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# Prophylactic Training in Asymptomatic Soccer Players With Ultrasonographic Abnormalities in Achilles and Patellar Tendons

## The Danish Super League Study

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**Background:** A recent study published in *The American Journal of Sports Medicine* showed that asymptomatic soccer players with an increased risk of developing Achilles and patellar tendon injuries within the next 12 months can be identified with use of ultrasonography.

**Hypothesis:** Prophylactic eccentric training and stretching can reduce both the frequency of asymptomatic ultrasonographic changes in Achilles and patellar tendons in soccer players and the risk of these asymptomatic intratendinous changes becoming symptomatic.

**Study Design:** Randomized controlled trial; Level of evidence, 1.

**Methods:** Two hundred and nine Danish professional soccer players from the best national league (Super League) were followed over 12 months with use of ultrasonography and injury registration. Half the teams were randomized to an intervention group with prophylactic eccentric training and stretching of the Achilles and patellar tendons during the soccer season.

**Results:** The eccentric training and stretching did not reduce the injury risk, and, contrary to all expectations, the injury risk during the season was increased in players with abnormal patellar tendons at the beginning of the study in January. Eccentric training and stretching in players with normal patellar tendons significantly reduced the proportion of players with ultrasonographic changes in the patellar tendons at the end of the season (risk difference [RD] = 12%; 95% confidence interval [CI], 2%-22%;  $P = .02$ ), but the training had no effect on the Achilles tendons (RD = 1%; 95% CI, -7% to 9%;  $P = .75$ ). The presence of preseason ultrasonographic abnormalities in the tendons significantly increased the risk of developing tendon symptoms during the season (relative risk = 1.9; 95% CI, 1.2-3.1;  $P = .009$ ).

**Conclusions:** This study demonstrates that with the use of ultrasonography, tendon changes in soccer players can be diagnosed before they become symptomatic. The prophylactic eccentric training and stretching program reduces the risk of developing ultrasonographic abnormalities in the patellar tendons but has no positive effects on the risk of injury. On the contrary, in asymptomatic players with ultrasonographically abnormal patellar tendons, prophylactic eccentric training and stretching increased the injury risk.

**Keywords:** Achilles; patellar; tendinopathy; eccentric training; ultrasonography; stretching

Prolonged overuse-related tendon pain in the Achilles tendon and patellar tendon (called “jumper’s knee”) is among

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the most frequent injuries in sports.<sup>4,36-38</sup> It is characterized by a history of gradual onset of pain during tendon load, morning stiffness in the tendon,<sup>35</sup> and sometimes localized swelling. Despite treatment—including active rest, eccentric training of the calf muscle<sup>57,61</sup> or the quadriceps femoris muscle,<sup>21,29,43</sup> use of nonsteroidal anti-inflammatory drugs,<sup>6,65</sup> local steroid injections,<sup>17,48</sup> sclerosing injections,<sup>1,28</sup> shockwave,<sup>23,63</sup> and surgery<sup>9,51,60</sup>—these tendon injuries often have a poor prognosis, with a high incidence of chronicity and recurrence,

and will often bring the athlete's sports activity to a premature end.<sup>12,33</sup> Instead of the disappointing treatment of chronic cases, early treatment is recommended.

Most Achilles tendon ruptures occur without warning symptoms, but in nearly all the ruptured tendons, degenerative changes can be demonstrated.<sup>32</sup> Several studies have shown ultrasonographic abnormalities in patellar tendons of asymptomatic athletes playing volleyball, basketball, and soccer, as well as track and field athletes.<sup>15,18,24,40,45</sup> Chronic tendinopathy can be compared to an iceberg, with pain being the tip of the iceberg. A recent pilot study published in *The American Journal of Sports Medicine*<sup>18</sup> showed that ultrasonography can help to identify a group of asymptomatic soccer players with an increased risk of developing serious tendon injuries during the next 12 months. In continuation of a previous pilot study, this prospective, randomized cohort study was performed to evaluate whether prophylactic eccentric training and stretching can reduce both the ultrasonographic changes in the Achilles and patellar tendons and the risk of these asymptomatic changes becoming symptomatic during the soccer season.

Despite limited evidence, eccentric exercise in Achilles and patellar tendinopathy probably has a positive effect on clinical outcomes, such as pain, function, and patient return to sport/work compared with various control interventions such as concentric exercise, stretching, and ultrasound; no study hitherto reported adverse effects.<sup>21,29,43,56,61,66</sup> Today, most players do not use eccentric exercise of Achilles and patellar tendons prophylactically.

Several studies have evaluated the effect of stretching.<sup>44,50</sup> Although little definitive evidence exists that clearly demonstrates the efficacy of stretching in reducing injury,<sup>52</sup> stretching has been universally adopted in sport because stretching produces gains in maximal range of joint motion and may improve maximal muscle strength. However, the currently available evidence does not support the notion that stretching can effectively reduce risk and injury,<sup>55</sup> and the effect on tendons needs to be further studied. Because all players at this level most likely participate in various forms of flexibility training, a standardized stretching program is incorporated together with eccentric training in this Danish Super League study.

As in the previous pilot study,<sup>18</sup> simple objective measurements (tendon thickness and intratendinous hypoechoic regions) were conducted with the use of ultrasonography. Neovascularization in the tendons increases in tendinopathy, and Doppler ultrasonography, which was not used in this study, can evaluate this phenomenon. At present, there are conflicting results of the value of Doppler ultrasonography in tendinopathy,<sup>25,53</sup> and there is still a lack of consensus in registration and quantifying the neovascularization.<sup>10,59</sup> Future studies are needed to establish the value of Doppler ultrasonography in tendinopathy.

One of the aims of the Danish Super League study was to evaluate if the presence of abnormal Achilles or patellar tendons would predict whether these players developed painful symptoms during the season. For this analysis, information about players' risk exposure (ie, information about player participation in training or matches) is important. To examine

the risk exposure, members of the male Danish Super League (highest domestic level of competition) were followed prospectively during the spring season (January to June), with registration of exposure time and injuries for players and teams. The results of this study were published by Hagglund et al.<sup>27</sup>

## MATERIALS AND METHODS

The Danish Super League for male players includes 12 clubs. The Danish season follows the traditional western European season, from autumn to spring.

Before starting the main study (the Danish Super League study), the exposure to soccer was examined by using a cohort study design in which 188 players (mean age of 25 years, range of 17-37; mean body mass of 79 kg, range of 61-95; mean height of 183 cm, range of 167-195) from 8 teams in the Danish Super League were followed during a spring season. All 12 teams in the Danish Super League were invited to participate in this study. Three teams did not wish to participate, and 1 team provided insufficient data and was excluded.

Each team kept attendance records for all training sessions and matches on a standardized form. Training and matches were separately recorded in minutes for each player. Training and matches with the second or youth team, as well as national teams, were included. The mean numbers of training sessions and matches were calculated at team level and for the individual player. Actual exposure to soccer was calculated for the individual player for training sessions and matches separately.<sup>27</sup>

The main study started in January 2002 and ended in December 2002. All 12 clubs planned to be included in this study. However, 1 club went bankrupt, and 1 club did poorly; both were relegated to a lower division after the end of the spring season in June. One club did not wish to send players to ultrasonography and therefore only participated in the injury registrations. These 3 clubs were replaced by 3 of the best clubs in the league a level just below. One of these 3 teams had just been relegated from the Super League, and the 2 other teams were promoted to the Super League shortly thereafter. Two hundred and nine players in those 12 clubs had their Achilles and patellar tendons examined with use of ultrasonography in January and December at the same clinic (Stadium Clinic, Atletion in Aarhus, Denmark), where all examinations were performed. Because the maximum distance from other cities in Denmark to this clinic is less than 300 km, all players could be examined in January and December, and all players with injuries of the Achilles and patellar tendons during the season could be seen at the same clinic.

Another 35 players were included, and their injuries recorded during the season, but they were only examined by ultrasonography in January. In this fashion, 209 players were included in the study on training and ultrasonographic intratendinous changes, and 244 (209 + 35) players were included in the study concerning training and injuries. In 2 of the 209 players, a bilateral anterior cruciate ligament operation with a patellar tendon graft was performed, and these 2 players were excluded from the



**Figure 1.** Instruction for stretching and eccentric exercises (given to the players in the training group). A and B, stand with 1 leg stretched backwards with the toes facing front. Slowly bend the knee so that the calf muscles become increasingly stretched. Hold the position for 20 seconds and relax, and do the same with the other leg. Repeat the exercise 3 times in each leg. C, stand with the leg outstretched with the ankle joint bent up against the wall. Press your abdomen against the wall so that the calf muscles become increasingly stretched. Hold the position for 20 seconds and relax, and do the same with the other leg. Repeat the exercise 3 times in each leg. D and E, stand with both forefeet on a stool or doorstep with the heel out over the edge. Slowly rise up onto your toes with your weight on 1 leg. Go slowly down on this leg as far as you can go. Use both legs to rise up onto your toes again. The exercise should be performed with stretched, as well with bent, knee. Repeat the exercise 25 times in each leg. F, stand with support from the back of a chair or a wall. Using your hand, bend the knee and draw the foot up and your knee slightly backward so that the muscles in the front of the thigh become increasingly stretched. Hold the position for 20 seconds and relax, and do the same with the other leg. Repeat the exercise 3 times in each leg. G and H, stand up on the stool, and go down slowly. Go up and down with first the right and then the left leg first. Repeat the exercise 25 times in each leg. (Modified with permission from [www.sportnetdoc.com](http://www.sportnetdoc.com).)

patella study. No form of Achilles tendon surgery was performed at any time in the other players. Players with symptoms from the Achilles and patellar tendons at the start of the study in January were excluded.

Six of the 12 clubs (including 1 of the 3 clubs from the league a level just below the Super League) were randomized to take part in a short training program (less than 10 minutes) throughout the whole season, including eccentric training and stretching of both Achilles and patellar tendons after training 3 times weekly according to, among others, Stanish (Figure 1).<sup>2,29,58</sup> All physiotherapists in the

club were instructed in the exercises, and all the players were given a folder with the exercises from the Web site [www.sportnetdoc.com](http://www.sportnetdoc.com) (Figure 1).

The other 6 clubs were controls, and the trainers and team physiotherapists were instructed not to perform eccentric training (usually they did not use eccentric training prophylactically) as a part of the normal training routine. However, they were allowed to continue the different kinds of flexibility training that they all used. Because 1 team randomized to the training group had not yet started the training program as of March 1 due to internal problems in the club, the

club was moved to the control group. Hence the control group consisted of 7 clubs and the intervention group of only 5 clubs. The mean height, body mass, and age of the players in the training group were 182 cm (range, 174-195), 79 kg (range, 65-92), and 25 years (range, 18-37), respectively, and in the control group, 184 cm (range, 167-195), 80 kg (range, 66-93), and 25 years (range, 18-38), respectively.

Because it is more clinically meaningful and statistically more correct to consider players instead of tendons (tendons in the same player cannot be assumed to be independent),<sup>39</sup> the players with symptoms from or ultrasonography abnormalities in either 1 or both of the 2 identical tendons (with respect to Achilles tendons or patellar tendons) were registered as "injured" and "abnormal," whereas only players with 2 asymptomatic or ultrasonographically normal Achilles or patellar tendons were registered as "noninjured" and "normal." Furthermore, when the 4 tendons were analyzed together (Achilles and patellar), the players with symptoms from or ultrasonography abnormalities in at least 1 of the 4 tendons were registered as injured and/or abnormal, whereas only players with 4 asymptomatic or normal tendons were registered as noninjured and normal.

Neither the players nor the team doctors and physiotherapists were informed of the results of the ultrasonography in January.

For ultrasonography of the Achilles and patellar tendons, we used a Toshiba Eccocee (Toshiba Medical Systems, Tochigi, Japan) with a 7.5-Hz linear transducer with a built-in water pad. The tendon thickness was measured in a longitudinal scan perpendicular to the greatest width of the tendon (the true thickness).<sup>19</sup> The thickness of the patellar tendons was measured 6 mm from the attachment at the lower patellar pole. The thickness of the normal Achilles tendons was measured 20 mm from the distal attachment at the calcaneus, and Achilles tendons with increased thickness were measured at the thickest point. The ultrasonic measurements were conducted by 2 observers with many years of experience in musculoskeletal ultrasound<sup>19,20</sup> and with an interobserver variability, an intraobserver variability, and a total coefficient of variation of less than 9% in measuring Achilles and patellar tendons (unpublished data).

All the players answered a questionnaire and were interviewed by the authors concerning their earlier and present injuries in January and December. To reduce bias in the data collection, the team physiotherapists continuously recorded the injuries and sent them to the authors in May, October, and December. In addition, players answered a questionnaire concerning their injuries and sent the questionnaires to the authors in May and October. If there were discrepancies between the player's and the team physiotherapist's registration of injuries, the physiotherapist was asked to check the data.

To maximize the level of compliance, all trainers, team doctors, and physiotherapists were informed of the study and agreed to participate. The team physiotherapists were responsible for the prophylactic training sessions, and there were regular contacts with the players and the team doctors and physiotherapists throughout the study (Table 1).

All teams were allowed to send players with Achilles or patellar tendon symptoms for acute examination at the

TABLE 1  
Timetable of Events in the Danish Super League Study

Time	Examination
Middle of January	Training starts after winter break
Middle of January	Ultrasonography and interview of players
Middle of March	Second half of tournament starts
May	Questionnaire for both players and physiotherapists
End of June	Tournament ends
July	4-week summer break
End of July	New tournament starts
Beginning of October	Questionnaire for both players and physiotherapists
Beginning of December	Ultrasonography and interview of players
Beginning of December to middle of January	6-week winter break
January to December	Acute ultrasonography of injured players

clinic, and this occurred 55 times during the season. When the teams were examined in January and December, the teams were allowed to make use of the Aarhus Stadium and the Team Denmark fitness center near the Stadium Clinic, Atletion for training. All teams and players had transportation costs refunded.

The research protocol was approved by the local ethics committee, and all players gave written informed consent. All players taking part in the Danish Super League study had the study explained to them using face-to-face presentation and were given a detailed information sheet and a training program (Figure 1).

## Definitions

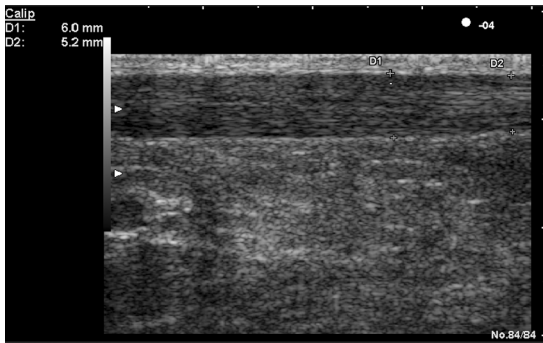
All definitions were in agreement with the consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries by Fuller et al.<sup>22</sup>

A training session was defined as any coach-directed, scheduled physical activity performed with the team.

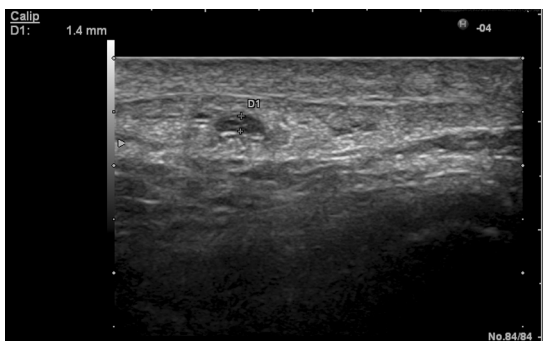
An injury was defined as any physical complaint sustained by a player resulting from a soccer match or soccer training, irrespective of the need for medical attention or time loss from soccer activities. An injury requiring medical attention was referred to as a "medical-attention" injury, and an injury preventing a player from being able to take a full part in future soccer training or match play was a "time-loss" injury. In this study, only symptoms directly related to the Achilles and patellar tendons were included.

A reinjury was defined as an injury of the same type and at the same site as an index injury and occurring after a player's return to full participation after the index injury.

Injuries were classified into 3 severity categories: (1) medical attention and according to the length of absence from training sessions and matches (time loss), (2) "minor" (1-28 days, including the day of injury), and (3) "major" (>28 days, including the day of injury). A player was



**Figure 2.** Sonogram showing slightly abnormal, hypochoic Achilles tendon with a tendon thickness 6.0 mm proximal (D1) and 5.2 mm more distal (D2).



**Figure 3.** Sonogram showing slightly abnormal patellar ligament with a hypochoic region (D1) 1.4 mm in anteroposterior diameter.

defined as injured until the club medical staff cleared him for participation in full training or match play. A player who performed alternative training or participated in only a part of the training session (eg, during rehabilitation after an injury, or due to a pain syndrome) was considered injured.

Achilles tendons with spindle-shaped ultrasonographic thickening of >1 mm in relation to the normal distal part of the tendon and patellar tendons with thickening and a hypochoic region >2 mm in the transverse scan plane were classified as “severely abnormal.” Hypochoic Achilles tendons with ultrasonographically detected tendon thickening between 0.5 and 1 mm and patellar tendons with hypochoic regions between 1 and 2 mm in the transverse scan plane were classified as “slightly abnormal” (Figures 2 and 3).

### Statistics

Proportions (risks) are stated with exact 95% confidence intervals (CIs) and compared by using the Fisher exact test. The risk difference (RD) is used to describe the effect of intervention, and a stratified analysis (stratified after ultrasonography findings in January) was performed, including a test for homogeneity and a weighted (combined) estimate. If the risk of ultrasonography findings in December and the risk of developing symptoms depend on ultrasonography findings in January, it may introduce some bias in the crude estimate of the RD, and hence

a stratified analysis was performed. An estimate (and standard errors of the estimates [SEEs]) of the RD was calculated for players with and without ultrasonography findings in January separately. The weights  $1/(\text{SEE}^2)$  have been used as weights when calculating weighted estimates. The test for homogeneity and the test for no effect of the intervention using the weighted estimate were performed by using a Wald test.

The association between ultrasonography findings in January and injuries was described by the relative risk (RR).

The changes in the risk of ultrasonography findings from January to December were analyzed by comparing 2 paired proportions within each of the 2 groups (intervention and control). Both a crude and a weighted (after stratification by clubs) estimate of the change in risk were calculated for each of the 2 groups. The tests for no effect of the intervention were performed by using a Wald test. If the risk of ultrasonography findings differs among the clubs, it may introduce some bias into the crude estimates, and hence a stratified analysis was performed. An estimate (and SEE) of the change in risk from January to December was calculated for each club. Because some clubs contributed fewer players than did others, we wanted these clubs to have a smaller effect on the common estimate of the change. This was done by weighting the estimates<sup>8</sup> for each club by  $1/(\text{SEE}^2)$ .

### RESULTS

A total of 27 321 hours of Danish Super League soccer were analyzed from January to June—23 095 training hours and 4226 match hours. During the spring season, Danish players averaged 145 hours of exposure (123 training hours and 22 match hours), 6.6 hours of training per match hour, and 2.1 injuries per player (14.4 injuries/1000 hours of soccer). The majority of injuries were medical-attention or minor, resulting in an absence of less than 7 days, and 30% of injuries were reinjuries.<sup>27</sup>

On ultrasonographic examination in January, 28% of the players had severely abnormal and 6% slightly abnormal patellar tendons, and 15% had severely abnormal and 7% slightly abnormal Achilles tendons. The frequencies of severely abnormal patellar tendons in January were similar in the training and the control groups (27% and 28%), but there was a larger difference in the frequencies of severely abnormal Achilles tendons in the intervention and the control groups (10% and 17%) (Table 2).

As seen in Table 2, in players with normal patellar tendons in January, the frequencies of ultrasonographic abnormalities in the patellar tendons in December were lower in the training group than in the control group (10% and 20%), and this was also true in players with abnormal patellar tendons in January (61% and 79%). The weighted RD of ultrasonographic abnormalities in the patellar tendons in December between the control group and the training group was 12% (95% CI, 2%-22%;  $P = .02$ ).

For the Achilles tendons, the weighted RD of ultrasonographic abnormalities in December between the control group and the training group was 1% (95% CI, -72% to

TABLE 2  
Intervention and Ultrasonographic Tendon Changes<sup>a</sup>

	Intervention Group			Control Group			Difference		
	n	US Abnormal December	95% CI	n	US Abnormal December	95% CI	RD <sup>b</sup>	95% CI	P
<b>Patellar tendon</b>									
All	86 (100%)	23%	15%-34%	121 (100%)	36%	28%-46%	13%	1% to 25%	.05
US normal January	63 (73%)	10%	4%-20%	87 (72%)	20%	12%-30%	10%	-1% to 21%	.10
US abnormal January	23 (27%)	61%	39%-80%	34 (28%)	79%	62%-91%	19%	-6% to 43%	.15
						Weighted	12%	2% to 22%	.02
<b>Achilles tendon</b>									
All	88 (100%)	11%	6%-20%	121 (100%)	15%	9%-15%	4%	-6% to 13%	.54
US normal January	79 (90%)	8%	3%-16%	100 (83%)	9%	4%-16%	1%	-7% to 10%	.79
US abnormal January	9 (10%)	44%	14%-79%	21 (17%)	43%	22%-66%	-2%	-40% to 37%	1.00
						Weighted	1%	-7% to 9%	.75
<b>Patellar tendon + Achilles tendon</b>									
All	86 (100%)	30%	21%-41%	121 (100%)	46%	37%-56%	16%	3% to 29%	.02
US normal January	57 (66%)	14%	6%-26%	76 (63%)	28%	18%-40%	14%	0% to 28%	.06
US abnormal January	29 (34%)	62%	42%-79%	45 (37%)	78%	63%-89%	16%	-6% to 37%	.19
						Weighted	15%	3% to 26%	.01

<sup>a</sup>US, ultrasonography; CI, confidence interval; RD, risk difference (between training group and intervention group). The table shows frequency of severely abnormal tendon sonograms in December for players in both the intervention and control groups. The frequencies of players with ultrasonographically abnormal tendons are significantly higher in the control group than in the intervention group for the patellar tendons and when all tendons are analyzed together but not for the Achilles tendon (ie, the training program does not reduce the frequency of players with abnormal Achilles tendons). All players were asymptomatic at baseline in January. The weighted RD is the combined estimate from the normal and abnormal group.

<sup>b</sup>Test for homogeneity (ie, RD for normal group = RD for abnormal group): patellar tendon + Achilles tendon, *P* = .89; patellar tendon, *P* = .54; Achilles tendon, *P* = .88.

92%; *P* = .75). This indicates that the training program reduces the frequency of ultrasonographic abnormalities in the patellar tendon but not in the Achilles tendon. For the 2 types of tendons combined, the weighted RD of ultrasonographic abnormalities in December between the control group and the training group was 15% (95% CI, 3%-26%; *P* = .01).

The changes in the risk of ultrasonographic abnormalities in the patellar tendons from January to December were estimated to be -4% (95% CI, -12% to 5%) in the training group and 8% (95% CI, 1%-16%) in the control group. The 2 estimates were very close to being significantly different (*P* = .050). The weighted (after stratification by clubs) estimates of the change in risk were -5% (95% CI, -12% to 3%) in the training group and 9% (95% CI, 1%-17%) in the control group. The weighted estimates were significantly different (*P* = .02).

For the Achilles tendons, neither the crude estimates of the changes in risk of ultrasonographic abnormalities from January to December (1% [95% CI, -6% to 9%] in the training group and -3% [95% CI, -10% to 8%] in the control group) nor the weighted estimates (-3% [95% CI, -9% to 4%] in the training group and 2% [95% CI, -4% to 8%] in the control group) were significantly different (*P* = .50 and *P* = .29). For the 2 types of tendons combined, the results were similar to the results for the patellar tendons. When the slight ultrasonographic abnormalities were included (not shown), the tendencies were the same, although less marked.

The risks of developing injuries from January to December are shown in Table 3. The intervention had no significant effect on the Achilles tendons or on Achilles tendons and patellar tendons together. There was a tendency (not significant) for the intervention to reduce the risk of developing symptoms of jumper's knee in players with ultrasonographically normal patellar tendons (from 8% to 1%, *P* = .08), but the same intervention significantly increased the risk of developing symptoms of jumper's knee from 5% to 24% (*P* = .04) in players with ultrasonographically severely abnormal patellar tendons. The test for homogeneity of the weighted RD between normal (6%) and abnormal (-19%) was rejected (*P* = .007); that is, a statistically significant difference in injury risk existed between the group with normal patellar tendons and the group with abnormal patellar tendons.

Asymptomatic ultrasonographic abnormalities in the tendons at the start of the season increased the risk of developing symptoms from the tendons during the season in both the intervention and the control groups (except in the patellar tendons in the control group). Players with severe ultrasonographic abnormalities of Achilles tendons had an RR for developing symptoms during the season of 2.8 (95% CI, 1.6-4.9; *P* = .002), whereas the corresponding RR for developing symptomatic jumper's knee if severe ultrasonographic abnormalities in the patellar tendons were detected before the start of the season was 2.2 (95% CI, 0.9-5.7; *P* = .09). The 2 groups of players with severe

TABLE 3  
Ultrasonography and Injury Risk During the Season in Relation to Intervention<sup>a</sup>

	All Players			Intervention Group			Control Group			Difference		
	N	Injury Risk	95% CI	n	Injury Risk	95% CI	N	Injury Risk	95% CI	RD <sup>b</sup>	95% CI	P
Patellar tendon												
All	242	7%	4%-11%	96	7%	3%-14%	146	7%	3%-12%	0%	-7% to 6%	1.0
US normal January	174	5%	2%-10%	71	1%	0%-8%	103	8%	3%-15%	6%	1% to 12%	.08
US abnormal January	68	12%	5%-22%	25	24%	9%-45%	43	5%	1%-16%	-19%	-37% to -2%	.04
									Weighted	4%	-2% to 9%	.17
Achilles tendon												
All	244	16%	12%-22%	98	15%	8%-24%	146	17%	11%-24%	2%	-8% to 10%	.86
US normal January	208	13%	9%-18%	88	13%	6%-21%	120	13%	8%-21%	0.8%	-8% to 10%	1.0
US abnormal January	36	36%	21%-54%	10	40%	12%-74%	26	35%	17%-56%	-5%	-41% to 30%	1.0
									Weighted	0%	-9% to 9%	.92
Patellar tendon + Achilles tendon												
All	242	21%	16%-21%	96	22%	14%-31%	146	21%	15%-29%	-1%	-11% to 10%	1.0
US normal January	155	16%	11%-23%	64	13%	6%-23%	91	18%	11%-28%	6%	-5% to 18%	.38
US abnormal January	87	31%	22%-42%	32	41%	24%-59%	55	26%	15%-39%	-15%	-36% to 5%	.16
									Weighted	1%	-9% to 11%	.82

<sup>a</sup>US, ultrasonography; CI, confidence interval; RD, risk difference (between training group and intervention group). The table shows the risks in both the control and intervention groups of developing minor or major injuries during the season in players with ultrasonographically normal and severely abnormal tendons in January. All players were asymptomatic at baseline in January. The weighted RD is the combined estimate from the normal and abnormal group.

<sup>b</sup>Test for homogeneity (RD normal group = RD abnormal group): patellar tendon + Achilles tendon,  $P = .075$ ; patellar tendon,  $P = .007$ ; Achilles tendon,  $P = .74$ .

ultrasonographic abnormalities of Achilles or patellar tendons had an RR of developing symptoms during the season of 1.9 (95% CI, 1.2-3.1;  $P = .009$ ) compared with the players with ultrasonographically normal tendons.

The frequencies of players with medical-attention and time-loss injuries (ie, all injuries included), time-loss injuries (both minor and major), and major injuries due to injuries in the Achilles tendon during the season were, respectively, 25% (16% of the Achilles tendons), 15% (9% of the Achilles tendons), and 5% (3% of the Achilles tendons). The frequencies of players with corresponding injuries in patellar tendons during the season were 9% (7% of the patellar tendons), 6% (3% of the patellar tendons), and 4% (2% of the patellar tendons).

Thirty-six percent of the players with major injuries in the Achilles tendons had bilateral symptoms, whereas none of the players with major patellar tendon injuries had bilateral symptoms.

Among players with symptoms from Achilles tendons, 44% were reinjuries, and for the patellar tendons, 21% were reinjuries. However, among the players with major injuries that necessitated rest for more than 28 days, reinjuries were responsible in only 14% of the players with Achilles tendinopathy and 7% of players with jumper's knee.

## DISCUSSION

Because of the disappointing treatment of chronic tendinopathy, preventive and early treatment is important. A recent pilot study in *The American Journal of Sports Medicine*

demonstrated a significant relationship between asymptomatic ultrasonographic abnormalities in the tendons and the risk of developing symptoms.<sup>18</sup>

Studies using postmortem biopsy material<sup>32</sup> indicate that tendon degeneration is present in up to 30% of asymptomatic individuals or nearly the same frequency of abnormalities found on ultrasonography in this study. In earlier studies, these ultrasonographic abnormalities have been found to correspond to the areas of altered collagen fiber structure and increased interfibrillar ground substance in Achilles tendinopathy<sup>41,46</sup> and mucoid degeneration<sup>34</sup> in patellar tendinopathy.<sup>42,47</sup>

It seems plausible that tendons undergo changes during an asymptomatic period over several months before the pain threshold is reached and the changes become symptomatic.

Instead of analyzing the number of tendons, the players in this study were analyzed as a unit because this is more clinically relevant and because right and left measurements are coupled and should not be pooled to obtain a larger study sample.<sup>7,39</sup> The 2 Achilles tendons are not independent, and even the Achilles and patellar tendons in the same player are not independent. Analyzing players instead of tendons is a more complex but statistically more correct method.<sup>39</sup> In this study, a player with 1 abnormal right patellar tendon in January and an abnormal left patellar tendon in December was registered as unchanged abnormal, despite the right tendon being cured and the left developing ultrasonographic abnormalities during the season. In contrast to earlier studies, in which tendons were analyzed instead of players, in this study, a player with 2, 3, or 4 tendinopathies was only counted once.

Ultrasonography demonstrated asymptomatic changes in the Achilles and patellar tendons that were clinically relevant. Table 3 shows the frequencies of players in January with at least 1 severely abnormal patellar tendon (28%) or Achilles tendon (15%). In our small study in 2002,<sup>18</sup> 18% of the patellar tendons and 11% of the Achilles tendons were abnormal, but in the study in 2002, we registered tendons and not players. In agreement with our earlier study, we found that ultrasonographic abnormalities in the tendons increased the risk of developing symptoms in the Achilles and patellar tendons. The risk of developing symptoms in the Achilles tendon was increased 3-fold and in the patellar tendon 2-fold. A number of investigators<sup>3,5,13,14,24-26,49,68</sup> have shown that ultrasonography can be used to predict the outcome of tendinopathy. Cook et al<sup>13</sup> found the RR of developing symptoms of jumper's knee was 4.2 times greater in elite junior basketball players with ultrasonographic hypoechoic areas in the patellar tendon than in controls with ultrasonographic normal patellar tendons, whereas Warden and Brukner<sup>64</sup> in their review found the risk of developing symptoms of jumper's knee increased from 4% to 26% if ultrasonographic abnormalities were found in the patellar tendon.

Hitherto it has generally been presumed that approximately one third of pathologic tendons in asymptomatic players will remain unchanged after 1 year, a third will resolve spontaneously, and a third of these tendons will remain abnormal and the players will develop symptoms.<sup>11</sup> Our results are not much different. In our studies, the risk of developing symptoms is greater in patients with abnormal Achilles tendons than in players with abnormal patellar tendons.

Eccentric training and stretching did not reduce the risk of developing symptoms, and in asymptomatic players with ultrasonographically abnormal patellar tendons, the training program significantly increased the injury risk. The results indicate that intensive eccentric training of players with severely abnormal asymptomatic patellar tendons should not be recommended. Our results are in disagreement with most earlier studies<sup>2,16,30,43,54,67</sup> but not all.<sup>62</sup> On the other hand, we found that eccentric training and stretching significantly reduced the frequency of ultrasonographic abnormalities in the patellar tendons but not in the Achilles tendons (Table 2). This lack of effect on the Achilles tendon may be because eccentric training and stretching had no effect or because the eccentric training in this study was not intensive enough. After the season was over, the notes of the physiotherapists, who attended all training sessions, showed that the players performed eccentric training and stretching a mean of 2.25 times per week. Despite attempts to maximize the level of compliance, the planned 3 training sessions per week could not be achieved. Twenty minutes of prophylactic training of Achilles and patellar tendons per week seemed to be the maximum that professional soccer players could be motivated to do. We have tried to standardize the stretching in the training group, but flexibility training is so widespread that probably all the players in the control group had continued stretching. Therefore it is most probable that the effect in the training group was due to the eccentric training. No studies have examined whether stretching might

interfere with the effect of eccentric training. Theoretically, the stretching in our training group could explain why the good results with eccentric training reported in other studies were not found in this study, but it seems unlikely because most athletes in the other studies most probably also had done stretching exercises. Most eccentric exercise and stretching programs in earlier studies were used to treat symptomatic tendinopathy, but in this study, eccentric exercise and stretching were used prophylactically. This can be another explanation for the lack of effect in this study in relation to most of the earlier studies.

An earlier, retrospective study showed that only one third of moderate injuries and less than 10% of mild injuries sustained during a season could be remembered after the season.<sup>31</sup> With this in mind, an attempt was made in this study to minimize the occurrence of errors associated with recall by continuous registration of injuries by the team physiotherapists and interviews with the players in January and December. Furthermore, the players answered a questionnaire in May and October, and all players with injuries of the Achilles and patellar tendons were examined immediately by the authors. While this was no guarantee that all injuries were registered, it likely reduced recall bias.

This study indicates that tendon abnormalities can be diagnosed with the use of ultrasonography before they become symptomatic, and, as far as we are aware, this is the first time that prophylactic eccentric training and stretching of asymptomatic tendons in soccer players have been shown to reduce the frequency of ultrasonographic abnormalities in the patellar tendons.

On the basis of the results in this study, we can recommend examining the Achilles and patellar tendons before the start of the season to identify players at high risk. If the abnormalities are diagnosed earlier, reduction of the tendon load can start even before the disease becomes symptomatic, and treatment can start before the disease becomes chronic. Eccentric training does not always treat symptoms from the tendons, and it might even be injurious, as shown in this study.

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