose-effect relationship?
5. What are the consequences of having a jumper's knee for work?
6. What individual risk factors are associated with the onset or worsening of jumper's knee?

Methods

To answer the research questions for the categories of disease, exposure, causality and individual risk factors, we systematically searched the literature within the period from March 25, 2008 to April 10, 2008 in (a) Medline (biomedical literature) (b) Embase (1980-2008), biomedical and pharmacological literature and (c) SportDiscus (EBSCOhost, including CINAHL plus). The search terms for jumper's knee *(ICD-10: M76.5 "tendonitis patellaris")* and its synonyms are presented in appendix 1, table 4. The specific research questions and its corresponding search terms are also shown in appendix 1, table 5-8.

Search strategy and inclusion criteria

The first step in the search strategy was the combination of the search terms for jumper's knee or its synonyms with "AND," along with search terms from specific categories such as disease, exposure, causality and individual risk factors, with no further limits. Step 2 consisted of the application of the general inclusion criteria to title and abstract (see Table 1).

Table 1: Definition of the general inclusion criteria

General inclusion criteria	− study or review describes results regarding jumper's knee (or its synonyms), and
	− working population (18-65 years), and
	− written in English, German, French or Dutch, and
	− a full text (with abstract) should be available, and
	− elite sport is seen as work, and
	− article is published after 1980

In order to maximize consistency across results, application of the general inclusion criteria was performed by the primary researcher (IT). If a title and abstract did not provide enough information to decide whether the general inclusion criteria were met, the article was included in the full text selection. Step 3 applied the specific inclusion criteria to the full text of the article after exclusion of the duplicates. These specific inclusion criteria were defined to ensure capturing all

relevant studies. The specific inclusion criteria were formulated in close relation with the research questions, see Table 2.

Table 2: Specific inclusion criteria for the questions regarding disease, exposure, causality and individual risk factors

Disease	− signs and/or symptoms of the disease are described, or
	− clinical test for the disease are described, or
	− sensitivity and/or specificity of clinical tests are described, or
	− prevalence and/or incidence of the disease are described, or
	− severity of the disease is described in terms of work ability or sick leave, or
	− the prognosis (in terms of work ability) of the disease is described
Exposure	− jobs, tasks or (sport) activities, (work-related or non-work-related) with an increased risk are described (for instance with odds ratios or prevalence ratios), or
	− the time of the onset or worsening of the disease in relation to the exposure is described, or
	− exposure is described in terms of intensity, duration and/ or frequency
Causality	− study has a longitudinal design, and
	− dose-response and dose-effect relations are described, or
	− the exposure and risk are operationalized
Individual risk factors	− individual risk factors for an increased risk for jumper's knee are described

Step 4 was defined as the "snowball method." This "snowball method" consisted of three actions: (1) We checked the references of the included full text articles; (2) we used the option 'related articles' in PubMed and (3) we performed a forward search with 'web of science' for highly relevant full-text articles. All possible relevant articles were included according to the same procedure as described above; first, application of the general inclusion criteria to title and abstract and second, application of the specific inclusion criteria to the full text. The remaining articles were the outcome of our systematic search strategy. In the final step 5, we checked the outcome articles for reviews. If a recently retrieved review was able to answer the specific research questions completely, we used the review article. In case this criterion was not met, we used all identified

articles (final result: step 3 + step 4) to answer the research questions for the four categories, as shown in Appendix 1. Application of the general and specific inclusion criteria was performed by the primary researcher (IT); for points requiring clarification, the second researcher was asked for his point of view (PK). A decision was made based on consensus. If a study was included after one specific search and appeared to be useful for answering another research question, this study was used as well. Moreover, studies suggested by the reviewers of this reference document and that fulfilled the inclusion criteria were also included.

Data extraction

The primary researcher (IT), after reading the full text of the included articles, selected the relevant information to include in table A. The publication date, the country, the type of research (cross-sectional, case-control, cohort [retro- or prospective] or review) were considered relevant information, as well as whether the research was performed in an occupational or sports setting. Second, all relevant data concerning the research questions from the specific categories of disease, exposure, causality and individual risk factors were included. The second (PK) and fourth researcher (MFD) read the extracted data and made critical revisions. Table B provides a summary of the literature results for the categories (disease, exposure, causality and individual risk factors) and their pursuant research questions.

Results

Disease

Literature Search

The results of the systematic literature search for the category "disease" are presented in Figure 1. A total of 494 articles were retrieved from our literature search in the three databases with step 1; this search combined the search terms for jumper's knee and the search terms for disease. Applying the general inclusion criteria to titles and abstracts (step 2) provided 204 articles. We then applied the specific inclusion criteria and excluded the duplicates (step 3) for the remaining articles; this process identified 58 articles deemed relevant. The snowball method resulted in 17 extra hits from which the full text was also read (step 4). The final step (step 5) resulted in three recent reviews (Khan et al., 1998, Fredberg et al., 1999, Peers & Luysens, 2005), which appeared well-suited to answer the research questions concerning the category "disease." Based on the suggestions of the reviewers, we included four extra studies in the results; one study is discussed in the discussion section. All included articles are presented in Table A (Appendix II). A summary of the literature for the specific research questions is given in Table B (Appendix III).

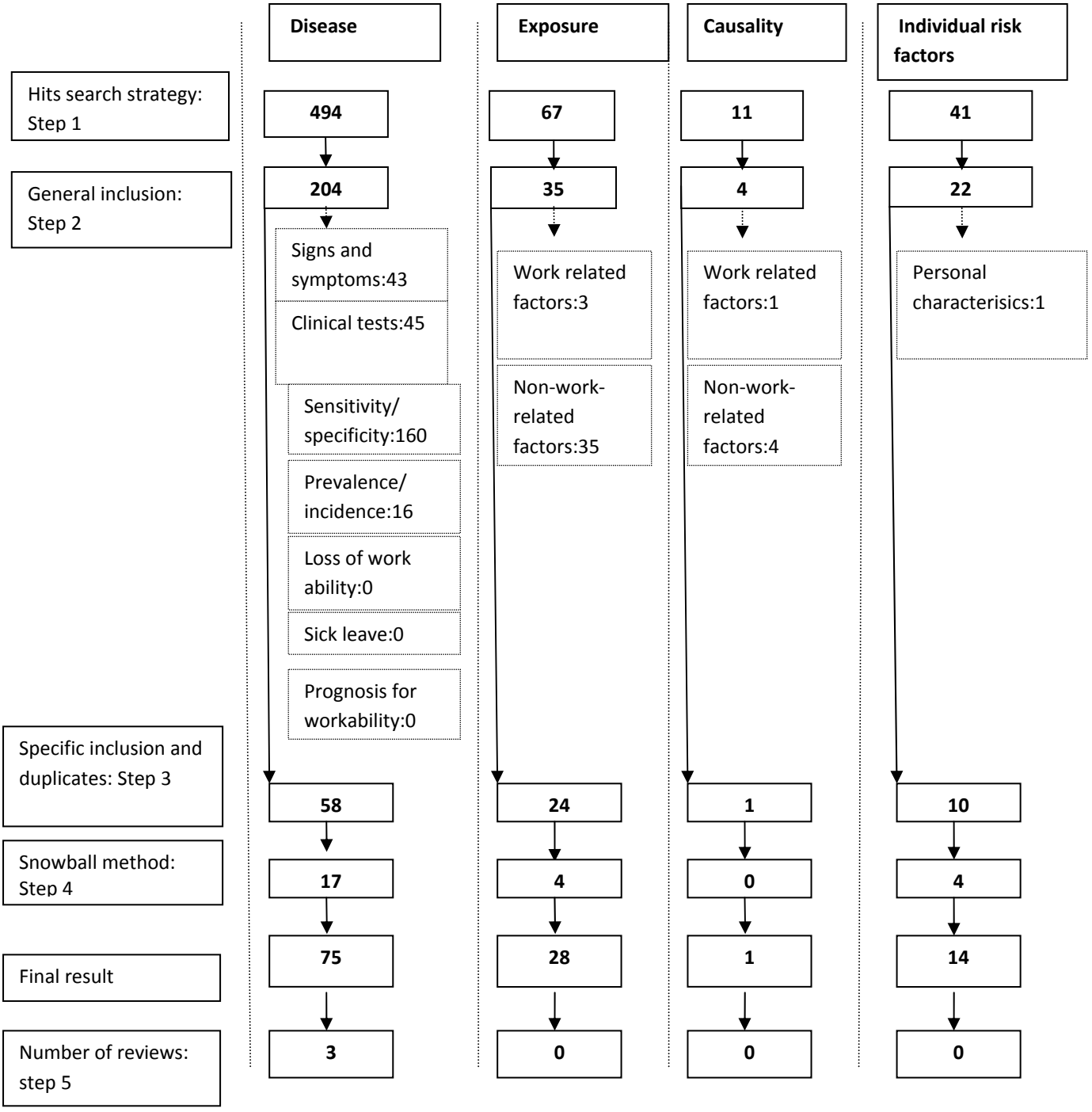

Figure 1: Flow chart of the search strategy (consisting of 5 steps) and the corresponding hits from the different databases tailored for the four research questions concerning disease, exposure, causality and individual risk factors

Specific research questions concerning disease

Signs and symptoms

The diagnosis of jumper's knee starts with the patient's subjective reports of pain, related to their activity levels. At first, the patient will complain about a dull ache in the anterior knee after strenuous activity (Khan et al, 1998). The pain is well localized and starts at the proximal insertion of the patella. The pain in this phase does not interfere with activity; however, when the symptoms of jumper's knee are developing, the pain becomes worse and limits performance. An acute case of jumper's knee may evolve to a chronic state that eventually may result in a rupture of the patellar tendon if the knee is left untreated and intensive activity is continued (Fredberg et al., 1999). The progressive phases of pain were first described by Blazina et al. (1973) and modified by Lian et al. (1996). The pattern of pain associated with jumper's knee is typically located either at the quadriceps tendon at the upper pole of the patella (25% of cases), at the lower pole of the patellar tendon (65% of cases) or at the tibial tuberosity (10% of cases, Ferretti et al., 1985). Other reported symptoms are atrophy of the muscles, malalignment and swelling (Panni et al., 2000).

Three studies (Malliaras et al., 2006a, Cook et al., 2000a, Khan et al., 1997) tried to predict jumper's knee symptoms in volleyball, basketball and elite basketball players over the course of one season. Malliaras et al. (2006a) found a high relative risk (95% CI) for an abnormal image and the development of jumper's knee problems, both with (51.5 [95% CI: 7.2-63.8]) and without pain (14.6 [95% CI: 1.9-111.4], compared to controls. Cook et al. (2000a) also found a relative risk of 4.2 for case tendons (tendons with abnormalities at baseline on US images) to develop jumper's knee symptoms, in comparison to control tendons. Khan et al. (1997) showed that the presence of symptoms of jumper's knee at baseline predicts symptoms of jumper's knee at follow-up ($p<0.05$).

Prevalence or incidence

Jumper's knee is highly prevalent in sports, mainly in volleyball players, showing prevalence in the range of 30%-51% (Bisseling et al., 2008, Gisslen et al., 2005ab, 2007, Lian et al., 2003, Panni et al., 2000, Richards et al., 1996, Ferretti et al., 1984). Among basketball players, prevalence is in the range of 25%-32% (Lian et al., 2005, Panni et al., 2000). Of the reports included in this study, only three reported on incidence. Over a three-year period, Gisslen et al. (2007) found that only 2 out of 27 patellar tendons among elite junior volleyball players developed jumper's knee. This conclusion

was based on clinical and sonographic criteria. Reeser et al. (2006) reported that jumper's knee with time-loss has an incidence of 0.2/1000 athlete exposure among female collegiate volleyball athletes; unfortunately, no time period is mentioned. Witvrouw et al. (2000) found a two-year incidence of 20% among female students playing competitive sports and 11% among male students engaged in competitive sports.

Jumper's knee is also associated with sports involving less jumping activity but with accelerating, decelerating, starting and stopping of the body. For example, among runners, there is a prevalence of 5% (Taunton et al., 2002); among football and netball, prevalence of 21% (Cook et al., 1998). No association is found for cycling or wrestling (prevalence of 0%, Lian et al., 2005).

Neither epidemiological data nor clinical studies were found that report on the prevalence or incidence of jumper's knee in occupational settings.

Sensitivity and specificity

The diagnosis of jumper's knee is based on a history and a clinical examination of the knee. The central theme in the history examination is the development of symptoms in relation to the type of activity performed. The use of subjective assessment questionnaires might help in diagnosing jumper's knee. Visentini et al. (1998) developed the Victiorian Institute of Sport Assessment (VISA) questionnaire. This is a reliable index for the severity of jumper's knee, with an excellent test-retest score (correlation coefficient, r >0.95), inter-tester reliability (r >0.95) and good short-term stability (r =0.87). A VISA score lower than 75 on a scale of 0-100, is generally seen as representative of severe jumper's knee symptoms. Another subjective assessment questionnaire that is sometimes used is the Nirschl scale (Nirschl et al., 1992). This scale (reliability unknown), originally developed for tennis elbow injury, is modified for knee pain and knee function. The last validated questionnaire that is used in the clinical examination for jumper's knee is the Kujala questionnaire (Kujala et al., 1986). This questionnaire (reliability unknown) evaluates subjective symptoms and functional limitations in patients with patellofemoral disorders.

Clinical examinations of jumper's knee can be divided into two kinds of tests: (1) palpation of the knee and (2) provocation tests. The key physical finding in jumper's knee is tenderness when palpating, at the inferior pole of the patella or in the main body of the tendon when the knee is fully extended and the quadriceps relaxed (Khan et al., 1998). Cook et al. (2001) studied the reproducibility and clinical utility of patellar tendon palpation in young basketball players and concluded that this technique is a non-specific (9%) but moderately sensitive (68%) test in

symptomatic athletes. Mild tenderness in asymptomatic athletes is considered as normal and should therefore not be over-interpreted. A study by Antich et al. (1986) found moderate sensitivity (62%) and specificity (67%) for palpation of the knee. The study by Cook et al. (2000b) found a significant association ($p<0.05$) between moderate and severe tenderness with palpation and a tendon abnormality.

The provocation tests that are used during the clinical examination all aim to elicit a specific and generally substantial locatable pain, which is specific for jumper's knee. The most popular provocation tests used in research are the squatting techniques (with one leg (Gisslen et al., 2007, Malliaras et al., 2006a, Purdam et al., 2003, Kettunen et al., 2002), with two legs bearing full body weight (Purdam et al., 2003, Torstensen et al., 1994) or with one or two legs on a decline board (Bains 2006, Malliaras et al., 2006b, Purdam et al., 2003)); the index measured is the isometric contraction of the quadriceps against resistance (Panni et al., 2000, Witvrouw et al., 2000, Boni et al., 1986). Other provocation tests are jumping tests (such as drop jumps (Gisslen et al., 2007), standing jumps (Lian et al., 2003), 15 sec maximal rebound jumps (Lian et al., 2003), one-leg jumps from a certain height (Gisslen et al., 2007)), passive flexion (Boni et al., 1986), passive mediolateral patellar range of movement (Kettunen et al., 2002), and passive maximum stretching (Panni et al., 2000). No studies were found that report on the validity or reliability of these provocation tests, except for Crossley et al. (2007), who reported that the provocation tests in his study all showed good short-term (one week) repeatability (intra-class correlation, ICC>0.8). The study of Purdam et al. (2003) concluded that the single leg squat is the recommended provocation test for the assessment of jumper's knee.

During diagnosis, jumper's knee can be mistaken for other disorders or injuries at the knee such as bursitis, menisci injuries, Osgood-Schlatter, Sinding-Larsen-Johansson syndrome, Hoffa's syndrome or patellofemoral pain syndrome (PFPS). In order to exclude these disorders or injuries, different imaging techniques are used: bone scan (Kinsella 2007, Fredberg et al., 1999), X-ray (röntgen, Pezzulo et al., 1992), scintigraphy (Anuar, 2004), xeroradiography (Bouffard et al., 1993), magnetic resonance imaging (MRI, Peers & Luysens 2005, Fredberg et al., 1999, Khan et al., 1996), ultrasonography (US, Peers & Luysens 2005, Fredberg et al., 1999, Khan et al., 1996), Power Doppler (Gisslen et al., 2007, Terslev et al., 2001), computed tomography (CT) scan (Tibesku et al.,2005, Anuar, 2004, Bouffard et al., 1993) and thermography (Mangine et al., 1997). The sensitivity (specificity unknown) for the bone scan in detection of jumper's knee symptoms is 71% (Green et al., 1996). The reliability of MRI and US has been investigated more frequently. The sensitivity of MRI ranges between 57%-75%, its specificity ranges between 29%-82% (Warden et al., 2007, Shalaby et

al., 1999). MRI also showed an excellent inter- and intra- tester reliability (depending on the knee angle, Tyler et al., 2002). It should be noted that sensitivity and specificity depends on which definition of MR signal changes are used; equivocal (McLoughin grade III or El-Khoury variant) or unequivocal (McLoughin grade I and II) (Shalaby et al., 1999). The sensitivity of US ranges between 75% -82%; its specificity ranges between 71%-87% (Warden et al., 2007, Terslev et al., 2001), with an test-retest reliability of 0.51 (Khan et al., 1999) and high diagnostic accuracy: 83% (Warden et al., 2007). The range of the sensitivity and specificity of power Doppler is high: 92%-94% and 70%-100%, respectively (Warden et al., 2007, Weinberg et al., 1998).

Ultrasonography and MRI are the imaging modalities of choice in patients with jumper's knee and other tendon disorders (Khan et al., 1998). Although CT scans have been shown to be of some prognostic value, they do not offer any significant advantage over methods which do not utilize ionizing radiation (Khan et al., 1998). Imaging of the patella tendon shows calcification, swelling or thickening and hypoechoic regions (fluid accumulation at the damaged location of the tendon). However, these changes in the tendon are rare during the first six months of symptoms and imply a more chronic jumper's knee when diagnosed with imaging techniques. The patellar tendon is well-suited for US evaluation, as the tendon is lying superficially and in parallel with the skin surface. The main advantages of US are that it is cheap, non-invasive, accurate and allows dynamic examination (Fredberg et al., 1999). The main disadvantage of US is that it requires a highly operator depending imaging technique. Jumper's knee symptoms visualized with MRI are best demonstrated on T2-weighted images with high signal intensity (Bains et al., 2006). MRI should be used to identify the exact location and the extent of tendon involvement. The main disadvantages of the MRI are cost and low specificity. In general, changes indicative for jumper's knee correlate (correlation not given) well with the histopathological findings in surgical biopsies (Khan et al., 1996). This good correlation does not necessarily correspond to a good clinical correlation, especially in athletes with less serious symptoms (Blazina's phase 1 and 2) (Cook et al., 2000c). Moreover, it has been shown that symptoms of jumper's knee on US can resolve, remain unchanged or expand without a corresponding change in clinical symptoms (Khan et al., 1997). Therefore, the literature generally agrees on the fact that jumper's knee should be diagnosed clinically and the diagnosis should not be based on imaging techniques alone (Peers & Lysens, 2005).

Work ability, sick leave and prognosis for work ability

As is shown in Figure 1, no studies were found in our systematic search regarding the loss of work ability, the increase of days of sick leave or the prognosis for work ability in an occupational

setting in relation to jumper's knee. Although no prognostic research was identified, a few studies assessed the time-course of jumper's knee symptoms. A study of Kettunen (2002) reported the prognosis of jumper's knee symptoms over a timecourse of fifteen years. One main conclusion in this study was that cases with jumper's knee at baseline showed a long-term (even after 15 years) prognosis of their symptoms (53% stopped their sporting activity due to jumper's knee, compared to 7% of the controls without jumper's knee at baseline). Relatedly, none of the cases with jumper's knee symptoms had changed their job due to their knee problems; however, 53% of the cases did quit their sporting activities (Kettunen et al., 2002).

Exposure

Literature Search

The results of the systematic literature search for the category exposure are also presented in Figure 1. A total of 67 articles were retrieved from our literature search of the three databases with Step 1. Applying the general inclusion criteria to titles and abstracts (step 2) left 35 articles. We then applied the specific inclusion criteria and excluded the duplicates (step 3) to the remaining articles. This resulted in the identification of twenty-four appropriate articles. The snowball method resulted in 4 extra hits. The final step (step 5) did not yield a recent review which was well-suited to answer the research questions concerning the category of exposure.

Specific research questions concerning exposure

Step one and two resulted in three studies about factors which are associated with jumper's knee (van Mechelen, 1992, Lian et al., 2003, Warden et al., 2007). All three studies were performed in a sports setting on runners, high-level male volleyball players and recreational athletes, respectively. The van Mechelen (1992) study was excluded because this study did not meet the specific inclusion criteria. The case-control study of Lian et al. (2003) compared 24 amateur volleyball players in the top division of the Norwegian competition with current jumper's knee with 20 of their counterparts without a history of jumper's knee. The cases significantly performed more hours of weight training per week (cases: 5 hours per week versus controls: 2 hours per week). The cases did not differ from the controls regarding the hours of jump training per week (cases: 0.4 hours per week versus controls: 0.6 hours per week) or the hours of volleyball training per week (cases: 8 hours per week versus controls: 7 hours per week). Warden et al. (2007) performed a case-control study

among 30 cases with jumper's knee and 33 activity-matched controls without jumper's knee. The hours of sporting per week, mainly volleyball, basketball and soccer, were not significantly different between the two groups: 4 hours per week versus 3 hours per week. This result is in agreement with the results of the case-control study of Kettunen et al. (2002). The 18 athletes with jumper's knee (mostly ball players and long-distance runners) and 14 control athletes without jumper's knee (also mostly ball players and long-distance runners) did not differ in the hours of physical activity per week. Notably, no mean hours of physical activity per week were reported; however, based on our calculations from Table 2, the average number of hours was approximately ten. Taunton et al. (2002) conducted a retrospective cohort study of two years among a subgroup of 96 runners with jumper's knee and found that the average number of hours per week of training (6) was not associated with an increased risk. Malliaras et al. (2006b) investigated, in a cross-sectional study, the association between years of volleyball playing and the weekly hours of training and playing over a period of 7 months, among male and female players in the Victorian State League competition in Australia. The outcomes measured were: 1) normal tendon (no pain or tendon abnormalities), 2) tendon abnormality without pain and 3) tendon abnormality with pain. The mean number of years of volleyball playing was eight and the mean weekly hours of training and playing was five. The years of volleyball playing and the weekly hours of training had no relation with tendon abnormality and/or pain.

Crossley et al. (2007) compared in their case-control study the number of sporting hours per week among three groups: 31 controls with no jumpers, 14 cases with jumper's knee in one leg and 13 cases with jumper's knee in two legs. They found mixed results regarding the reported number of sport hours per week. The number of sport hours in the cases with jumper's knee in both legs was significantly higher than in the cases with jumper's knee in one leg as compared to controls: 7 hours a week versus 4 hours and 3 hours per week, respectively (mean difference: 3.2 hours per week, 95% CI 0.6-5.8). The latter two groups, however, did not differ in sport hours per week. The type of sport was not described.

However, other studies did find an association between hours of training and jumper's knee. A cross-sectional study by Ferretti et al. (1984) on elite-volleyball players (>14 hours per week) concluded that the number of playing and training sessions per week increased the prevalence of jumper's knee: 3% with two sessions a week, 15% with 3 sessions, 29% with 4 sessions and 42% with >4 sessions. Cook et al. (2000a) performed a prospective cohort study over a period of 16 months among 26 elite junior basketball players (number of playing and training hours is not mentioned; 15

hours of weight bearing activities per week). They found that 30% of the basketball players with hypoechoic tendons and 7% of the basketball players without hypoechoic tendons developed jumper's knee. Moreover, the significant increase in training volume for men was associated with a significant increase in tendon abnormalities. Cook et al. (2000c) performed a cross-sectional study among elite junior basketball players and state-level swimmers (basketball players (n=134). They documented 15 hours of exercise per week and 12 hours of weight-bearing exercise per week for basketball players. For swimmers (n=29), they reported 17 hours of exercise per week and 3 hours of weight-bearing exercise. At least 7% of the basketball players had jumper's knee but none of the swimmers had the condition. Gaida et al. (2004) compared, in a case-control study, the number of training hours per week among elite female basketball players with no hypoechoic tendons (controls, n=24), hypoechoic tendon in one leg (unilateral cases, n=8) or in both legs (bilateral cases, n=7). They found that in the preceding one to six months, both types of cases trained about 3 hours per week more than the controls. The cases trained on average 12 hours per week and the controls trained 9 hours per week on average.

Finally, Ferretti et al. (1984) found a significant association ($p<0.05$) that a hard playing surface (cement versus parquet) was associated with an increased prevalence of jumper's knee.

In summary, exposure in the context of volleyball (Ferretti et al., 1984) and basketball (Cook et al., 2000a and 2000c, Gaida et al. 2004), in combination with training and playing hours of at least 12 hours per week and/or in combination with weight training of at least 5 hours per week (Lian et al., 2003, Cook et al., 2000c), and/or with playing or training on a hard surface, (Ferretti et al., 1984) seems associated with the prevalence of jumper's knee.

Causality

Literature Search

A total of 11 articles were retrieved from our literature search of the three databases with step 1 (see Figure 1). Applying the general inclusion criteria to titles and abstracts (step 2) left 4 articles. We then applied the specific inclusion criteria and excluded the duplicates (step 3) to the remaining articles. This resulted in identifying one appropriate article. The snowball method did not result in any extra hits nor did the final step (step 5) result in a recent review which was appropriate for answering all research questions concerning the category "exposure."

Specific research questions concerning causality

Steps one and two resulted in one identified article about work-related factors (Jensen & Di Fabio., 1989) and four articles about non-work-related factors (Salas et al., 2003, Karantanas et al., 2001, Yu 1995, Jensen & Di Fabio., 1989) that are associated with jumper's knee and that can be described with a dose-response or dose-effect relation. The identified study about the work-related factors, however, was not about work; rather, it concerned non-professional athletes. This study did not meet the specific inclusion criteria and was therefore not included. Again, our systematic search did not result in any work-related or non-work-related factors that could be described in a dose-response or dose-effect relation in association with jumper's knee. No study was identified that calculated the risk for developing jumper's knee using a longitudinal design. Therefore, the specific research questions concerning causality cannot be answered in this study.

Individual risk factors

Literature Search

A total of 41 articles were retrieved from our literature search of the three databases with step 1. Applying the general inclusion criteria to titles and abstracts (step 2) left 22 articles. We then applied the specific inclusion criteria and excluded duplicates (step 3) of the remaining articles. This resulted in identifying 10 appropriate articles. The snowball method resulted in 4 extra hits. The final step (step 5) did not result in a recent review which was appropriate to answer all research questions concerning the category of exposure.

Specific research questions concerning individual risk factors

The individual risk factors that are associated with the onset or worsening of jumper's knee can be divided into two categories: the intrinsic factors and the extrinsic factors. Certain athletes participating in the same sports, playing in the same positions, on the same team and attending an equal number of training sessions are affected, while others are not. This suggests a role for intrinsic factors in the development of jumper's knee. Intrinsic factors are somatic and morphological characteristics of the individual, for example, upper leg length, age and sex. Extrinsic factors are stimuli external to the athlete but that often increase stress on the tendon, inducing jumper's knee. Examples include the type of playing surface, the number of training sessions and the type of sport activities (Ferretti et al., 1986). The intrinsic factors which have been studied based on the studies we

found are age, anthropometric variables, biomechanical factors (such as jumping ability and landing strategy), body weight, body height, muscle strength, muscle flexibility and sex. The extrinsic factors that have been studied are frequency of play, playing surface and type of activities. These factors were already described in the paragraph regarding exposure.

Intrinsic factors

No consistent evidence was found for gender. The studies from Cook et al. (2000c/2000a/1997) showed that males were more likely to develop jumper's knee than females. However, other studies (Taunton et al., 2002, Witvrouw et al., 2000, Ferretti et la., 1984) did not find this association.

No consistent evidence was found for age as a risk factor for the onset or worsening of jumper's knee. Studies from Cook et al. (2000c/2000a, 1997) and Taunton et al. (2002) did find an association, but other studies from Cook et al. (2004) and Ferretti et al. (1984) did not find this association. However, it does seem consistently true that if there is an association, people within the range of 17-34 years are the population at risk. Aging is not associated with a higher risk for the development of jumper's knee.

No consistent evidence was found for a role played by body weight (Crossley et al., 2007, Warden et al., 2007, Lain et al., 2005, Gaida et al., 2004, Lian et al., 2003, Cook et al., 2000a, Taunton et al., 2000, Antich et al., 1986) and body height (Lian et al., 2005, Taunton et al., 2000, Cook et al., 2000a) as risk factors for the development of jumper's knee. Four studies did find an effect (Crossley et al., 2007, Warden et al., 2007, Lian et al., 2005, Lian et al., 2003) for body weight as a possible risk factor for the development of jumper's knee, while four did not find such a relationship (Gaida et al., 2004, Cook et al., 2000a, Taunton et al., 2000, Antich et al., 1986). One study did find an effect (Lian et al., 2005) for body height as a possible risk factor for the development of jumper's knee, while two (Taunton et al., 2000, Cook et al., 2000a) did not.

Devan et al. (2004) found evidence that muscle strength is associated with the onset or worsening of jumper's knee through utilization of an iso-kinetic force test. If the Hamstring: Quadriceps ratio was below the normal range at 300º/s, the authors found a significant increase in the risk of developing jumpers' knee ($p<0.05$). Other studies did not find this association (Malliaras et al., 2006b, Witvrouw et al., 2000). Limited evidence existed for the relation between patellar tendinopathy and low hamstring and quadriceps flexibility (Witvrouw et al., 2001). There was conflicting evidence for an association between sit and reach flexibility and patellar tendinopathy

(Mallarias et al 2006b; Cook et al. 2003; Crossley et al., 2007); one study supported the finding that sit and reach flexibility is associated with jumper's knee (Crossley et al., 2007).

No consistent evidence is found for the anatomic variable of discrepancy in leg length (Crossley et al., 2007, Witvrouw et al., 2000). Some studies identify an association between high patellar height (Kettunen et al., 2002), reduced ankle dorsiflexion (Malliaras et al., 2006b), greater tendon width (Shalaby et al., 1999) and an increased risk for the onset or worsening of jumper's knee (see table A). No consistent evidence is found for hypoechoic regions. Myllymäki et al. (1990) and Fredberg et al. (2002) both found that hypoechoic regions in the patellar tendon were associated with symptoms of jumper's knee. Cook et al. (2000a) found a 4.2-fold higher risk for the development of jumper's knee symptoms in tendons with hypoechoic regions than in tendons without these regions. Terslev et al. (2001) found no correlation between these regions and symptoms of jumper's knee. In line with these results, Cook et al. (2000c) found that hypoechoic regions are three times as common in clinical manifestations of jumper's knee.

The biomechanical factors that are assessed while jumping are: vertical ground reaction force, knee flexion angles, knee torques, tibial torsional moments and jumping height. A high vertical ground reaction force, deep knee flexion angles and high tibial moments are associated with the onset or worsening of jumper's knee (Richards et al., 1996). No consistent dose-effect relationship is found for better jumping ability (Malliaras et al., 2006b, Cook et al., 2004/2000a, Lian et al., 2005/2003). The biomechanical factors that comprise the landing and are associated with the onset or worsening of jumper's knee are: high inversion moments, high angular velocities, high plantar flexion, high loading rate and a stiff landing technique (Bisseling et al., 2007/2008).

Extrinsic factors

The extrinsic factors that have been studied are frequency of play, playing surface and type of activities. These are described in the paragraph on exposure.

Discussion

Main research question

Jumper's knee is diagnosed based on a history (a dull ache in the anterior knee after strenuous activity) and clinical examination (palpation of the knee and provocation tests). Imaging techniques should be used to exclude other disorders of the knee. No criteria could be formulated for the work-relatedness of jumper's knee in an occupational setting, due to the absence of relevant studies. Only for the elite sports of professional volleyball and basketball is there a significant correlation between the prevalence of jumper's knee on one hand and, on the other, training and playing hours of at least 12 hours per week and/or weight training of at least 5 hours per week and/or playing or training on a hard surface. If certain occupations or activities are particularly conducive to the condition, it should become clear in future research utilizing prospective longitudinal cohorts with clear case definitions and exposure criteria in terms of duration, intensity and frequency.

Was our search in the literature sufficient?

No studies were found that described an association between jumper's knee and work and that described risk factors contributing to the onset or worsening of jumper's knee. To demonstrate the comprehensive nature of our approach, we would like to present three reasons to support the strength of our search strategy.

First, this project focuses on the work-relatedness of jumper's knee. Therefore, we used the most sensitive search string known for "work" from the Cochrane library and searched three databases. By using a less sensitive string which was more specific, our search strategy might have come up with more studies but which would probably have been less appropriate. Moreover, we checked the references of the included articles; we used the option 'related articles' in PubMed and we performed a forward search with 'web of science' for highly relevant articles. Second, because our goal was primarily to explore the evidence for a possible case definition for work-related jumper's knee, we did not apply any methodological criteria in the selection. Therefore, all included studies, with their unique findings, are described and none are left out. Third, the draft of the document was reviewed by experts in the field. Based on their suggestion, four extra studies were included. These included studies were about prevalence and personal risk factors and not about work-related risk factors in an occupational setting.

Is jumper's knee work-related?

The few studies we found that described the risks of developing the jumper's knee were all performed in the context of sports. No studies regarding jumper's knee in occupational settings were found. The study by Myllymaki et al. (1993), suggested to us by a reviewer, compared two occupational groups (carpet-layers [n=95] and house-painters [n=73]) for tendon abnormalities diagnosed by ultrasonograhy that might be related to jumper's knee. Tendon abnormalities were present in one carpet-layer and in two house-painters. Because no symptoms were reported, the study was excluded.

Regarding sports, exposure to volleyball (Ferretti et al., 1984) and basketball (Cook et al., 2000a and 2000c, Gaida et al. 2004), with training and playing hours of at least 12 hours per week and/or in combination with weight training of at least 5 hours per week (Lian et al., 2003, Cook et al., 2000c) and/or with playing or training on a hard surface (Ferretti et al., 1984) seems associated with the prevalence of jumper's knee. These activities probably result in a high load on the patellar tendon, which might increase the risk of jumper's knee. Taking into account the younger age and higher fitness level of the elite athletes compared to the 'average worker', these results hamper generalisation of the work-relatedness of jumper's knee for the occupational setting. A probably prerequisite is that in occupations at risk, high patellar loads will be present. This might be the case in occupations in which physical training is a part of the job, such as in police-work or in fire-fighting. However, exposure in terms of training hours might be relatively low. Moreover, knee-straining activities such as the frequent climbing of stairs while handling loads and/or jumping of objects might be risk factors for window-cleaners, construction workers, and truck-drivers that handle packaged goods (Kinsella, 2007). As mentioned previously, no studies were found that examined these assumptions. However, we would like to refer to a study recently begun at the University of Groningen in Netherlands; it is a cohort study with a prospective, longitudinal design. This study investigates the development of jumper's knee in a large group of volleyball players and will assess the effectiveness of an implemented intervention program. Not only is exposure in terms of hours playing and training assessed, but also the exposure due to knee-straining activities such as stair-climbing or knee-bending.

Future research

There was a lack of standard case definitions for jumper's knee, making it hard to compare the results of different studies. Some studies defined jumper's knee in terms of (history of) pain and/or VISA scores during physical activity and/or palpation, while others defined it as an evident focal hypoechoic region in both longitudinal and transverse images and/or appearance of a diffused hypoechoic region and thickening in the proximal tendon. Studies should use unequivocal case-definitions of jumper's knee and use similar diagnostic methods so that the results can be compared with validity. We suggest, based on the evidence found in this project, defining jumper's knee in the way that Blazina et al. (1973) did: "a gradual insidious onset of aching in the knee centered over the infrapatellar or suprapatellar region, especially localized to the superior or inferior poles of the patella." Moreover, exposure to knee-straining activities in the contexts of sports and work should be assessed in terms of frequency, duration and intensity. Due to the relevance of a high patellar load, the intensity should preferably be expressed in terms of a biomechanical load that can be compared across studies, similar to the protocol used in work-related studies regarding loads on the shoulder and lower back.

Conclusion

(1) What are jumper's knee signs and symptoms and how are these diagnosed?

Diagnosing jumper's knee is done with a history (a dull ache in the anterior knee after strenuous activity) and clinical examination (palpation of the knee and provocation tests). Imaging techniques should be used to exclude other disorders of the knee. However, work-related factors require a more prominent role in the history examination, as the current focus in all identified studies is on sporting activities alone.

(2) What is the prevalence and/or incidence of jumper's knee?

The prevalence for jumper's knee ranged from 30%-51% in volleyball; 25%-32% in basketball; and 0% for cycling and wrestling. The reported incidence measures for jumper's knee in sports were not mutually comparable: 2 out of 27 patellar tendons in a three-year period among elite junior volleyball players developed jumper's knee. Jumper's knee with time-loss has an incidence of 0.2/1000 athlete exposure among female collegiate volleyball athletes; there is a 2-year incidence of 20% among female students in competitive sports and of 11% among male students in competitive sports. No prevalence or incidence figures were found for work.

(3) What are the work- and non-work-related factors associated with the onset or worsening of jumper's knee?

No work-related factors in the context of work were found in the literature. With regard to sports, exposure to volleyball and basketball seems associated with the prevalence of jumper's knee. These sports are characterized by frequent jumping and landing. The assumption is that a high patellar load due to accelerating and decelerating while bending and extending the knees, during jumping and landing, causes the onset of jumper's knee.

(4) Is it possible to describe the work-related and non-work-related factors in a dose-effect relation?

No studies described the work-related and non-work-related exposures in an occupational setting in a dose-effect relation. According to some of the studies, training and playing hours of at least 12 hours per week and/or in combination with weight training of at least 5 hours per week and/or with playing or training on a hard surface increases the risk of jumper's knee.

(5) How does having a jumper's knee affect work?

Due to the limited availability of research about work-related jumper's knee, we cannot answer the questions about the relation between jumper's knee and work ability, or the questions regarding the prognosis for work and the days of sick leave.

(6) What individual risk factors are associated with the onset or worsening of jumper's knee?

No consistent evidence is found for any individual risk factors that are associated with the onset or worsening of jumper's knee. Limited evidence is found for some anatomic variables and some biomechanical factors. The factors that are identified are: age between 17-34, high patellar height, reduced ankle dorsiflexion and low hamstring or quadriceps flexibility.

Acknowledgements

The authors thank the reviewers Dr LK Jensen MD, S Rytter MD and KP Martimo MD for their critical appraisal of the draft of the reference document and their constructive comments that have improved the quality of the reference document.

References

Antich TJ, Randall CC, Westbrook FA, Morrissey MC, Brewster CE. 1986. Evaluation of knee extensor mechanism disorders: clinical presentation of 112 patients. Journal of Orthopaedic & Sports Physical Therapy 8:248-254.

Anuar K. 2004. Current concepts in the pathology and diagnosis of patellar tendinopathy. Physiotherapy Singapore 7: Sep.

Bains BSP. 2006. Lower limb tendinopathy in athletes. Trauma 8:213-224.

Beam JW, Lozman PR, Uribe JW. 1995. Surgical treatment of chronic patellar tendinitis in a collegiate football player. Journal of Athletic Training 30:342-344.

Bisseling RW, Hof AL, Bredeweg SW, Zwerver J, Mulder T. 2007. Relationship between landing strategy and patellar tendinopathy in volleyball. Br J Sports Med 41:e8.

Bisseling RW, Hof AL, Bredeweg SW, Zwerver J, Mulder T. 2008. Are the takeoff and landing phase dynamics of the volleyball spike jump related to patellar tendinopathy? Br J Sports Med Epub ahead of print.

Blazina ME, Kerlan RK, Jobe FW, Carter VS, Carlson GJ. 1973. Jumper's knee. Orthop Clin North Am 4:665-678.

Boni M, Benazzo F, Castelli C, Barnabei G. 1986. Jumper's knee. New Studies in Athletics 1:65-80.

Bouffard JAE. 1993. Sonography of tendons. Ultrasound Quarterly 11:1993.

Briner J. 1997. Common injuries in volleyball. Mechanisms of injury, prevention and rehabilitation. Sports Medicine 24:65-71.

Chung B, Wiley JP. 2002. Extracorporeal shockwave therapy: a review. Sports Med 32:851-865.

Cook JL, Khan KM, Harcourt PR, Grant M, Young DA, Bonar SF. 1997. A cross sectional study of 100 athletes with jumper's knee managed conservatively and surgically. The Victorian Institute of Sport Tendon Study Group. Br J Sports Med 31:332-336.

Cook JL, Khan KM, Harcourt PR, Kiss ZS, Fehrmann MW, Griffiths L, Wark JD. 1998. Patellar tendon ultrasonography in asymptomatic active athletes reveals hypoechoic regions: a study of 320 tendons. Victorian Institute of Sport Tendon Study Group. Clin J Sport Med 8:73-77.

Cook JLK. 2000a. Prospective imaging study of asymptomatic patellar tendinopathy in elite junior basketball players. Journal of Ultrasound in Medicine 19:473-479.

Cook JL, Khan KM, Maffulli N, Purdam C. 2000b. Overuse tendinosis, not tendinitis. Part 2: applying the new approach to patellar tendinopathy. Physician & Sportsmedicine 28:31-32.

Cook JL, Khan KM, Kiss ZS, Griffiths L. 2000c. Patellar tendinopathy in junior basketball players: a controlled clinical and ultrasonographic study of 268 patellar tendons in players aged 14-18 years. Scandinavian Journal of Medicine & Science in Sports 10:216-220.

Cook JL, Khan KM, Kiss ZS, Purdam CR, Griffiths L. 2001. Reproducibility and clinical utility of tendon palpation to detect patellar tendinopathy in young basketball players. British Journal of Sports Medicine 35:65-69.

Cook JL, Kiss ZS, Khan KM, Purdam CR, Webster KE. 2004. Anthropometry, physical performance, and ultrasound patellar tendon abnormality in elite junior basketball players: a cross-sectional study. British Journal of Sports Medicine 38:206-209.

Crossley KMT. 2007. Clinical features of patellar tendinopathy and their implications for rehabilitation. Journal of Orthopaedic Research 25:1164-1175.

Devan MR, Pescatello LS, Faghri P, Anderson J. 2004. A prospective study of overuse knee injuries among female athletes with muscle imbalances and structural abnormalities. Journal of Athletic Training 39:263-267.

Dubravcic-Simunjak S, Pecina M, Kuipers H, Moran J, Haspl M. 2003. The incidence of injuries in elite junior figure skaters. Am J Sports Med 31:511-517.

Ferretti A, Puddu G, Mariani PP, Neri M. 1984. Jumper's knee: An epidemiological study of volleyball players. the physician and sportmedicine 12:97-106.

Ferretti A. 1986. Epidemiology of jumper's knee. Sports Med 3:289-295.

Fredberg U. 1997. Local corticosteroid injection in sport: review of literature and guidelines for treatment. Scand J Med Sci Sports 7:131-139.

Fredberg U. 1999. Jumper's knee: review of the literature. Scand J Med Sci Sports 9:66-73.

Fredberg U, Bolvig L. 2002. Significance of Ultrasonographically Detected Asymptomatic Tendinosis in the Patellar and Achilles Tendons of Elite Soccer Players: A Longitudinal Study. Am. J. Sports Med. 30:488-491.

Fredberg U, Bolvig L, Andersen NT. 2008. Prophylactic Training in Asymptomatic Soccer Players With Ultrasonographic Abnormalities in Achilles and Patellar Tendons. American Journal of Sports Medicine 36:451-460.

Gaida JEC. 2004. Are unilateral and bilateral patellar tendinopathy distinguished by differences in anthropometry, body composition, or muscle strength in elite female basketball players? British Journal of Sports Medicine 38:581-584.

Gisslen K, Gyulai C, Söderman K, Alfredson H. 2005a. High prevalence of jumper’s knee and sonographic changes in Swedish elite junior volleyball players compared to matched controls. Br J Sports Med 39:298–301.

Gisslen K, Alfredson H. 2005b Neovascularisation and pain in jumper's knee: a prospective clinical and sonographic study in elite junior volleyball players. Br J Sports Med 39:423–428.

Gisslen KG. 2007. Normal clinical and ultrasound findings indicate a low risk to sustain jumper's knee patellar tendinopathy: A longitudinal study on Swedish elite junior volleyball players. British Journal of Sports Medicine 41:253-258.

Green JS, Morgan B, Lauder I, Finlay DB, Allen M, Belton I. 1996. The correlation of bone scintigraphy and histological findings in patellar tendinitis. Nucl Med Commun 17:231-234.

Hamilton B, Purdam C. 2004. Patellar tendinosis as an adaptive process: a new hypothesis. Br J Sports Med 38:758-761.

Jensen K, Di Fabio RP. 1989. Evaluation of eccentric exercise in treatment of patellar tendinitis. Physical Therapy 69:211-216.

Johnson DP, Wakeley CJ, Watt I. 1996. Magnetic resonance imaging of patellar tendonitis. J Bone Joint Surg Br 78:452-457.

Kannus P. 1997. Etiology and pathophysiology of chronic tendon disorders in sports. Scand J Med Sci Sports 7:78-85.

Karantanas AHZ. 2001. Increased signal intensity on fat-suppressed three-dimensional T1-weighted pulse sequences in patellar tendon: Magic angle effect?
1. Skeletal Radiology 30:2001.

Kettunen JA, Kvist M, Alanen E, Kujala UM. 2002. Long-term prognosis for jumper's knee in male athletes. A prospective follow-up study. Am J Sports Med 30:689-692.

Khan KM, Bonar F, Desmond PM, Cook JL, Young DA, Visentini PJ, Fehrmann MW, Kiss ZS, O'Brien PA, Harcourt PR, Dowling RJ, O'Sullivan RM, Crichton KJ, Tress BM, Wark JD. 1996. Patellar tendinosis (jumper's knee): findings at histopathologic examination, US, and MR imaging. Victorian Institute of Sport Tendon Study Group. Radiology 200:821-827.

Khan KM, Cook JL, Kiss ZS, Visentini PJ, Fehrmann MW, Harcourt PR, Tress BW, Wark JD. 1997. Patellar tendon ultrasonography and jumper's knee in female basketball players: a longitudinal study. Clin J Sport Med 7:199-206.

Khan KM, Maffulli N, Coleman BD, Cook JL, Taunton JE. 1998. Patellar tendinopathy: some aspects of basic science and clinical management. Br J Sports Med 32:346-355.

Khan KM, Visentini PJ, Kiss ZS, Desmond PM, Coleman BD, Cook JL, Tress BM, Wark JD, Forster BB. 1999. Correlation of ultrasound and magnetic resonance imaging with clinical outcome after patellar tenotomy: prospective and retrospective studies. Clin J Sport Med 9:129-137.

Kinsella D. 2007. Methods of addressing anterior knee pain (AKP), specifically patellar tendinopathy in an Australian Rules Football Club. Strength & Conditioning Coach 15:11-24.

Kujala UM, Osterman K, Kvist M, Aalto T, Friberg O. 1986. Factors predisposing to patellar chondropathy and patellar apicitis in athletes 172. Int Orthop 10:195-200.

Lian O, Refsnes PE, Engebretsen L, Bahr R. 2003. Performance characteristics of volleyball players with patellar tendinopathy. American Journal of Sports Medicine 31:408-413.

Lian OB, Engebretsen L, Bahr R. 2005. Prevalence of jumper's knee among elite athletes from different sports: a cross-sectional study. Am J Sports Med 33:561-567.

Maffulli N, Testa V, Capasso G, Ewen SW, Sullo A, Benazzo F, King JB. 2004. Similar Histopathological Picture in Males with Achilles and Patellar Tendinopathy
12. Medicine & Science in Sports & Exercise 36:1470-1475.

Malanga GA, Andrus S, Nadler SF, McLean J. 2003. Physical examination of the knee: a review of the original test description and scientific validity of common orthopedic tests. Arch Phys Med Rehabil 84:592-603.

Malliaras P, Cook J. 2006a. Patellar tendons with normal imaging and pain: change in imaging and pain status over a volleyball season. Clin J Sport Med 16:388-391.

Malliaras P, Cook J, Kent P. 2006b. Reduced ankle dorsiflexion range may increase the risk of patellar tendon injury among volleyball players. Journal of Science & Medicine in Sport 9:304-309.

Malliaras P, Cook JL, Kent PM. 2007. Anthropometric risk factors for patellar tendon injury among volleyball players. Br J Sports Med 41:259-263.

Mangine RE, Siqueland KA, Noyes FR. 1987. The use of thermography for the diagnosis and management of patellar tendinitis. Journal of Orthopaedic & Sports Physical Therapy 9:132-140.

McLoughlin RFR. 1995. Patellar tendinitis: MR imaging features, with suggested pathogenesis and proposed classification. Radiology 197:843-848.

Myllymaki T, Bondestam S, Suramo I, Cederberg A, Peltokallio P. 1990. Ultrasonography of jumper’s knee. Acta Radiologica 31:147-149.

Myllymaki T, Tikkakoski T, Typpo T, Kivimaki J, Peltokallio P Suramo I. 1993. Carpet-layer’s knee: an ultrasonographic study. Acta Radiologica 34:496-499.

Nirschl R. 1992. Elbow tendinosis/ tennis elbow. Clin J Sport Med 11:851-870.

Panni AS, Tartarone M, Maffulli N. 2000. Patellar tendinopathy in athletes. Outcome of nonoperative and operative management. Am J Sports Med 28:392-397.

Peace KAL. 2006. Imaging the infrapatellar tendon in the elite athlete. Clinical Radiology 61:570-578.

Peers KH, Lysens RJ. 2005. Patellar tendinopathy in athletes: current diagnostic and therapeutic recommendations. Sports Med 35:71-87.

Pezzullo DJ, Irrgang JJ, Whitney SL. 1992. Patellar tendonitis: jumper's knee. Journal of Sport Rehabilitation 1:56-68.

Purdam C, Cook J, Hopper DM, Khan KM. 2003. Discriminative ability of functional loading tests for adolescent jumper's knee. Physical therapy in sports 4:3-9.

Reeser JC, Verhagen E, Briner WW, Askeland TI, Bahr R. 2006. Strategies for the prevention of volleyball related injuries. Br J Sports Med 40:594-600.

Richards DP, Ajemian SV, Wiley JP, Zernicke RF. 1996. Knee joint dynamics predict patellar tendinitis in elite volleyball players. American Journal of Sports Medicine 24:676-683.

Richards DPA. 2002. Relation between ankle joint dynamics and patellar tendinopathy in elite volleyball players. Clinical Journal of Sport Medicine 12:Sep.

Sallis RE. 2003. Hip Strength and Patellofemoral Pain Syndrome. Physician & Sportsmedicine 31:13-18.

Schmid MR, Hodler J, Cathrein P, Duewell S, Jacob HA, Romero J. 2002. Is impingement the cause of jumper's knee? Dynamic and static magnetic resonance imaging of patellar tendinitis in an open-configuration system. Am J Sports Med 30:388-395.

Shalaby M, Almekinders LC. 1999. Patellar tendinitis: the significance of magnetic resonance imaging findings. American Journal of Sports Medicine 27:345-349.

Taunton JE, Ryan MB, Clement DB, McKenzie DC, Lloyd-Smith DR, Zumbo BD. 2002. A retrospective case-control analysis of 2002 running injuries. Br J Sports Med 36:95-101.

Terslev L, Qvistgaard E, Torp-Pedersen S, Laetgaard J, nneskiold-Samsoe B, Bliddal H. 2001. Ultrasound and Power Doppler findings in jumper's knee - preliminary observations. Eur J Ultrasound 13:183-189.

Tibesku CO, Passler HH. 2005. Jumper's knee-a review. Sportverletz Sportschaden 19:63-71.

Torstensen ETB. 1994. Patellar tendinitis: A review of current concepts and treatment. Clinical Journal of Sport Medicine 4:77-82.

Tyler TF, Hershman EB, Nicholas SJ, Berg JH, McHugh MP. 2002. Evidence of abnormal anteroposterior patellar tilt in patients with patellar tendinitis with use of a new radiographic measurement. American Journal of Sports Medicine 30:396-401.

Van MW. 1992. Running injuries. A review of the epidemiological literature. Sports Med 14:320-335.

Visentini PJ, Khan KM, Cook JL, Kiss ZS, Harcourt PR, Wark JD. 1998. The VISA score: an index of severity of symptoms in patients with jumper's knee (patellar tendinosis). Victorian Institute of Sport Tendon Study Group. J Sci Med Sport 1:22-28.

Visnes H, Bahr R. 2007. The evolution of eccentric training as treatment for patellar tendinopathy (jumper's knee): a critical review of exercise programmes. Br J Sports Med 41:217-223.

Warden SJ, Kiss ZS, Malara FA, Ooi ABT, Cook JL, Crossley KM. 2007. Comparative Accuracy of Magnetic Resonance Imaging and Ultrasonography in Confirming Clinically Diagnosed Patellar Tendinopathy. American Journal of Sports Medicine 35:427-436.

Weiler JM. 1992. Medical modifiers of sports injury. The use of nonsteroidal anti-inflammatory drugs (NSAIDs) in sports soft-tissue injury. Clin Sports Med 11:625-644.

Weinberg EP, Adams MJ, Hollenberg GM. 1998. Color Doppler sonography of patellar tendinosis. AJR Am J Roentgenol 171:743-744.

Westrich GH, Haas SB, Bono JV. 1996. Occupational knee injuries. Orthop Clin North Am 27:805-814.

Witvrouw E, Bellemans J, Lysens R, Danneels L, Cambier D. 2001. Intrinsic risk factors for the development of patellar tendinitis in an athletic population: a two-year prospective study. American Journal of Sports Medicine 29:190-195.

Yu JSP. 1995. Correlation of MR imaging and pathologic findings in athletes undergoing surgery for chronic patellar tendinitis. American Journal of Roentgenology 165:1995.

Appendix I: Specific research questions and search terms for jumper's knee, disease, exposure, causality and individual risk factors

Table 4: The search terms for jumper's knee and its synonyms

	Search terms
Jumper's knee	Jumper's knee OR patellar tendinopathy OR patellar tendinitis OR patellar tendonitis OR patellar insertion tendinopathy OR chronic patellar tendinopathy OR infrapatellar tendinitis OR insertion tendinitis OR tendinopathy OR quadriceps tendinopathy OR quadriceps tendinitis OR quadriceps tendonitis AND knee

Table 5: Disease, the specific research questions and the search terms

Research question	***Search terms*** ***(tw= free text word)***
What are the **prevalence** and/or **incidence** of jumper's knee?	Prevalence [MeSH term] or Incidence [MeSH term]
What are **signs** and/or **symptoms** of jumper's knee?	Signs (tw) or symptoms (tw) or complaints (tw)
What are **clinical tests** for diagnosing jumper's knee?	Test (tw) or tests (tw) or examination (tw) or golden standard (tw)
What are the **sensitivity** and/or **specificity** of these clinical tests for jumper's knee?	(sensitiv*[TiAb] OR sensitivity and specificity[MeSH Terms] OR diagnos*[Title/Abstract] OR diagnosis[MeSH:noexp] OR diagnostic* OR diagnosis,differential [MeSH:noexp] OR diagnosis[Subheading:noexp])
Does having a jumper's knee lead to a **loss of work ability**?	Fitness level (tw) or work ability (tw)

Does having a jumper's knee lead to an increase of days of **sick leave**?	Out of competition (tw) or sick leave (tw)
What is the **prognosis for work ability** in relation to work-related jumper's knee?	Prognosis [MeSH term] and work ability (tw)

(tw)=text word, MeSH term= term in Pubmed related to its key word, TIAB= title and abstract

Table 6: Exposure, the specific research questions and the search terms

Research question	***Search terms*** ***(tw= free text word)***
What search string is most sensitive for "work"	work[tw] OR works*[tw] OR work'*[tw] OR worka*[tw] OR worke*[tw] OR workg*[tw] OR worki*[tw] OR workl*[tw] OR workp*[tw] OR occupation* [tw]
What **work-related factors**, preferably described in terms of intensity, duration or frequency, are associated with the onset or worsening of jumper's knee?	(jobs [tw] or tasks [tw] or activities [tw] or sports [tw]) and (intensity [tw] or duration [tw] or frequency [tw] or level [tw] or magnitude [tw]) in combination with sensitive search string for "work" and with search terms for jumper's knee
What **non-work-related factors**, described in terms of intensity, duration or frequency, are associated with the onset or worsening of jumper's knee?	(jobs [tw] or tasks [tw] or activities [tw] or sports [tw]) and (intensity [tw] or duration [tw] or frequency [tw] or level [tw] or magnitude [tw]) in combination with search terms for jumper's knee

(tw)=text word

Table 7: Causality, the specific research questions and the search terms

Research question	***Search terms*** ***(tw= free text word)***
Is it possible to describe the **work-related factors** that are associated with jumper's knee in a dose-response or dose-effect relation?	Causality [MeSH term] or dose response (tw) or correlation (tw) in combination with sensitive search string for "work" and with search terms for jumper's knee
Is it possible to describe the **non-work-related factors** that are associated with jumper's knee in a dose-response or dose-effect relation?	Causality [MeSH term] or dose response (tw) or correlation (tw) in combination with search terms for jumper's knee

(tw)=text word, MeSH term= term in Pubmed related to its key word

Table 8: Individual risk factors, the specific research questions and the search terms

Research question	***Search terms*** ***(tw= free text word)***
What **individual risk factors** are associated with the onset or worsening of jumper's knee?	individual risk factors (tw) or individual factors (tw) or risk factors (MeSH term) or risk factors in combination with search terms for jumper's knee

(tw)=text word, MeSH term= term in Pubmed related to its key word

Appendix II Table A: Included articles and data extraction

1e author/year/ country	Occupational / Sport	Research design (review-> number of references)	Population	Disease	Exposure	Causality	Individual risk factors	Results
Antich/ 1986/ USA (Wisconsin)	Sport	Cross-sectional	N=112, 61 males, 51 females, A=30±12 Activity: running, basketball, tennis	Clinical tests: -palpation of the knee	Questionnaire about the specific activities of the subjects:2 professionals, 40, >5 times a week, 35, 3-4 times a week, 18 only in weekend and 12 did no sporting	xx	Intrinsic factors: -range of motion -tight girth -muscle tone -quadriceps setting	Disease: -prevalence: 21% of the subjects were diagnosed with JK -palpation of the knee: sensitivity: 62%, specifictiy:67% (golden standard, history examination/ symptoms) Competitive: -range of motion of the JK knee limb was less ($p<0.05$) than in uninvolved limb -thigh girth: no difference ($p>0.05$) in JK limb compared to uninvolved JK limb -no difference in muscle tone -quadriceps setting tests were painful in 34% in JK knee with extension
Anuar/ 2004/ Malaysia	Sport	Review (35)	-	Clinical tests: -palpation of the knee imaging of the patella tendon: radiographic, US, MRI, CT scan, scintigraphy Prevalence: 20% of the athletic population	Elite athletes appear to be more affected by JK than recreational athletes, due to higher frequency and duration of activity	xx	Intrinsic factors: -malaligment -limb-length discrepancy -muscular imbalance -combination of the above -age, under 34 yrs, higher risk of developing JK Extrinsic factors:	

							-amount of training -intensity/ frequency of training -surface -environmental conditions -footwear -training technique	
Bains/2006/ United Kingdom	Sport	Review (64)	-	Provocation test: -Decline squat test Clinical test: - imaging of the patella tendon: MRI scan MRI: T2 weighted sequences more sensitive than T1 weighted sequences for diagnosing JK	xx	xx	Intrinsic factors: -age -vascular perfusion -anatomic variants -joint laxity -biomechanical factors -muscle weakness -gender -body weight -systemic disease Extrinsic factors: -occupation -sport -Physical load -training errors -shoes and equipments -environment	
Beam/1995/ USA (Miami)	Sport	Case report	N=1, male, A =20 Activity: football player	Physical examination Clinical test: - imaging of the patella tendon: MRI, Radiography	xx	xx	Intrinsic factors: -quadriceps inflexibility -atrophy -hamstring tightness -patellar hyper mobility Extrinsic factors: -playing surface -frequency of training	Disease: -MRI revealed a thickening of the proximal tendon and degeneration, JK was assessed and after failure of conservative treatment, successful surgical treatment was performed
Bisseling/ 2007/ Netherlands	Sport	Case control	N=24, Three groups: -controls,8 (CON)	xx	xx	xx	Intrinsic factors: -landing strategy	Competitive: PJK compared to other 2 groups: -higher angular velocity ($p<0.01$)

			A=24±3, H=189±13, W=85±13 -previous JK,7 (PJK) A=22±3, H=189±0.1, W=80±6 - recent JK,9 (RJK) A=24±3, H=192±0.1, W=85±10 Activity: Volleyball players					-smaller plantair flexion (p<0.01) -stiffer landing technique Are seen as risk factors for JK development RJK compared to other 2 groups: -lower peak knee moment (p<0.05), avoidance of high patellar loading
Bisseling/2008/ Netherlands	Sport	Cross-sectional	N=15, Two groups: -no JK, 8 A=24±3, H=189±0.1, W=85±13 -previous JK (but a-symptomatic), 7 A=22±3 H=189±0.1, W=80±6 Activity: Volleyball players	Prevalence of JK	Training average: -No JK: 7.7±2.7 hrs/wk -Previous JK: 7.9±4.0 hrs/wk	xx	Intrinsic factors: -plantar flexion -knee range of motion at impact -loading rate of the knee at take off	Disease: prevalence of JK in this group: 45% Competitive: -smaller (p<0.05) plantar flexion in previous JK group -smaller (p=0.04) knee range of motion at impact in previous JK group -higher (p=0.04) loading rate in previous JK group All three intrinsic factors are seen as risk factors in the development of JK
Boni/1986/ Italy	Sport	Review (17)	-	Symptoms: -pain on inferior pole Clinical tests: -palpation of the knee -resistance while extending the knee	xx	xx	Intrinsic factors: -health of athlete -motor coordination -morphotype -leg-length discrepancy -patellar sub luxation -dynamic altered foot	

				-passive flexion of the knee -imaging of the patella tendon:US			placement Extrinsic factors: -training method -environment -playing surface -shoes	
Bouffard/1993/ USA (Michigan)	Sport	Review (47)	-	Clinical examination: - imaging of the patella tendon: CT, US MRI and xeroradiography	xx	xx	xx	Disease: -Xeroradiography useful for detection of calcification of the tendon but not for degeneration -US, compared to MRI, CT, the method of choice for JK; US is the least expensive, the quickest and most accurate
Briner/1997/ USA (Illinois)	Sport	Review (31)	-	Symptoms: Pain at lower pole of the patella, less frequent involvement of the upper pole and the tuberositas tibae	xx	xx	Intrinsic factors: -athletes generating high power output during rebound jump and counter-movement jump -combination of high rate of force development while jumping, high impacts during landing, substantial tibial external torsion at take-off and deep knee angles -age, between 20- 25 years Extrinsic factors: -playing intensity, playing >4 times a wk compared to less, (p=0.05) -playing duration, playing 2-5 years, peak at third year -playing surface, lower	

							incidence while playing on wooden floor compared to hard surface	
Cook/1997/ Australia	Sport	Cohort retrospective (9 year period)	N=100, 80 males, 20 females, A:27±8 Activity: different kind of sports	Clinical tests: -palpation of the knee -questionnaire (symptoms/ exposure) - imaging of the patella tendon: US	xx	xx	Intrinsic factors: -age -sex Extrinsic factors: -participation in sports	Disease: -high correspondence between location of tenderness with palpation and US abnormality ->US suitable for assessment JK clinically Competitive: -71% of athletes developed JK before age 23 -predominance for men - volleyball, soccer and basketball sports with high prevalence JK
Cook/1998/ Australia	Sport	Cross-sectional	N=227, A: 23±5, H:184±12, W:81±16 two groups: -200 athletes -27 controls activity: football, netball, basketball and cricket	Symptoms: -hypoechoic regions -calcification of the patella tendon History and clinical examination: -imaging of the patella tendon: US	xx	xx	Intrinsic factors: -sex Extrinsic factors: -sport activity -type of sport activity	Disease: -JK in 22% of the athletes compared to 4% in controls based on hypoechoic regions and calcification -sensitivity of US affected as hypoechoic regions are prevalent but athletes are a-symptomatic Competitive: -hypoechoic regions are more prevalent (30%) in male tendons than in female tendons (14%) -hypoechoic regions are more prevalent (32%) in basketball players than in other athletes (9%, p<0.01).However, athletes were a-symptomatic
Cook/2000a/ Australia	Sport	Cohort prospective (16 months)	N=26, 8 males, 18 females, A=[14-18] All a-symptomatic	Clinical tests: -Questionnaire (symptoms/ exposure)	-average training hours a week; unknown,	-relative risk	Intrinsic factors: -age -sex -body height	Disease: -VISA score sign lower in cases (94.5->84.1) than controls 93.1-> 94.1)(p<0.01)

			at baseline Activity: elite basketball players	-VISA score - imaging of the hypoechoic patella tendon: US	14.5 hours of weight-bearing training per week		-body weight -hypoechoic tendon Extrinsic factors: -vertical jump	-RR for developing symptoms of JK 4.2 times greater in hypoechoic tendons compared to control tendons Exposure: - at start: training volume of females was higher than for males -training volume of male players increased - at follow up: training volumes of males and females was the same -> men more likely to develop US abnormalities (p=0.03) Competitive: -players in age group 14-18-> 4 times higher risk to develop JK -male more likely to develop JK than female: p<0.025) -no significant differences in weight, height and vertical jump ability
Cook/2000b/ Australia	Sport	Review (10)	-	Symptoms: -clearly described pain area Clinical tests: -history - palpation of the knee -> moderate and severe tenderness are associated with tendon abnormality (p<0.05) on US -Provocation test: decline squat test shows good reproducibility -imaging of the patella tendon: MRI/ US	xx	xx	Intrinsic factors: -anatomic characteristics; foot, knee, thigh, hip -biomechanical characteristics; hamstring tightness, weakness of gluteal, abdominal, quadriceps and calf muscles -sex -both the anatomic and biomechanical factors produce an overload of the tendon resulting in JK	

							-hamstring tightness is associated with increased prevalence JK	
Cook/2000c/ Australia	Sport	Cross-sectional	N=163, two groups: -N=134, elite basketball players, 70 males 64 females, A=16 [14-18], H= 186 [162-211], W=75 [47-98] -N=29, swimming athletes acting as controls, 17 males, 12 females, A=17[13-21], H=174 [154-192], W=62 [38-82]	Clinical tests: -questionnaire (symptoms/ exposure) -clinical examination - imaging of the patella tendon: US	-average training hours a week	xx	Intrinsic factors: -age -sex -hypoechoic regions in patella tendon Extrinsic factors: -weight baring during practice	Disease: -7% JK on clinical examination, 26% JK on US -Basketball players (7%) showed greater prevalence of jumper's knee than swimmers (0%) ($p<0.05$) Exposure: -controls: 16.6 hrs/wk -cases: 14.8 hrs/wk Competitive: -US abnormalities more prevalent in oldest tertile (17-18 yrs) than in youngest tertile (14-16 yrs) -males more likely to develop JK than females, $p<0.01$) -Cases trained more with weights than controls, $p<0.01$
Cook/2001/ Australia	Sport	Cross-sectional	N= 163, 80 males, 83 females A:[14-19] with and without complaints Activity: junior basketball players	Clinical tests: -history and clinical examination -palpation of the knee - imaging of the patella tendon: US/ MRI -Nirschl scale	xx	xx	xx	Disease: -patellar tendon palpation for a single examiner was reliable: pearson correlation=0.82 (US golden standard) -in symptomatic tendons, sensitivity: 68%, specificity: 9% - in a- symptomatic tendons, sensitivity: 56%, specificity: 47% -moderate and severe tenderness better predictor than absent or mild tenderness -tender and symptomatic tendon more likely to have US abnormality than tenderness alone ($p<0.01$)
Cook/2004/	Sport	Cross-	N=135, 71 males,	Clinical test:	xx	xx	Intrinsic factors:	Competitive:

Australia		sectional	64 females, six groups, sex and: -normal tendon, males: H=191±9, W=81±10, females: H=177±9, W=68±9 -unilateral abnormality in tendon, males: H=193±7, W=84±8, females: H=181±5, W=70±7 -bilateral abnormality in tendons, males: H=195±5, W=86±9, females: H=175±8, W=67±10 Activity: elite basketball players	- imaging of the patella tendon: US			-agility -leg length -endurance -flexibility -sex	-Lower flexibility (sit and reach test) results in higher chance of developing JK, both for male and female (p<0.03) -Better performance on the vertical jump test is associated with JK only for women (p=0.02)
Crossley/2007/ Australia	Sport	Case control	N=58, three groups; -no symptoms, N=31, A=24±6, H=177±.0.9, W=71±11 -unilateral JK,N= 14, A=26±7, H=178±1, W=80±16 -bilateral JK, N=13, A=28±8, H=176±1, W=82±14	Symptoms: -pain when active -pain affects activity last 6 months Clinical tests: - clinical examination: palpation of the knee, thigh strength and flexibility, calf endurance, ankle flexibility, alignment measures and functional measures -questionnaire	-average training hours a week	xx	Intrinsic factors: -thigh strength and flexibility -active knee extension flexibility -calf endurance -ankle flexibility -alignment measures -body height -body weight -BMI -leg length discrepancy Extrinsic factors:	Competitive: -repeatability of clinical tests good (All ICC > 0.8), only not for heel-rise test (ICC= 0.57) -lower thigh flexibility and strength associated with developing JK -higher thigh strength and ankle stability good predictor of function despite having JK (represented by the VISA score) -weight and BMI higher in groups with JK (p<0.02) -leg length difference associated with JK

Ferretti/1986/ Italy	Sport	Review (25)	- Activity: tennis, volleyball, basketball, netball or soccer	(prevalence of JK in volleyball) 40% -VISA - imaging of the patella tendon: US	xx	xx	-sporting hrs/wk Age, sex, alignment of knee, extensor mechanism, position patella, characteristics of the knee joint, rotation of the femur or tibae or genu recurvatum	-bilateral JK more sporting hrs/wk (p=0.02) than other two groups -higher frequency of play is associated with JK
Devan/2004/ United Kingdom	Sport	Cohort prospective (athletic season 1999-2000)	N= 53, all females A: 19±1, H:168±10, W:65±10 Activity: field hockey, soccer or basketball	Clinical test: -hamstring: quadriceps (H:Q) ratio (determined with isokenitic force test)			-H:Q ratio -genu recurvatum Extrinsic factors: years of play, type of training (weight training/no weight training)=>no effect	Competitive: -H:Q ratio below the normal range at 300º/s, increase risk of JK (p<0.05) -presence of genu recurvatum, increase risk of JK (p<0.05)
Dubravcic /2003/ Croatia	Sport	Cross-sectional	N=469, 233 males, 236 females, A:[13-20] Activity: figure skating	Questionnaire/ interviews -prevalence of JK	xx	xx	xx -wooden playing surface better than hard playing surface, high number of training sessions, more strength, less flexibility of the quadriceps and frequent jumping => risk factors for JK	Disease: Male skaters: -prevalence: 16.1% Female skaters: -prevalence: 14.9%
Ferretti/1984/ Italy	Sport	Cross-sectional	N=407, both males and females Activity: elite volleyball players	Questionnaire/ interviews -prevalence of JK	xx	xx	Intrinsic factors: -sex -age Intrinsic factors less important than extrinsic factors Extrinsic factors: -years of play	Disease: Prevalence of JK: 22.8% (location: 62% inferior pole, 28% superior pole and 10% tuberositas tibae)
Fredberg/ 1999/ Denmark	Sport	Review (98)	-	-localized pain, well defined during or after activity according to the phase JK is developed. Blazina's et al.(1973) -diagnosis: history and clinical examination: imaging the patellar tendon: US, MRI, echo, bone scan, CT scan -bone scan is sensitive in early detection of JK	xx	xx	xx -hrs /wk -number of training session -games per wk -playing surface -type of training (weight lifting/jumping and bouncing)	Competitive: -sex: no effect -age: no effect -years of play no effect, but peak is seen at third year of participation -5 or more training sessions a wk (p<0.05) (more than 14 hrs /wk) -prevalence increases with increase in games per wk (p<0.05) -playing surface (p<0.05) (parquet better than cement) -type of training: no effect
				-US discrepancy in				

				sensitivity in different studies. Lack of histological (exposure) data -MRI is more sensitive than CT scan -imaging techniques should be used beside the history and clinical examination, not instead				
Fredberg/ 2002/ Denmark	Sport	Cohort Prospective (>11 months)	N=54, all males, A: [18-35] Activity: soccer	98 Asymptomatic patellar tendons based on imaging of the patella: US cohort: 18 with hypoechoic lesions 80 without hypoechoic lesions	Professional soccer players in Elite Danish league during one season	xx	Intrinsic factors: -hypoechoic regions with a diameter > 1 mm	Cohort with hypoechoic lesions (3/18): 17% risk of symptomatic jumper's knee Cohort without hypoechoic lesions (0/80): 0% risk of symptomatic jumper's knee
Fredberg/ 2008/ Denmark	Sport	Cohort Prospective (12 months)	N=209, all males A: 25 [17-37], H:183 [167-195], W:79 [61-95] Activity: soccer	-questionnaire (symptoms/ exposure) -imaging of the patella tendon: US	-average exposure: 145 hrs of exposure (game and training) in 6 months	xx	Intrinsic factors: -abnormalities knee tendon (proxy for JK symptoms) abnormalities defined by: hypoechoic regions, calcification and thickness of the patellar tendon)	Disease: -at baseline: 28% abnormal tendons, 6% slightly abnormal tendons (indicative for JK) Competitive: -abnormalities preseason on US, increased the risk of developing JK (RR=2.2 [0.9-5.7] during the season
Gaida/2004/ Australia	Sport	Case control	N=39, all elite female basketball players, three groups; -no JK (controls), N=24, A=21±3, H=176±7,W=74±9 -unilateral JK,N=8, A=20±2,H=178±	-questionnaire (symptoms/ exposure) -Clinical examination -VISA - imaging of the patella tendon: US	-average training hours a week	xx	Intrinsic factors: -body composition -anthropometry -muscle strength -frequency of play associated with JK, only during the past 1-6 months before	Disease: -VISA score lower for unilateral JK and bilateral JK groups compared to controls; ($p<0.05$) Exposure: -Subjects with 1 or 2 hypoechoic regions trained 2.6 (±1.4) hrs/wk more than controls

			10,W=73±13 -bilateral, N=7, A=21±3, H=178±9, W=74±9 Activity: basketball players				investigation, but not for the past month or the past 6-12 months	Competitive: Unilateral- controls: -smaller leg fat: total fat ratio -longer tibia length: stature ratio -higher waist: hip ratio -higher leg lean: total lean ratio All risk factors for JK ($p<0.05$) bilateral- controls: -no identified risk factors for JK in bilateral group, indicating etiology of unilateral and bilateral JK is different
Gisslen/2005a/Sweden	Sport	Cross sectional	-N=112, two groups, -N=57 elite volleyball players, 29 males, 28 females, A: 17 - N=55, high school students not regularly sports active, 27 males, 28 females, A: 17	History (>4 weeks) of exercise volleyball associated pain at the patellar tendon insertion into the inferior pole of the patella, tenderness to palpation, and pain during provocative test of the knee extensors	Volleyball players studying at the Swedish National Centre for high school volleyball	xx	xx	Disease: -prevalence JK among elite volleyball players: 11% - prevalence JK among high school students not regularly sports active: 0%
Gisslen/2005b/Sweden	Sport	Cohort, Prospective (7 months)	-N=60 elite volleyball players, 29 males, 31 females, A: 17	History (>4 weeks) of exercise volleyball associated pain at the patellar tendon insertion into the inferior pole of the patella, tenderness to palpation, and pain during provocative test of the knee extensors	Volleyball players studying at the Swedish National Centre for high school volleyball	xx	xx	Disease: -prevalence JK among elite volleyball players: 14%
Gisslen/ 2007/ Sweden	Sport	Cohort, Prospective	N= 22, 11 males, 11 females,	Clinical test: -palpation of the knee	-years of volleyball	xx	xx	Disease: -prevalence JK: 18%

		(3 years)	A: [15-16] at baseline Activity: elite volleyball players	-provocation test; one leg body weight squat and drop jump - imaging of the patella tendon: US, power doppler (used to study vascularity in tendons)	played: 3.7 (±1.9) years played at baseline			-incidence (3 years): 5% -JK prevalent at baseline, symptoms remain after 3 years -abnormalities do not predict JK outcome -power Doppler adds information to clinical examination
Green/ 1996/ United Kingdom	Sport	Cross sectional	N=34, 28 males, 6 females, A= 31 [17-48]	Clinical test: -histological (golden standard) -bone scan	xx	xx	xx	Sensitivity bone scan: 71% Advantage: bone scan detect abnormalities of the tendon more early than US, MRI and CT
Kettunen/ 2002/ Finland	Sport	Case control, Prospective (15 years)	N= 47, (all males) two groups: -N=20, no JK (controls) -N=27, with JK (cases) Activity: ball players, long distance runners	Symptoms: -pain with palpation of the knee -Kujala score (higher score-> more JK symptoms) -long term prognosis JK symptoms (15 yrs) Clinical test: -questionnaire (symptoms/ exposure) -provocation test: squatting -VAS (pain scale) - imaging of the patella tendon: MRI	Duration, frequency and intensity of work and leisure time physical activity	xx	Intrinsic factors: -patellar height	Disease: -Cases showed higher Kujala scores compared to controls ($p<0.01$) at follow up -JK causes long term symptoms; 53% of cases, 7% of controls stopped sport activity due to JK -None of the cases had changed their job due to the JK problems at follow up -VAS, the cases showed higher VAS scores compared to controls ($p<0.01$) Exposure: -No difference in duration, frequency and intensity of work and leisure time physical activity between two groups at follow up Competitive: -Patellar height associated with JK ($r=0.51$), increase of patellar height -> more JK symptoms
Khan/1996/ Australia	Sport	Case control	N= 55, three groups:	History and clinical examination:	xx	xx	xx	Disease: -MRI: T2-weighted gradient more

			-with JK, N=24, 23 males and 1 female, A: 31±2 -without JK (controls), N=11, A=32±1 -Cadavers, N=20 A:61±4	-imaging of the patella tendon: US, MRI				sensitive for JK symptoms than T1 weighted -both US and MRI revealed an abnormal zone at the proximal tendon attachment compared to no zone in controls (p<0.01)
Khan/1997/ Australia	Sport	Cohort prospective (12 months)	N=15, all females A: 24±6, H:181±8, W:74±11 Activity: elite basketball players	History and clinical examination: - imaging of the patella tendon: US	xx	xx	xx	Disease: -presence of a baseline abnormality predicted symptoms of JK at follow up (p<0.05) -presence of symptoms of JK at baseline predicts symptoms of JK at follow up (p<0.05) -hypoechoic regions may resolve, resume or expand without predicting symptoms of JK clinically
Khan/1998/ Australia	Sport	Review (115)	-	-symptoms JK: dull ache during/after strenuous activity (interferes with performance) -provocation tests for JK; tenderness with extended knee, with less extension pain diminishes -US/ MRI: tendon imaging, both are used to exclude other pathologies and are used to identify the exact location -CT; also prognostics value but no significant advantage above US and MRI	xx	xx	xx	
Khan/1999/	Sport	Cohort	Prospective study:	History and clinical	xx	xx	xx	Disease:

Australia		both retrospective (67 months) and prospective (12 months) using different patients	N=13, A=31±9 Retrospective study: N=17, A=27±8 Activity: Basketball, cricket, running and karate	examination: -VISA -imaging of the patella tendon: US, MRI				-US test-retest reliability: 0.51 -retrospective study: no correlation (p=0.17) between VISA score and abnormality of patella tendon -prospective study: no correlation (p=0.12) between VISA score and abnormality of patella tendon -JK should be assessed clinically and not be based on imaging
Kinsella/ 2007/ Australia	Occupational and Sport	Review (57)	-	Clinical examination: -VISA, good intra en inter tester reliability and stability -imaging of the patella tendon: US (tendon thickening and hypoechoic area's), most popular method for assessing JK -MRI, bone scan, CT scan	xx	xx	Extrinsic factors -surface, wooden floor lower prevalence compared to hard floor -performance, high frequency/ intensity and duration more risk of developing JK Occupational: professions with activities like walking up and down stairs, or sitting for extensive periods, higher risk for JK	
Lian/ 2003/ Norway	Sport	Case control	N=47, all males two groups: -N=24 with JK (cases), A:22±4 H=191±7, W=87±8 -N=23 no JK (controls), A=22±4, H=190, W=82±8 Activity: volleyball	Clinical tests: -standing jump (with and without barbells) -counter movement jump -drop jump -15 sec maximal rebound jump test	xx	xx	Intrinsic factors: -body height -body weight Extrinsic factors -type of training -jump performance -jump technique -number of training hrs/wk	Disease: Prevalence: 51% Competitive: -higher weight associated with JK (p=0.05) -more weight training is associated with JK (p<0.01) -good jumping performance is associated with JK (p=0.02) -no association between hours of training and JK (p>0.05)
Lian/2005/	Sport	Cross-	N=613, both	History and	Questionnaire	xx	Intrinsic factors:	Disease:

Norway		sectional	males and females, A=24±4, H=183±6, W=77±9 Activity: variety of sports; athletics, volleyball, basketball, ice hockey, cycling, soccer, wrestling and handball	Clinical examination: -interview/ questionnaire -VISA score: 64±19 -palpation of the knee	- Yrs of exposure: 15.2± 5.1 Training hrs /wk: 11.8± 3.9		-sex -body weight -body height Extrinsic factors: -type of training -type of sport	-overall prevalence JK: 14.2% -high risk sports; prevalence volleyball (44.6%, basketball:31.9% -low risk sports; prevalence cycling and wrestling: 0% -duration of symptoms:32±25 months Competitive: -men higher risk of developing JK than women: p=0.04) -higher body weight and body height associated with developing JK: p=0.01) -better jumping ability, more frequent jumping, more weight training and more plyometric training is associated with developing JK (p=0.01)
Malanga/ 2003/ USA (New-Jersey)	Sport	Review (84)	-	Clinical examination: -patellofemoral tests; grinding test (no studies found that reported sensitivity or specificity), compression test and the apprehension test (sens: 39%, spec. not reported)	xx	xx	xx	
Malliaras/ 2006a/ Australia	Sport	Cohort prospective (six months)	N=101, 66 males and 35 females athletes, A=26±5, H=180±7, W=78±9 Controls: Normal image without JK symptoms Activity: volleyball	History and clinical examination: -imaging of the patella tendon: US -single leg decline squat test	xx	xx	Xx	Disease: -normal image with pain: RR=15.1 (2.0-120.8) -abnormal image without pain: RR=14.6 (1.9-111.4) -abnormal image with pain: RR=51.5 7.2-63.8), all had a greater risk of having JK at the end of the season compared to controls -US imaging cannot be used clinically to determine whether

								pain is JK based
Malliaras/ 2006b/ Australia	Occupational and Sport	Cross sectional	N=113, 73 males and 40 females, A:26±5, H=79±13, W=181±0 activity: volleyball	Clinical examination: -questionnaire (symptoms/ exposure) -provocation test: single leg decline test -imaging of the patella tendon: US	Questionnaire -years of exposure: 4.6±1.6 -training hrs/ week: 8.4±4.6	xx	Intrinsic factors: -sit and reach flexibility -ankle dorsiflexion range -jump height -plantar flexion strength Extrinsic factors: -years of volleyball competition -activity level	Competitve: -Of all factors only reduced ankle dorsiflexion range may increase the risk of JK (p=0.03) Range smaller than 45º -> risk increased by 1.8-2.8 times
Malliaras/ 2007/ Australia	Sport	Cross sectional	N=113, 73 males and 40 females, A:26±5, H=79±13, W=181±0 activity: volleyball	Clinical examination: -imaging of the patella tendon: US	xx	xx	Intrinsic factors: -body height -body weight -BMI -waist girth -hip girth -waist to hip ratio	Competitive: -no significant interaction between patellar abnormality and body weight, height BMI, waist girth, hip girth, waist to hip ratio for females -higher body weight, higher BMI, larger waist, larger hip a are associated with JK in males (all, p<0.05) -waist to hip ratio > 83 cm is associated with JK (p=0.05, RR 2.5)
Mangine/ 1987/USA (Cincinnati)	Sport	Cross sectional And Cohort Prospective (2-4 weeks)	Cross sectional: N =17, 8 males, 9 females, A=[12-28] Cohort: N=5 (out of the 17 from cross sectional study) Activity: soccer, basketball, volleyball, diving and aerobics	Clinical examination: -imaging of the patella tendon: Computerized thermography	xx	xx	xx	Cross sectional Disease: -abnormal thermal pattern is identified for JK diagnosis: 12 out of 16 subject showed focal hot spots, 2 out of 16 subjects showed focal cold spots Cohort Disease: -high correlation (r=0.8) is found between changes in symptoms over time (2-4 weeks) and changes in thermal pattern
Mcloughin/ 1995/Canada	Sport	Cross sectional	N=15, 10 males, 5 females	Clinical examination: -imaging of the patella	xx	xx	xx	Three grades are identified for JK with MRI:

			A:27±8 Different kinds of activities	tendon: MRI (to characterize MRI features of JK diagnosed subjects)				-phase 1: enhancing area adjacent to patellar apical chondral-bone avulsion -phase 2: same signs as phase 1 but without avulsion -phase 3: homogeneous non enhancing area of intermediate signal intensity
Myllymäki/ 1990/Finland	Sport	Cross sectional	N=?: -N=57 with JK (cases), 62 A:27[13-58] -N=? , no JK (controls)=110 knees of reference group or contralateral knees of cases	Clinical examination: -Ultrasound in longitudinal and transverse directions of quadriceps and patellar tendon	xx	xx	Intrinsic factors: - hypoechoic lesions,	Cases : - 37 hypoechoic lesions, 25 no hypoechoic lesions Controls: - no hypoechoic lesions in 110 knees
Panni/2000/ Italy	Sport	Cohort prospective (on average 56 weeks)	N =42, 29 males, 13 females, A:24 [18-32] Activity: soccer, volleyball, basketball or parachutist	History and clinical examination: provocation tests: -pain during isometric contraction quadriceps against resistance -passive maximum stretching	xx	xx	xx	Disease: -symptoms: pain during isometric contractions against resistance, localized pain, during palpation, atrophy of muscles, malaligment, swelling -prevalence; volleyball: 50%, basketball: 31%
Peace/2006/ United Kingdom	Sport	Review (23)	-	Clinical examination and symptoms: -Symptoms US in case of JK: fibriller pattern, disruption, swollen tendon, focal areas of reduced echogenicity, calcification, vascular ingrowth -Symptoms MRI in case of JK: focal areas of different	xx	xx	Intrinsic factors: -prominent inferior patella (impingement)	

				signal intensities, bone marrow, oedema, loss of definition of tendon surface, calcification				
Peers/2005/ Belgium	Sport	Review (155)	-	Symptoms: pain origin remains an unsolved mystery (inflammation, impingement or tendinosis) -acute symptoms: pain (well localized), tenderness, start with anterior knee pain and functional deficit -Clinical examination: image technique of choice remains controversial -imaging of the patella tendon: -MRI and US findings indicative for JK correlate well with surgical biopsies -MRI not sensitive for calcification of the tendon -clinical correlation with MRI and US findings much smaller -MRI and US should be used for indication for surgery -doppler US extra tool for vascularization, correlates well with tendon degeneration	xx	xx	xx	
Pezzulo/1992/	Sport	Review	-	History and clinical	xx	xx	Intrinsic factors:	

USA (Pennsylvania		(29)		examination: imaging of the patella tendon: -US greater sensitivity than X-ray and CT			-age, >15, the incidence of JK increases -muscle contraction, eccentric action produces more stress on patellar tendon than concentric action -decreased range of motion of the knee associated with JK development Extrinsic factors: -higher prevalence of JK with increase in number of training sessions -higher incidence of JK with less resilient surfaces	
Purdam/ 2003/ Australia	Sport	Cohort Prospective (5 days)	N=56, all males A:17±1, H=184±11, W=75±13, three groups based on VISA score: -JK group VISA <90: 17 subjects -control group: VISA score 100: 15 subject -intermediate group, VISA score:[90-99]:18 subjects Activity: basketball	Clinical examination: -VISA -provocation tests: all squat based tests; step up, double leg squat, double leg squat with decline board, single leg squat with decline board and decline hop	xx	xx	xx	Disease: -single leg decline squat ($p< 0.01$) and decline hop ($p<0.01$) different between day 1 and day 5 after intensive program -single leg test is recommended for assessment of JK
Reeser/2006/	Sport	Review	Activity: volleyball	-prevalence: range	xx	xx	Intrinsic factors:	

USA (Wisconsin)		(57)		between 40 -55%, -incidence 0.2/ 1000 athletes exposure for female players			-core stability -jumping ability -prior history -sex -spike approach -landing technique Extrinsic factors: -court surface -volume of training -presented factors are known risk factors for JK, all are modifiable without sex and prior history	
Richards/1996/Canada	Sport	Case control	N=10, all males A: 23±1, H:198±2, W:92 ±1 Activity: volleyball	History and clinical examination: -palpation of the knee	xx	xx	Intrinsic factors: knee joint dynamics during spike and block: -vertical ground reaction force -knee flexion angle -external tibial torsional moment	Disease: -prevalence: 30% Competitive: -high vertical ground reaction force during take off (p=0.01), deep knee flexion angle (p=0.02) during landing and high external tibial torsional moment (p=0.01) (during take off) are associated with JK development
Richards/2002/Canada	Sport	Case control	N=10, all males A:23±1, H:198±2, W:92±1 Activity: volleyball	History and clinical examination: -palpation of the knee	xx	xx	Intrinsic factors: ankle joint dynamics during spike and block:	Competitive: -inversion moment during the landing of the spike jump is associated with JK development (p=0.03)
Shalaby/1999/USA (North Carolina)	Sport	Case control	N=25, two groups: -N= 10, with JK A:33 -N=15, without JK A:34	Clinical examination: - imaging of the patella tendon: MRI	xx	xx	Intrinsic factors: -tendon width -tendon length -tendon surface	Disease: -sensitivity MRI: 75%, Specificity MRI:29% (golden standard: history and clinical examination) -MRI of use in older patients with Blazina stage 3 symptoms, in

			Activity: elite athletes and matched (long distance) runners or jumping sports					younger patients with milder symptoms, the use of MRI is restricted Competitive: -Tendon width greater in JK group (p<0.05)
Taunton/ 2002/ Canada	Sport	Cohort prospective (two years)	Patellar tendinopathy (JK) N=96, A:34, 55 males, H=171 W=83 41 females, H=159 W=64 Activity: Running	-clinical examination -biomechanical assessment including leg length inequality, leg alignment and Q angle (angle between line patella-anterior iliac spine and line tuberositas tibae-centre of patella)	questionnaire -years of exposure:10.0 ±3.7 -training hrs/ week:6.1±0.7	xx	Intrinsic factors: -age -sex -body height -body weight -BMI -biomechanical factors: varus knee, valgus knee, pes planus, pes cavus, patellar squinting, High Q angle, leg discrepancy Extrinsic factors: -weekly activity -activity history -caliber of runner	Disease: -prevalence JK: 4.8% Exposure: -exposure is not associated with JK (P>0.05) Competitive: -men younger than 34 yrs, risk factor for developing JK: OR= 4.2 [1.97-8.89] -other intrinsic and extrinsic factors, no risk factor for JK development
Terslev/2001/ Denmark	Sport	Case control	N=18, all males, 7 participants were examined before a match as well (controls) activity: elite basketball players	-History and clinical examination: -palpation of the knee - imaging of the patella tendon: US, power doppler	questionnaire -years of exposure -training hrs/ week	xx	xx	Disease: -no correlation between clinical findings (thickening, calcification and hypoechoic regions) by US and/or power doppler and symptoms -sensitivity US: 75% and specificity US: 71% (golden standard: history and clinical examination) -power doppler technique adds information about vascularisation but should not be used instead clinical examination
Tibesku/2005/ Germany	Sport	Review (73)	-	History and clinical examination:	xx	xx	Intrinsic factors: -higher age	

Warden/2007/ USA (Indianapolis)	Sport	Case control	N=63, two groups; -symptomatic, 30: 20 males, 10 females, A=27±7, H=177±1, W=80±16 - a-symptomatic, 33: 22 males, 11 females, A=25±7,	-history of the knee -palpation of the knee -provocation test -imaging of the patella tendon: US, MRI, CT and Color Doppler (Do)	Exposure: sport hrs/wk: Symptomatic group: 4.2±2.7 A-symptomatic group: 3.4±1.6	xx	Intrinsic factors: -high position patella -stiff landing technique -leg dominancy -body weight -body height -BMI Extrinsic factors: -frequent jumping and good jumping ability -hard surface -high number of training hrs/wk	Disease: -prevalence JK elite athletes: 14% (Golden standard; history and physical examination) -diagnostic accuracy MRI/US/Do: 70%, 83%, 83% -sensitivity MRI/ US/ Do:57%, 82%, 94% -specificity MRI/ US/ Do: 82%, 87%, 70%
Torstensen/ 1994/ Canada	Sport	Review (37)	H=177±1, W=72±12	-Symptoms JK: 4 phases according to Roels: phase 1; pain after activity, phase 2; pain at start of exercise which disappears after warm up, phase 3; permanent pain, phase 4:	xx	xx	Intrinsic factors: -age [15-45] -male higher risk than female -high body height -malaligment of the knee extensor mechanism	-combination of US and Do best method for confirming clinically diagnosed JK Competitive: -BMI and body weight greater in symptomatic group (p=<0.05)
Weinberg/ 1998/USA (New York)	Sport	Cross-sectional	N=14, 5 females and 9 males, all symptomatic, A= 24[11-43]	Clinical examination: -palpation of the patella, -imaging of the patella, developed gray scale US, single Doppler sonography -provocation tests: squatting	xx	xx	xx -high patellar laxity Extrinsic factors: -elite sporting higher risk for JK than recreational - hard surface	Disease: -sensitivity Doppler: 92%, specificity Doppler: 100% (golden standard: US outcome) Gray –scale and Doppler show
Tyler/2002/ USA (New York)	Sport	Case control	N=72, 3 groups:	Clinical examination: radiographically	xx	xx	Intrinsic factor: -anterior posterior patellar tilt angle	Disease: -excellent agreement: r=0.92 for diagnosed JK image technique
Westrich/1996/ USA (New York)	Occupational	Review (25)	-cadavers,N=5 -controls, N=58 A:40±14 -group with JK, N=19	xx assessment of the anteroposterior patellar tilt angle (angle between lines; two points along anterior cortex femur and central longitudinal ridge of patella)	xx	xx	patellar tilt angle: -poor flexibility of muscles -patellofemoral asymmetry -subluxation of patella -hyper mobility of patella	showed excellent inter and intra tester reliability (depending on the knee angle) -patients with JK showed lower patellar tilt angles than a-symptomatic controls (p<0.01)
Visentini/1998/ Australia	Sport	Cross-sectional	N=201 A:27±6	Development of the clinical test: -VISA	xx	xx	xx -limb length discrepancy Extrinsic factors: -hard, concrete work surface -rigid footwear	Disease: -excellent test -retest (r>0.95) and -inter tester reliability (r>0.95) -good short term stability (r=0.87) Reliable index for the severity of JK

							-high intensity and duration of labor - JK more prevalent in workers that perform frequent kneeling, squatting, bending and stair climbing while working	
Witvrouw/ 2000/ Belgium	Sport	Cohort prospective (two year)	N=138, 99 males, 39 females, two groups: -With JK, N=19 A=19±1, H=177±9, W=65±8 -Without JK, N=119 A=19±2, H=175±8, W=67±8 All students active within the same program	History and clinical examination: -clinical tests, diagnosis: -pain > 6 wks during sporting activities -pain with compression/ palpation/ isometric contraction -no abnormality in US	questionnaire external sport activity -years of exposure -training hrs/ week: 12-14 hrs of sports per week	xx	Intrinsic factors: -sex -body height, body weight, BMI -age -leg length difference -medial tibial distance -flexibility -quadriceps strength -hamstring strength Extrinsic factors: -sport activity	Disease: -19 student became symptomatic, and 119 remained a-symptomatic of JK -Incidence: male students: 11% (11/99), female students: 20%(8/39) Competitive: -risk factors for JK are less flexible hamstrings (p=0.04) and less flexible quadriceps (p<0.01) -no factor for JK: sex (p=0.36), external sport activity (p=0.62), leg length difference (p=0.59), medial tibial distance (p=0.49), quadriceps strength and hamstring strength

xx= no information within this specific category is published,
JK= jumper's knee,
N= number of subjects, hrs= hours, wk =week
A= age (yrs) ± Sd or [ ]=range, H=height (cm) ± Sd, W=weight (kg) ± Sd,
US= Ultrasonography, MRI= Magnetic resonance imaging, CT= computed tomography, hypoechoic region= fluid regions,
VISA= Victorian Institute of Sport Assessment questionnaire, Kujala score= score questionnaire to evaluate subjective symptoms and functional limitations in patients with patellofemoral disorders, Nirschl score= score questionnaire to evaluate the function of knee, VAS= visual analog scale,
T1 weighted= the time needed for the magnetization tot return to its original value, T2 weighted= the time needed for the transverse magnetization to lose value,
ICC= intra class correlation coefficient,
Spike=attacking smash within volleyball game.

Appendix III. Table B: Summary of the literature results for the specific categories and its research questions

Category	Research question	Study
Disease	Signs/ symptoms	Cook/2000a/Australia, Cook/2001/Australia, Kettunen/ 2002/ Finland, Khan/1997/Australia, Khan/1998/ Australia, Panni/2000/Italy, Peers/2005/ Belgium, Torstensen/ 1994/ Canada
	Clinical tests	Cook/2000a/Australia, Cook/2000c/Australia, Cook/2001/Australia, Fredberg/1999/ Denmark, Gaida/2004/Australia, Gisslen/ 2007/ Sweden, Green/ 1996/United Kingdom, Kettunen/ 2002/ Finland, Khan/1998/ Australia, Kinsella/ 2007/ Australia, Malanga/2003/ USA (New-Jersey), Malliaras/2006a/Australia, Malliaras/2006b/Australia, Mangine/1987/ USA (Cincinnati), Peace/2006/ United Kingdom, Peers/2005/ Belgium, Purdam/ 2003/Australia, Taunton/ 2002/ Canada, Tibesku/2005/ Germany, Warden/2007/USA (Indianapolis), Witvrouw/ 2000/ Belgium
	Clinical tests- US	Bouffard/1993/ USA (Michigan), Cook/1997/Australia, Cook/1998/Australia, Khan/1999/ Australia, Malliaras/2006a/Australia, Malliaras/2007/ Australia, Peace/2006/ United Kingdom, Peers/2005/ Belgium, Pezzulo/1992/USA (Pennsylvania), Terslev/2001/ Denmark
	Clinical tests- MRI	Beam/1995/ USA (Miami), Khan/1996/ Australia, Mcloughin/1995/Canada, Peace/2006/ United Kingdom, Peers/2005/ Belgium, Shalaby/1999/ USA (North Carolina)
	Sensitivity/ specificity	Antich/ 1986/ USA (Wisconsin), Cook/2001/Australia, Green/ 1996/United Kingdom, Malanga/2003/ USA (New-Jersey), Visentini/1998/ Australia, Tyler/2002/ USA (New York), Warden/2007/USA (Indianapolis), Weinberg/1998/USA (New York)
	Prevalence/ incidence	Antich/ 1986/ USA (Wisconsin), Bisseling/ 2008/ Netherlands, Cook/1997/Australia, Cook/1998/Australia, Cook/2000c/Australia, Dubravcic /2003/ Croatia, Ferretti/1984/Italy, Gisslen/ 2005ab/ Sweden, Gisslen/ 2007/ Sweden, Lian/ 2003/Norway, Lian/2005/ Norway, Panni/2000/Italy, Reeser/2006/ USA (Wisconsin), Richards/1996/ Canada, Taunton/ 2002/ Canada, Terslev/2001/ Denmark, Witvrouw/ 2000/ Belgium
	Loss of work ability	-
	Sick leave	-
	Prognosis for work ability	Cook/2000a/Australia, Khan/1997/ Australia, Malliaras/2006a/Australia
Exposure	Work related factors	Cook/2000a/Australia, Cook/2000c/Australia, Ferretti/1984/Italy, Gaida/2004/Australia, Kettunen/ 2002/ Finland, Lian/ 2003/Norway, Taunton/ 2002/ Canada, Witvrouw/ 2000/ Belgium, Warden/2007/USA (Indianapolis)
	Non work related factors	-
Causality	Work-related factors	-
	Non work-related factors	-
Individual risk factors	Personal characteristics- intrinsic	Antich/ 1986/ USA (Wisconsin), Anuar/ 2004/Malaysia, Bains/2006/ United Kingdom, Bisseling/ 2007/ Netherlands Bisseling/ 2008/ Netherlands, Boni/1986/Italy, Briner/1997/USA (Illinois), Cook/1997/Australia, Cook/2000a/Australia, Cook/2000b/Australia, Cook/2000c/Australia, Cook/2004/Australia, Crossley/2007/ Australia, Devan/2004/United Kingdom, Ferretti/1986/ Italy, Fredberg/2002/Denmark Fredberg/2008/Denmark, Gaida/2004/Australia, Kettunen/ 2002/ Finland, Lian/ 2003/Norway, Lian/2005/ Norway, Malliaras/2006b/Australia, Malliaras/2007/ Australia, Myllymäki/1990/Finland, Reeser/2006/ USA (Wisconsin), Pezzulo/1992/USA (Pennsylvania), Richards/1996/ Canada, Richards/2002/Canada, Shalaby/1999/ USA (North Carolina), Taunton/ 2002/ Canada, Tibesku/2005/ Germany, Torstensen/ 1994/ Canada, Westrich/1996/ USA (New York), Witvrouw/ 2000/ Belgium

Appendix IV Response on comments of the reviewers

In this document we respond to the comments raised by the reviewer 1 (page 59) and 2 (page 65). Each comment is handled separately, and we have indicated if and where we changed the text of the revised manuscript accordingly. Our response is printed in *italic after the =>.*

Comments made by reviewer 1

First of all, let me thank you for the interesting opportunity to share my comments and views on your review. I think the document has been compiled in a very professional way, and the process of the systematic review was easy to follow.

I do, however, have some criticism and questions concerning the review and some discrepancies I found in it. I will present them in the same order they appear in the document.

In the beginning I tried to find the rationale behind making this document. In the introduction it is mentioned that mainly professional sportsmen and -women are affected by jumper's knee. Are they regarded as a professional group with work-related disorders in this review? In fact, in the definition of the general inclusion criteria it is mentioned that "elite sport is seen as work". However, in discussion this question is raised again: "Work-related factors associated with the onset or worsening of the jumper's knee are only identified in case sporting activities (professional) are seen as work."

=>We agree with this criticism. We have tried to define in the introduction that elite sport is seen as work (fourth paragraph) and that activities in sports might also occur in certain jobs.

Then reference is made to the article by Kinsella stating that walking up and down stairs as well as sitting for extensive periods at work might pose a risk for jumper's knee. The title of this article refers to a study made in Australian Rules Football Club, so one only wonders how grounded this assumption related to work and the disorder might be - or is it merely a recommendation for further studies? In fact, later on the same page it is said that it is unknown if jumper's knee can be related to work and working activities.

=>We checked the reference and tried to be more specific Semi professional athletes who had to work as well complained of symptoms due to specific working activities.

I am also interested if, in the beginning of the document, the statement on decrease of work ability, functioning and an increase in sick leave due to "a high prevalent number of jumper's knee on the work floor" was made based on evidence?

=> We revised the first two paragraphs, and tried to make it more clear that this was an assumption.

The search is well described, but does it cover also case studies? If some cases or clusters could be found where jumper's knee is suspected or confirmed to be work-related, it could have given more grounds for this review.

=>As we tried to describe in the method section our search was explorative and therefore we included every study, including case studies if they met our defined inclusion criteria.

In Introduction the aims of the reference document have been given: to summarize whether there are possible causalities between physical exposure at work and the development of jumper's knee. I will use this aim as the backbone of my comments.

It should be added that the given ICD-10 code (M70.9) is not exclusively for jumper's knee, but it refers to all "unspecified soft tissue conditions in connection with use, overstraining and pressure".

=>We agree and made it more specific in the text; we changed ICD code in M76.5 "tendonitis patellaris"

The categories used in the review are mentioned as disease, exposure, causality and competitive. All others are self-explanatory, but "competitive" should be replaced with a more precise term. In table 5 (page 4), the category is explained as "competitive and pre-existing diseases or conditions", but the inclusion criteria are only "personal characteristics with an increased risk for jumper's knee". Shouldn't it refer to all non-work related factors that could explain the onset or worsening of jumper's knee? In search terms, indeed, also individual factors and risk factors are included. This, on the other hand, overlaps with the category of "exposure".

=>We agree and changed the category with individual risk factors as this was the purpose of this category. All non work-related risk factors were identified within the search in the category exposure.

- Spelling error: Tables 4 and 5 have the same title. Table 5 should include criteria for the "competitive"? Tables inside of the text and in the appendices are numbers in a similar way; this might cause confusion.

=>We agree and changed the text accordingly. We agree and numbered the tables in the text and in the appendix differently.

The specific research questions concerning "disease" have been studied in details (perhaps even too much to me). The main finding from the aims of the reference point of view is that no epidemiological or clinical studies were found reporting on the prevalence or incidence of jumper's knee in occupational settings. Neither was there any literature found about the loss of work ability, increase of days of sick leave or the prognosis for work ability in relation to jumper's knee. According to Kettunen et al 2002, however, none of the cases with jumper's knee symptoms had changed their jobs due to knee problems.

=>We agree and therefore we decided to be more specific about the results of the literature search in the paragraph about work ability, sick leave and prognosis; no literature is found on cases in an occupational setting as contrary to the sport setting.

I found only Kujala et al 1986, but Kujala et al 1993 was missing in the reference list.

=>The reference to Kujala 1993 was a mistake; this should be Kujala 1986 as was mentioned in the reference list.

In the section concerning "exposure", it is written that three articles about work-related factors were identified. In the next sentence, however, work-relatedness is corrected to sports-relatedness. Hence, no articles on work-related factors were found. This could the conclusion already in the beginning.

=>We apologize for the confusion and adjusted the specific line in the text. As noted before elite athletes are seen as work as well in this review. But a distinction between an occupational setting and sport setting is of course relevant.

Lian et al (2003) did not find an association between frequency of play and jumper's knee. Neither in the other article by Lian at al (2003) was any association found between exposure (frequency) and symptoms of jumper's knee. Three other studied support this finding. In contrast to these studies, two were found with evidence that excessive exposure in number of hours per week is associated with development of jumper's knee.

What surprises me after having read these mixed results of the included studies is that the authors jump into very detailed conclusions concerning exposure to work-related factors and development of jumper's knee. In addition, I find it very controversial to give even an exact time limit (10 hours per week) for kneeling and stair climbing. Taking into consideration the high number of professions where this limit is exceeded on regular basis, more evidence on work-related jumper's knee should be available to justify the limit and exposures. At least, this conclusion made by the authors should not be included in the results section but preferably in discussion, because it is not based on the studied articles but authors' opinions

=> *First of all, the reference of Lian et al. (2003) concerns the same study. No association between exposure (frequency) and symptoms is found in the study of Warden et al. (2007). We agree on the criticism regarding the concluding remarks. Therefore we decided not to use the word conclude but replaced this word with assume. No reference can be given for the statement about hours of exposure (10hrs/wk). This border is given by us based on the hours of exposure given in the different studies and the (lack of) effect. We decided to replace the last 4 sentences to the discussion session (see last paragraph) as these were not results.*

In the reference list of four articles about "causality" and non work related factors, only three articles are mentioned (Salas et al 2003, Karantanas et al 2001 and Yu 1995). What was the fourth one?

=>We apologize for the omission. The fourth study was by Jensen & Di Fabio (1989).

The systematic search did not result in any work related or non work related factors that could be described in a dose response or dose effect relation in association with jumper's knee. However, dose in relation to the development of the disorder was discussed already in relation to exposure, so these two areas overlap.

=>We agree that there is a certain overlap in the category exposure and causality. However, the search is more specific on dose response in the causality category. The only dose response relation we

have found is that when the dose is high the risk of developing jumper's knee is also higher. To make this clearer, we added one sentence in this paragraph.

Concerning personal characteristics, the main disadvantage of the included studies is that they have examined athletes, not regular working age men and women. This must lead to some kind of bias and difficulties to generalize the results outside sportsmen. In addition, from the document's aims point of view, individual characteristics should not be in focus when assessing whether jumper's knee might be work-related or not.

=>We tried to make it more clear in the text that elite sports are also seen as work. Therefore, these studies are included in the document. For the occupational setting no conclusions can be drawn because no studies were found. In the sport setting several studies are found and therefore we can be more conclusive. This is formulated in the fourth paragraph of the discussion.

Spelling error: Becoming older does not imply...

Spelling error: Although Ferretti... did not find an effect...

=>We changed the text.

In discussion part, I would separate the following two sentences to make it more comprehensible: "Therefore, we were not able to describe work related and non-work related (exposure) in a dose effect relations. (According to some of the included studies, in sportsmen) excessive (amount of) hours of exposure to repetitive activities that result in high patellar tendon load (may) lead to a higher risk of jumper's knee."

=>We agree on this separation and changed the text accordingly

I agree with the conclusion of the authors that due to the limited (spelling error) availability (or even lack of) research about work related jumper's knee, we cannot answer the questions about the relation between jumper's knee and work ability, prognosis for work and days of sick leave. Also I agree with the conclusion that evidence is lacking on a possible association between jumper's knee and work.

=>We changed the text.

The document gives good suggestions for future studies concerning the use of definition of jumper's knee and the underlying aetiological hypotheses.

=> We thank the reviewer for his supportive remark.

Spelling error: No consistent evidence was found...

=>W*e changed the text.*

Because treatment of jumper's knee was not in the focus of the review, I suggest removing or at least condensing the paragraph on treatment in the discussion part.

=>We agree and removed the paragraph about treatment.

In the end of the document the Dutch system to report occupational diseases is described. It would have been interesting to know a little more about the scientific background on work-relatedness of jumper's knee in the Dutch document. Is there something else that has been published but not included in this review? What is the data on the number and characteristics of notified work-related jumper's knee in the Netherlands or any other country?

=>We decided the leave the remark about the Dutch system and Dutch document out of the this reference document to prevent any misunderstanding regarding the status of the present document.

Spelling error: employee, not employer, shows symptoms.

=>*We changed the text.*

In addition to appropriate diagnosis as pointed out in the Dutch document, a disorder has to fulfil some other requirements, too, in order to be considered work related. In the Finnish legislation, there has to be evidence on sufficient exposure at work that has been shown to be associated with the disorder within a logical timeframe. Also other possible exposures have to be excluded (e.g., sports activities and non work related traumas). According to the present document, at the moment we have too little data to make reliable conclusions on either the sufficient work-related exposures or other competing exposures or risk factors. Therefore, I disagree with the last lines of the review, where both certain work-related activities have been presented as risks, and certain professions have

been considered to be at greater risk. These conclusions are not based on the results of the review but the authors' own opinions.

=>We agree that we can not be so conclusive about the work-relatedness of jumper's knee. We tried to emphasize more that we can not make any definitive conclusiosn because too little studies are present at the moment.

The last sentence of the review with the recommendation for future studies is very justifiable.

=> Thanks.

Comments made by reviewer 2

Introduction

We suggest that you first describe and define the term jumper's knee and afterwards comments known and unknown associations.

Page 1, first paragraph line 5-6. It is stated "jumper's knee on the work floor will result in a decrease in work ability etc". Due to sparse information's in the literature on this issue, we believe that this should be an assumption rather than a statement. We suggest that you revise the last four lines in this paragraph.

=> We agree with both comments and the first two paragraphs of the introduction have been revised.

Page 1, third paragraph. We agree that the term patellar tendinopathy has been advocated to describe a degenerative condition of the patella tendon including jumper's knee. However, it is not clearly indicated that jumper's knee is characterized clinically by activity-related anterior knee pain, focal tendon tenderness and paraclinically by intra-tendinous imaging changes (swelling of the patella tendon, hypoechoic regions and possible intra-tendinous calcifications). You describe this later in the result section but we think it would be proper to mention this already in the introduction.

=> We partially agree with you, as this is one of the specific research questions. Therefore, we decided to mention it already in the introduction (see paragraph 3) but not as exclusively as you proposed.

Methods

Page 2, first paragraph line 1. We believe that the main ICD-10 code for jumper's knee is M76.5 "Tendonitis patellaris".

=>We agree, this is a more specific code and we changed it in the text accordingly

Page 3, table 1. As indicated in your document there is clearly a lack of studies dealing with occupational related jumper's knee. However, we find it problematic that you equate elite sports with work, which can be misunderstood without a closer explanation. We acknowledge that sports are considered as an occupation among elite athletes, and that these athletes come within the law of workers compensation for work-related injuries. However, we suggest that you make this more clearly for the reader, and mention this already in the introduction.

=> We agree and therefore have chosen to add this clarification in the introduction (paragraph 4)

Page 2-4, "Search strategy". Although a rather detailed exposition of the method used for the search, we find it rather difficult to assess the strategy. It worries us that potential relevant studies not appear on your reference list e.g. studies by Myllymäki (Acta Radiologica 1990;31:147-9 and 1993;34:496-9), Gisslén (Br J Sports Med 2005a;36:298-301 and 2005b;39:423-8), Reid (Sports Med 1988;6:295-307), Kahn (Sports Med 1995;19:341-57) and others. These studies may have been excluded between step 1 and step 2 in your search strategy. However, as mentioned above we find it hard to assess this from the described strategy. Maybe you could simplify the description of the search strategy thereby making it more limpid for the reader. Anyhow, due to the lack of studies dealing with occupational related factors we think it would be proper to include/mention the study by Myllymäki (Carpet-layers knee. An ultrasonographic study. Acta Radiologica 1993;34:496-9), which is the only study evaluating pathology of the patella tendon in respect to occupational (kneeling) factors.

=> We tried to describe the search strategy as clearly as possible to the reader without omitting essential details. Due to the chosen search terms, it is always possible some relevant articles are missed. Therefore, we added the snowball method (step 4) and we will take into account the studies the reviewers have suggested. When applying the inclusion criteria to the suggested studies from reviewer 1, the studies from Myllymäki (1990, 1993) and Gisslén (2005a, 2005b) are included.

Page 2, “Methods”, first paragraph and page 3 “Table 1”. Why do you only include articles published after 1980? This isn’t explained.

=>This is just a matter of choice as we believe that the period (1980-till present) is sufficient long to answer all our research questions with the most up to date scientific data. With the exception that if we found a highly relevant article published before 1980 with the snowball method we would include it as well.

Results

Page 6-10, (“The specific research questions concerning disease”). This section lacks structure. It is difficult to find a red thread through the text. To obtain more structure we suggest that you use subheadings in this section. The other paragraphs in the result sections are better structured especially the last section concerning competitive research questions.

=> We agree and have added subheadings in the categories disease.

Page 7, second paragraph line 5-7. We suggest that you describe that an acute jumper’s knee may evolve to a chronic state that eventually may result in a rupture of the tendon if the condition is left untreated and intensive activity are continued.

=> We agree and changed the text accordingly.

Page 7, third paragraph line 4-5. Subjective assessment and/or questionnaires should not be categorised as a clinical/physical examination.

=>We agree and described first the history examination in which the questionnaires might be of help in the diagnosis and then the two tests for clinical examinations.

Page 8, third paragraph line 11-12. We believe that you have mixed up the sensitivity 82% (should be 57%) and the specificity 57% (should be 82%) of MRI that you refer from the article by Warden SJ. Additionally, the sensitivity and specificity of MRI referred from the article by Shalaby M. depended on which definition of MR signal changes there were used; equivocal (McLoughin grade III or El-Khoury variant) or unequivocal (McLoughin grade I and II).

=> We agree that we have mixed up the sensitivity and specificity of the study of Warden and added in the text that sensitivity and specificity are depending on the MR signal that is used.

Page 9, second paragraph. You describe advantages and disadvantages using MRI for the evaluation of jumper's knee but only indicate advantages for ultrasound evaluation. It would be proper to mention disadvantages for ultrasound examinations also; mainly that it is a highly operator depending imaging technique.

=> We have added this information in the text.

Page 10, "Exposure". Given that there were no obtainable studies describing work-related factors associated with jumper's knee it would be desirable and relevant if you instead evaluated the risk of developing jumper's knee in relation to type of sports exposure, the frequency and duration of specific sports exposures.

=> We added extra information about the hours of exposure per week and the type of sporting activity in this paragraph.

Page 11, first paragraph line 7-12. We suggest that you do not make conclusions in the result section but rather moved this section to the discussion. Furthermore, instead of using a strong word as, conclude in line 7, it would be better to make an assumption. We also miss a reference at the end of the last sentence in this paragraph.

=> We agree and merged these sentences to the concluding paragraph of the discussion. The last sentence of the paragraph is changed and does not need a reference anymore.

Page 11, "Causality". Although no studies indicated a dose-response relation there may somehow exist such a relation as elite athletes are at a greater risk compared to recreational athletes.

=>We agree on this possible dose response relation. However, this was not a result of our search strategy for causality and therefore we decided not to use this in the result section but in the final paragraph of the discussion.

In general, instead of commenting numerous studies in the result section you could with advantage select a fewer key articles and report them more thoroughly.

=>We don't agree with the suggestion to select a few key articles as no key articles are found in accordance with the main aim of this document.

Discussion

Page 14, "Discussion". We suggest that you divide the discussion into sections e.g. a section where you discuss the applied method and its advantages and disadvantages; a section where you discuss various sports related strains in relation to jumper's knee and a section where you discuss different occupational strains in relation to jumper's knee. The later is difficult given the lack of studies. However, it would instead be interesting if you could go deeper into a discussion where you describe biomechanical factors involved in different sports activities that increases the risk of jumper's knee and compare them with biomechanical factors involved in typical occupational activities such as kneeling, jumping, heavy lifting and climbing stairs etc.

=> We agree on dividing the discussion into sections and to add a section in which we describe in more detail about comparable biomechanical factors involved in jumper's knee.

In regard to sports related strains in relation to the development of jumper's knee it would be advisable if you tried to assess and if possible to categorise the existing evidence for a causal relation. A high prevalence among volleyball and basketball players does not necessarily indicate a causal association. Lilli has recently published a review article (Occup Environ Med 2008;65:72-89) where she summarised the existing evidence for a causal relationship between knee osteoarthritis and different physical work demands. In this article it is described how she assessed the study quality and assessed the level of evidence for such a causal relationship. We could recommend you to read this article for further inspiration.

=>Thank you for the suggestion. Do to the limit number of studies regarding work and sports we did not find it useful to add quality criteria for inclusion.

Furthermore, you only very briefly describe which branches of sports that are associated with jumper's knee in the result section (page 6-7) and discussion section (page 14). Based on the existing

knowledge the best evidence for a causal relation are with sports related factors. We therefore think that you should describe and discuss the association between specific branches of sports and jumper's knee more thoroughly. You could for example select key articles and illustrate results in a table divided into separate branches of sports.

=> The main topic of this document is work and not professional sport. Therefore we would not like to emphasize the importance of sport by adding another table, solemnly devoted to sports. We agree by describing the results in more extent.

Page 15, fifth paragraph line 1. Jumper's knee may very well have a multi-factorial aetiology. We agree in that assumption. However, to base this indication on a limited evidence for a wide range of risk factors is somehow incorrect. We suggest that you revise these sentences.

=> We agree and have revised the sentences about the aetiology.

You write in the end of the discussion section (page 16, last paragraph) that kneeling, jumping, heavy lifting and climbing stairs might contribute a risk in the development of jumper's knee. This may very well be so. However, given the limited numbers or rather lack of studies concerning such an association it is wrong to state or conclude this. You should acknowledge this and instead conclude on the existing knowledge regarding sports related risk factors.

=>We agree and revised these sentences in the last paragraph.

Tables and figures

Tables in the method section and the appendix are labelled with the same numbers, which is a bit confusing (there is for example three tables labelled 1). Furthermore, figure 1 is mentioned in the methods section (page 2) but first illustrated at page 6 in the result section. We suggest that you place figure 1 in the method section with table 1-5, and rename tables in the appendix. Alternatively, you could move table 1-5 and figure 1 from the text into the appendix.

=> We apologize on the confusion about the numbers of the tables. We have changed the numbers of the tables in the text. Figure 1 is a result of the search strategy and therefore presented on page 6 (results). We changed the text and do not refer to figure 1 on page 2.

Minor comments:

Front page

Use the term tendinosis instead of tendinitis in the knee illustration.

=> We have omitted the illustration.

Introduction

Page 2, line 2. Misspelling of “asses”, should be assess.

=> We changed it in the text accordingly.

Methods

The two first lines at page 3 and page 4 are nearly iterative. We suggest that you unify this information and only write this once in the end of the section at page 5.

=> We agree and changed the text accordingly.

Results

Page 8, third paragraph line 1-2. It would be more proper to use the term patellofemoral pain syndrome (PFPS) instead of chondromalacia. Furthermore, anterior knee pain can also be due to patellofemoral and tibiofemoral osteoarthritis, the fat pad syndrome (Hoffa’s syndrome) and a plica synovialis patellaris.

=> This is changed and added in the text.

Page 8, first paragraph. How is the reliability of the Kujala questionnaire? This information is given for all the other tests you describe in this section.

=> We agree and the reliability information is added in the text.

Page 13, third paragraph line 7. Misspelling of “plantair” should be plantar.

=>This misspelling is changed in the text.

Discussion

Page 14, first paragraph line 3-4. The prevalence of jumper's knee in different branches of sports has already been presented in the result section on page 6 and 7. We suggest that you do not repeat these results (percentages) again in the discussion section.
=>In the first paragraph of the discussion we want to present the specific answers to the research questions stated in the introduction.

Page 16, second paragraph line 10. You use the term *"stage 3"* of more pronounced symptoms. If this is the classification you have described on page 1 in the second paragraph, we suggest that you use the same terminology (stages) there.

=> We agree and changed it in the text accordingly.

Page 16, second paragraph line 10-11. It must be acknowledged there is some risk of recurrence after surgical treatment, and that surgery not always results in good follow up results (Ferretti A, Int Orthop 1985;8:239-42).

=> We agree and added this into the text.

Tables and figures

Tables and figures are generally well structured and clear. However, tables in the appendix could be improved and give a better overview if you copied the first row (headlines/ explanations) into each page. Furthermore, use bold letters for explanations in the first row as done in table 2 in the appendix.
=> We decided not to copy the first row into each page due to the limit number of studies that would fit on each page. We think that the reader understands the heading of the table based on the information presented in the table. We have used the bold letters.

The list of abbreviations at the end of table 1 (page 48) is not easy to read. Could be better structured and illustrated.

=> We agree and changed this in the text.

The figure legend in table 2 (page 49) has a larger letter size compared to the figure legend in table 1 (page 26).

=>This is corrected; both legends now have the same letter size.

We suggest that you add the text “step 4” and “step 5” in the textboxes of figure 1.

=> We agree and changed this in figure 1.

In table 2-5 on page 3 and 4 each sentence starts with a dash, which isn’t the case in table 1, page 3.

=>We decided to start each sentence with a dash.

General notes

Abbreviation of jumper’s knee (JK) is not used consequently in the text. You generally write *“the jumper’s knee”*. However, wouldn’t it be more proper just writing “jumper’s knee”.

=> We decided not to use the abbreviation JK but to use jumper’s knee; this is changed throughout the text.

There are several space errors between words in the text.

=> We corrected the space errors in the text.

There are some places in the text where you write in the present tense but where we believe it should be in the past tense, e.g. page 1, first line second paragraph “The term jumper’s knee *was* first ...” instead of *is,* and on page 3, second line “the second researcher *was* asked …” instead of *is*. Overall the language could be improved by some language corrections.

=> We have checked the text again and the language in the final document is checked by a professional translator.

For further reading we could recommend a book by Rene Cailliet: Knee pain and disability. F.A. Davis Company – Philadelpia.

=> Thanks for the suggestion! In the present document we only use the studies as retrieved from the review.