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INCIDENCE AND RISK FACTORS FOR BACK PAIN IN YOUNG FLOORBALL AND BASKETBALL PLAYERS: A PROSPECTIVE STUDY

RUNNING HEAD: RISK FACTORS FOR BACK PAIN

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ABSTRACT
The aim of this study was to investigate the incidence of back pain in young basketball and floorball players under 21 years of age. The secondary aim was to examine risk factors especially for low back pain (LBP).
Nine basketball and nine floorball teams (n=396) participated in this prospective follow-up study (2011–2014). Young athletes (mean age 15.8±1.9) performed physical tests and completed a questionnaire at baseline. The follow-up lasted one to three years per player. During the follow-up, back pain reported by the players was registered on a weekly basis and verified by a study physician. The exposure time (AE) on team practices and games was recorded by the coach.
Altogether back pain was reported 61 times by 51 players. The incidence of back pain was 87 per 1000 athlete-years and 0.4 per 1000 hours of AE. Hamstrings, quadriceps and iliopsoas extensibility and general joint hypermobility were not associated with LBP. Furthermore, no association between LBP and leg extension strength or isometric hip abduction strength asymmetry was found in these young basketball and floorball players.
In conclusion, back pain can lead to a considerable time-loss from training and competition among young basketball and floorball players and the pain tends to reoccur. Lower extremity muscle extensibility, general joint hypermobility or investigated lower extremity strength measures were not associated with the risk of LBP.

**Keywords**: Youth athlete, team sports, sports injury, spinal pain, back injury

## INTRODUCTION

Lifetime occurrence of back pain has been reported to range between 47 to 90% in the adult athlete population and most frequently pain occurs in the low back[1]. Back pain, especially in the low back (LBP), is also common in the young athlete population[2 3 4]. For example, Van Hilst et al.[3] reported 33–64% annual prevalence in field hockey, 64% in football and Schmidt et al.[4] 57% in athletes participating in various sports.

In Finland, half of all children and adolescents take part in organised sports club activities, floorball and basketball being among the most popular sports[5]. Basketball has approximately 450 million players around the world[6]. Floorball, also called innebandy, indoor bandy, and unihockey, is a popular sport in Scandinavia and some European countries such as the Czech Republic and Switzerland. Floorball, has nearly 310,000 licenced players and the number is still growing[7]. Both sports include sprinting; sudden turns, stops, and landings; and dual tasking in terms of handling a ball while moving. In addition, both sports include rotational movements and asymmetrical manoeuvres. Furthermore, the stance is similar, with the knees and hips being bent. In floorball, the playing position also often includes trunk flexion and rotation and asymmetrical positions due to the use of a stick. According to our previous report annual prevalence of LBP in young basketball and floorball players ranges from 44% up to 62%[8].

Back pain, especially LBP, has long-term consequences[9]. It is also known to be associated with other musculoskeletal complaints[10] and neuromuscular impairments in the low back and pelvic area[11]. It is not entirely clear whether these impairments are the cause or the effect of LBP. Nevertheless, these impairments have been reported to predispose athletes to lower extremity injuries[12]. A history of back pain has also been reported to decrease performance[13] and a previous back injury is reported to be associated with new changes seen in imagining studies in the lower back in young athletes[14].

To our knowledge, prospective studies investigating the incidence and risk factors for back pain in young athletes under 21 years of age are limited. To develop effective preventive methods, the magnitude and causes behind the problem need to be established[15]. Therefore, the primary aim of this study was to investigate the incidence of back pain among young floorball and basketball players in Finland. The secondary aim was to explore possible risk factors for low back pain (LBP) and especially for non-traumatic LBP.

## MATERIALS AND METHODS

### Design and Participants

This study is part of the large PROFITS-study (Predictors of Lower Extremity Injuries in Team Sports) carried out in Finland between 2011 and 2015. More detailed information on the PROFITS-study is described elsewhere[16]. Briefly, from the Tampere City district in Finland, 10 basketball and 10 floorball teams were invited from six sports clubs. Nine basketball teams and nine floorball teams agreed to participate. The flow diagram of teams and players can be seen in Figure 1. Altogether, 396 young basketball and floorball players took part (mean age 15.8 ±1.9 yrs.). The baseline characteristics of the subjects are presented in Table 1 and Supplement 1. The players entered the study in the

April-May of 2011, 2012, or 2013 (Supplement 2). A total of 261 players were observed prospectively for one study year, 80 for two study years and 55 for three study years. A total of 586 athlete-years and 134,849 training and game hours (athlete exposure; AE) were recorded during the follow-up (2011–2014).

**Baseline Questionnaire and Tests**

At baseline, the players performed physical tests and completed a baseline questionnaire at the UKK Institute, Tampere, Finland. The baseline questionnaire covered the following demographics: age, sex, dominant leg, diet, alcohol and nicotine use, menstrual history, chronic illnesses, medication use, family history of musculoskeletal disorders, playing years, playing position and level, previous injuries, back pain history (Standardized Nordic questionnaire of musculoskeletal symptoms / modified version for athletes)[17 18] and training and playing history during the previous twelve months. The Physical tests were performed at the UKK Institute over one day. The tests included anthropometric measurements; hamstring, quadriceps, and iliopsoas extensibility; generalised joint laxity (Beighton-Horan index); isometric hip abduction strength; and a one repetition maximum (1RM) of the leg press. The tests are described in detail in Supplement 3 and in the study protocol[16]. All AE (games and training) was collected for each player by the coaches.

**Back Pain Definitions and Data Collection**

Fuller et al.'s consensus statement for sports injury definitions and data collection is widely used in sports injury research[19] and in this study the definition of back pain was based on it. Thus, back pain was defined as pain in the upper and/or lower back area, that prevented the player from fully participating in the team training and playing during the following twenty-four hours. Severity was expressed as time lost from training and playing. Back pain was registered if it occurred during or after scheduled team practice or game. During the follow-up, back pain was registered weekly and verified by one of the five study physicians. A study physician contacted the teams once a week to gain information about new back complaints and to interview the players.

A structured injury questionnaire (Supplement 4) was used to register back pain including the location, cause, type, time of onset and suspected mechanism (acute traumatic vs. non-traumatic), as recommended by Fuller et al.[19]. Back pain resulting from a specific and identifiable event, such as falling, was referred as acute traumatic back pain. Back pain without single identifiable event was referred as non-traumatic back pain. Situations where acute traumatic back pain occurred were categorised as "contact", "indirect contact", and "non-contact" injuries[20]. A contact injury was defined as an injury sustained by the injured body region because of direct contact with another player or object. An indirect contact and non-contact injury was defined as occurring without direct contact to the injured body region. All back pain resulting from direct contact (n=8) were excluded from this study. These included coccyx fracture (n=2), sacrum contusion (n=1), upper back contusion (n=1), and lower back contusion (n=4). The reason for the exclusion was that it was considered unlikely that the risk factors investigated in this study are associated with direct contact injury, such as a blow to the back with a stick.

**Ethics Approval**

Informed consent was collected from each player (and parent or guardian if the player was under 18 years of age) in writing. The study was approved by the Ethics Committee of Pirkanmaa Hospital District (ETL-code R10169) before the start of the study, and it was carried out in accordance with the Declaration of Helsinki and the guidelines for good scientific practice.

**Statistical Methods**

IBM SPSS Statistics (v. 23-24.0) was used to carry out descriptive statistical analyses. Differences between the baseline characteristics of the groups were assessed using crosstabs and the Chi-square test (and the *t*-test/Mann–Whitney test when appropriate), and the results are reported as the mean, standard deviation (SD), and 95% confidence intervals (95% CI). The baseline was the first year the player took part in the study, leading to the follow-up being one to three years, depending on the player. The primary outcome was back pain, including both acute traumatic and non-traumatic onset back pain, that resulted in time lost from training and/or games. The incidence of back pain was expressed as the number of injured players per 1,000 athlete-years and per 1,000 hours of AE.

Cox's proportional hazard models with mixed effects were used to investigate the associations between baseline characteristics and low back pain, except for iliopsoas and quadriceps extensibility. Measurements for quadriceps and iliopsoas extensibility started during the second study year, so players who had low back pain in the first study year were excluded from the analyses for these two variables. Analyses were performed separately for non-traumatic low back pain (ntLBP) and all low back pain (aLBP) the latter also including acute traumatic low back pain. For players reporting more than one LBP period following baseline testing, only the first was included in the risk factor analysis. The sports club was used in all models as a random effect. Monthly exposure time, including all training and games, from the start of the follow-up until the first LBP or the end of follow-up was included in the models. Age, sex, BMI, nicotine use, family history of LBP, starting age in the sport, participation in other sports, and LBP during the previous 12 months, as reported in the baseline, were initially entered to the model, but only variables with a *p* -value close to 0.20 or less were entered into the final model. R (v 3.1.2; R Foundation for Statistical Computing)[21] package coxme[22] was used for the risk factor analyses. The results are presented as hazard ratios (HR) and reported with 95% CIs.

## RESULTS

**Back Pain Incidence and Onset Mechanisms**

During the follow-up, back pain was reported 61 times by 51 players (13%). The incidence of back pain in floorball and basketball players was 87 per 1,000 athlete-years and 0.4 per 1,000 hours of AE. The incidence of back pain by sport is shown in Table 2. Acute traumatic back pain was reported 17 (27%) times and non-traumatic back pain 44 (73%) times.

The incidence of non-traumatic back pain was 75 per 1000 athlete-years (0.3 per 1,000 hours of AE) in floorball players and 61 per 1,000 (0.3 per 1000 hours of AE) in basketball players. Of the non-traumatic back pain, 61% (n=27) was reported to be recurrent. Most of the non-traumatic back pain (77%) was classified as non-specific, and 98% (n=43) located in the lumbar-pelvic area. Of the non-traumatic back pain, nearly half (46%) in floorball and 35% in basketball resulted in more than twenty-nine days of absence from normal training (Figure 2).

Most of the acute traumatic back pain occurred in non-contact situations (n=14, 82%), with only three (17%) resulting from indirect contact. Of the acute traumatic back pain, 24% (n=4) was classified as muscle-tendon injuries, such as a spasm or strain. The most reported situations (59%, n=10) leading to acute traumatic back pain were landing from a jump or sudden/unexpected movement. The majority (76%, n=12) of acute traumatic back pain occurred during practice, mostly during conditioning training.

**Risk Factors for Low Back Pain**

Thirty-nine non-traumatic LBP and nine acute traumatic LBP were included in the risk factor analysis. The hazard ratios for the Cox's Regression models are shown in Table 3. Hamstring extensibility (p=0.540 for ntLBP, p=0.360 for aLBP), extensibility asymmetry (p=0. 430 for ntLBP, p=0.650 for aLBP), quadriceps (p=0.640 for ntLBP, p=0.430 for aLBP) and iliopsoas extensibility (p=0.790 for ntLBP, p=0.760 for LBP), and general joint hypermobility (p=0.890 for ntLBP, p=0.720 for aLBP) were not statistically significantly associated with LBP. Furthermore, no association between LBP and lower extremity strength measures were found in these young basketball and floorball players (Leg press 1RM p=0. 240 for ntLBP, p=0.450 for aLBP; isometric hip abduction strength asymmetry p=0.310 for ntLBP, p=0.340 for aLBP).

## DISCUSSION

This study showed that the incidence of time-loss back pain in floorball and basketball players was 87 per 1,000 athlete-years (0.4 per 1,000 hours of AE). The incidence of non-traumatic back pain was 75 per 1,000 athlete-years (0.3 per 1,000 hours of AE) in floorball players and 61 per 1,000 (0.4 per 1,000 hours of AE) in basketball players. Nearly half of the non-traumatic back pain resulted in more than twenty-nine days missed from normal training and more than half were reported to be recurrent. No significant associations were observed between LBP and generalised joint mobility, lower extremity muscle extensibility, leg extension strength (leg press 1 RM) or hip abduction strength asymmetry.

The definition of back pain used in this study excluded minor back complaints that did not prevent participation in normal training during the following twenty-four hours. Therefore, it is likely that the prevalence and incidence of any back complaints in this population are even higher. In fact, in the baseline questionnaire, the players were asked about any low back complaints and 53% of the players reported low back pain during the preceding twelve months. In addition, in our previous cross-sectional study, we found an annual prevalence of any back pain as high as 44% in basketball players and 62% in floorball players[8] which is in line with previous studies[18] [3]. Van Hilst et al.[3] found the prevalence of LBP to be 54–66% in young speed skaters, 33–64% in field hockey players and 64% in football players. Bahr et al.[18] reported prevalence rates of 63% among skiers, 55% among rowers, and 50% among orienteers. The recurrence rate in this study was similar to that previously reported in young athletes[3]. Van Hilst et al. reported the recurrence of LBP being 50–60%[3]. Non-traumatic back pain was also more severe in terms of time lost from normal training. Nearly half of the injured players were not able to participate in normal training for twenty-nine days or longer. Considering the recurrence and severity of the reported back pain, it is therefore unsurprising that it has been argued LBP has a detrimental effect on athletic performance[13].

In cross-sectional studies focusing on athletic populations, LBP has been reported to be associated with the function of the trunk and pelvis muscles[23 24], as well as spinal movements during walking and running[25]. Hip muscle strength and asymmetry have been reported to be associated with other lower extremity injuries[26 27]. However, it is unclear if the deficits in neuromuscular function in the lumbar–pelvic area are the cause or effect of back complaints. In the prospective setting, we did not find lower extremity strength or hip abduction strength asymmetry to be a risk factor for time-loss low back pain in young athletes. Pain has been shown to inhibit maximal voluntary muscle force in experimental studies[28] and the results of this current study indicate that deficits in neuromuscular function in the lumbar–pelvic area might be more of an effect than a cause of LBP.

General joint hypermobility in children has been associated with decreased proprioception and muscle performance[29], and therefore it could be hypothesised to be a possible risk factor for back complaints. Previous studies have not found an association between back pain and general hypermobility in adults[30 31], and according to our results, it is not a risk factor for back pain in young athletes either. Hamstring extensibility has been found to be associated with LBP in adolescents[32]. Nevertheless, only a few studies have investigated the association between hamstring[33 34] and quadriceps[33] extensibility and LBP prospectively in the adolescent population. Only one of the two studies found a significant association between hamstring extensibility and LBP. According to our results, hamstring extensibility is not associated with the incidence of LBP in young athletes, and the result supports the findings of a previous study involving young athletes[34]. We also noticed that neither iliopsoas nor quadriceps extensibility were associated with the incidence of LBP in young athletes. Similar findings regarding the quadriceps in young people have been reported previously Feldman at al.[33], but contrary findings have also been reported by Kanachanomai et al.[35]. The difference between the findings could be due to the differing definitions of LBP, and/or the different measurements used. Kanachanomai et al.[35] measured hamstring extensibility using the active knee extension test. Feldman et al.[33] used the knee extension test in a similar manner as we did in our study, but they failed to mention if active knee extension was used or if the end-point of the knee extension was determined by the subjective feeling of a stretch or a standardised pulling force.

There are some strengths and limitations to this study. To our knowledge, this study is among the largest prospective studies assessing risk factors for back pain in young athletes. However, in cohort studies with a follow-up, the investigated factors may change over time, especially in cohorts with young people. Thirty-nine of the first low back pain periods occurred during the players' first study year, eight during the second year, and one during the third study year, meaning that in most cases (81%), the time between the baseline test and the first low back pain period was one year or less. The lack of inclusion of psychosocial factors in the LBP risk factors is a limitation, as they have been shown to be associated with LBP in young people[36] and LBP becoming chronic in athletes[37]. In addition, we were unaware of the time spent in everyday physical activity or inactivity by the athletes outside their sport or the training characteristics of other sports they might play. For example, screen time has been shown by Rossi et al.[2] and Hakala et al.[38] to be associated with LBP. In addition, we did run the analysis with players without previous history of back pain. However, the number of events was too small for complicated models. The analysis of the sub-group, without any adjusting factors, did not find significant risk factors for LBP. Therefore, in the final analysis we decided not to exclude players with previous back complaints, but we adjusted for previous LBP in the risk factor analysis. As we did not find predisposing factors for back pain, the prolonged back pain could be associated with anatomic changes in the growing spine due to high loading. These changes may include vertebral end plate and ring apophysis changes[14] and posterior vertebral arch stress fractures[39]. However, our study protocol did not include systematic imaging studies to find out the possible structural reasons for back pain.

In summary, back pain seems to result in considerable time-loss from training and competing among young basketball and floorball players, and the pain tends to reoccur. According to this three-year prospective follow-up study, lower extremity extensibility, general hypermobility, lower extremity strength, and hip abduction strength asymmetry are not associated with the incidence of time-loss low back pain in young basketball and floorball players.

## PERSPECTIVE

As measured in the current study, the investigated factors cannot be used to assess the risk for low back pain in young team ball game players. However, the association between low back pain and functional tests assessing neutral zone control and neuromuscular movement control of the low back and pelvis area require further studies.

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**Table 1.** Baseline characteristics (n=396)

| | Basketball | Floorball | | Total | |
|---|---|---|---|---|---|
| Variables | | | P-value | Median | Mean |
| **Age, yrs (mean, (SD))** | | | | | |
| All | 14.9 (1.6) | 16.8 (1.6) | ≤0.001 | 16.0 | 15.8 (1.9) |
| Female | 14.6 (1.6) | 16.5 (1.9) | | | |
| Male | 15.2 (1.6) | 16.9 (1.3) | | | |
| **Height, cm (mean, SD)** | | | | | |
| All | 173.8 (9.8) | 173.5 (8.6) | 0.774 | 173.5 | 173.7 (9.2) |
| Female | 168.4 (6.5) | 166.6 (5.7) | | | |
| Male | 179.3 (9.5) | 178.6 (6.5) | | | |
| **Weight, kg (mean, SD)** | | | | | |
| All | 64.8 (12.1) | 66.4 (9.3) | 0.078 | 64.7 | 65.6 (10.8) |
| Female | 60.9 (9.4) | 61.2 (7.5) | | | |
| Male | 68.9 (13.2) | 70.1 (8.7) | | | |
| **BMI (mean, SD)** | | | | | |
| All | 21.4 (3.0) | 22.0 (2.4) | ≤0.001 | 21.4 | 21.7 (2.7) |
| Female | 21.4 (2.9) | 22.1 (2.6) | | | |
| Male | 21.3 (3.1) | 22.0 (2.3) | | | |
| **Playing years (mean, SD)** | | | | | |
| All | 6.9 (2.9) | 7.7 (3.0) | 0.013 | 7.0 | 7.3 (3.0) |
| Female | 6.5 (2.6) | 6.2 (2.6) | | | |
| Male | 7.3 (3.2) | 8.7 (2.8) | | | |
| **Training hours [a] (mean, SD)** | | | | | |
| All | 215.1 (102.9) | 236.0 (114.1) | 0.093 | 229.6 | 225.3 (108.9) |
| Female | 179.4 (77.7) | 221.5 (88.7) | | | |
| Male | 252.0 (112.7) | 246.6 (128.9) | | | |
| **Game hours [b] (mean, SD)** | | | | | |
| All | 6.7 (4.6) | 9.7 (6.7) | ≤0.001 | 7.5 | 8.2 (5.9) |
| Female | 7.2 (4.9) | 9.1 (6.5) | | | |
| Male | 6.3 (4.2) | 10.1 (6.8) | | | |

*p-values shown refer to the t-test/Mann-Whitney test between sports groups
Boys: basketball n=100, floorball n=111
Girls: basketball n=103, floorball n=82
[a] Team practice hours/season
[b] Active playing time in games during the season.

**Table 2.** Incidence of back pain[#] per 1000 AE (95% CI)

| | Floorball[a] | | | Basketball[b] | | | Total[c] | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total number (%) | Incidence[a] | 95%CI | Total number (%) | Incidence[b] | 95%CI | Total number (%) | Incidence[c] | 95%CI |
| **Low back/pelvis** | | | | | | | | | |
| Non-traumatic | 22 (81.5) | 71.7 | (47.9, 107.2) | 17 (70.8) | 60.9 | (38.4, 96.6) | 39 (76.5) | 66.6 | (49.1, 90.1) |
| Acute traumatic | 3 (11.1) | 9.8 | (3.2, 30.1) | 6 (25.0) | 21.5 | (9.8, 47.5) | 9 (17.6) | 15.4 | (8.0, 29.4) |
| Total | 25 (92.6) | 81.4 | (55.9, 118.6) | 23 (95.8) | 82.4 | (55.7, 121.9) | 48 (94.1) | 81.9 | (62.5, 107.4) |
| **Upper Back** | | | | | | | | | |
| Non-traumatic | 1 (3.7) | 3.3 | (0.5, 23.1) | 0 (0.0) | 0.0 | (0.0, 0.0) | 1 (2.0) | 1.7 | (0.2, 12.1) |
| Acute traumatic | 1 (3.7) | 3.3 | (0.5, 23.1) | 1 (4.2) | 3.6 | (0.5, 25.4) | 2 (3.9) | 3.4 | (0.9, 13.6) |
| Total | 2 (7.4) | 6.5 | (1.6, 25.9) | 1 (4.2) | 3.6 | (0.5, 25.4) | 3 (5.9) | 5.1 | (1.7, 15.8) |
| **All** | | | | | | | | | |
| Non-traumatic | 23 (85.2) | 74.9 | (50.6, 111.0) | 17 (70.8) | 60.9 | (38.4, 96.6) | 40 (78.4) | 68.3 | (50.6, 92.1) |
| Acute traumatic | 4 (14.8) | 13.0 | (4.9, 34.5) | 7 (29.2) | 25.1 | (12.1, 52.1) | 11 (21.6) | 18.8 | (10.5, 33.7) |
| Total | 27 (100.0) | 88.0 | (61.3, 126.1) | 24 (100.0) | 86.0 | (58.7, 126.1) | 51 (100.0) | 87.0 | (67.0, 113.1) |

[#] Ten players reported more than one back pain episode, but only the first is included in the incidence calculations.

[a] Incidence per 1000 athlete years (athlete-years n= 307)

[b] Incidence per 1000 athlete years (athlete-years n=279)

[c] Incidence per 1000 athlete years (athlete-years n=586)

**Table 3.** Hazard ratios for non-traumatic low back pain (ntLBP) and all low back pain (aLBP)

| | | Adjustement Factors | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variable | Risk Factor | Age | Sex | BMI | Nicotine use (yes) | Family history of LBP (yes) | Starting age | Other sports participation | Previous 12month LBP (yes) |
| **HR for ntLBP (95% CI)** | | | | | | | | | |
| Leg press 1RM | 1.00 | N/A | N/A | N/A | **3.60** | 1.94 | 1.06 | N/A | 1.54 |
| | (0.99, 1.00) | | | | (1.23, 10.54); No 1 | (0.84, 4.47); No 1 | (0.94, 1.20) | | (0.77, 3.06); No 1 |
| Hip Abduction strength asymmetry | 0.86 | N/A | N/A | N/A | **3.18** | 1.92 | 1.05 | N/A | 1.42 |
| | (0.64, 1.15) | | | | (1.11, 9.06); No 1 | (0.87, 4.23); No 1 | (0.94, 1.19) | | (0.73, 2.77); No 1 |
| Iliopsoas flexibility | 0.99 | N/A | N/A | N/A | **3.32** | 2.03 | 1.01 | N/A | 1.53 |
| | (0.96, 1.03) | | | | (1.15, 9.56); No 1 | (0.87, 4.73); No 1 | (0.89, 1.15) | | (0.75, 3.11); No 1 |
| Quadriceps flexibility | 1.01 | N/A | N/A | N/A | **3.35** | 1.99 | 1.01 | N/A | 1.54 |
| | (0.97, 1.04) | | | | (1.16, 9.66); No 1 | (0.86, 4.60); No 1 | (0.89, 1.14) | | (0.76, 3.13); No 1 |
| Hamstring flexibility asymmetry | 1.02 | N/A | N/A | N/A | **3.02** | 1.93 | 1.06 | N/A | 1.43 |
| | (0.97, 1.09) | | | | (1.05, 8.67); No 1 | (0.87, 4.26); No 1 | (0.94, 1.19) | | 0.74, 2.80); No 1 |
| Hamstring flexibility | 0.99 | 0.87 | N/A | N/A | **4.19** | 2.16 | N/A | N/A | N/A |
| | (0.97, 1.01) | (0.71, 1.07) | | | (1.38, 12.74); No 1 | (0.98, 4.77); No 1 | | | |
| Beighton Horan Laxity index[a] (normal) | 0.95 | 0.87 | N/A | N/A | **4.24** | 2.19 | N/A | N/A | N/A |
| | (0.41, 2.18); Hyperflex 1 | (0.71, 1.07) | | | (1.40, 12.91); No 1 | (0.98, 4.87); No 1 | | | |
| **HR for aLBP (95% CI)** | | | | | | | | | |
| Leg press 1RM | 1.00 | N/A | N/A | N/A | 2.71 | 2.08 | 1.10 | N/A | 1.66 |
| | (0.99, 1.00) | | | | (0.94, 7.77); No 1 | (0.99, 4.37); No 1 | (0.99, 1.23) | | (0.89, 3.12); No 1 |
| Hip Abduction strength asymmetry | 0.88 | N/A | N/A | N/A | 2.53 | **2.30** | 1.10 | N/A | 1.49 |
| | (0.67, 1.14) | | | | (0.90, 7.09); No 1 | (1.16, 4.56); No 1 | (0.99, 1.23) | | (0.82, 2.71); No 1 |
| Iliopsoas flexibility | 0.99 | N/A | N/A | N/A | 1.67 | 1.10 | 1.89 | N/A | 2.65 |
| | (0.96, 1.03) | | | | (0.87, 3.20); No 1 | (0.98, 1.24); No 1 | (0.86, 4.15) | | (0.94, 7.51); No 1 |
| Quadriceps flexibility | 1.01 | N/A | N/A | N/A | 2.73 | 1.84 | 1.10 | N/A | 1.69 |
| | (0.98, 1.04) | | | | (0.96, 7.77); No 1 | (0.84, 4.00); No 1 | (0.98, 1.23) | | (0.88, 3.23); No 1 |
| Hamstring flexibility asymmetry | 1.01 | N/A | N/A | N/A | 2.46 | **2.31** | 1.11 | N/A | 1.49 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | (0.96, 1.07) | | | | (0.88, 6.92); No 1 | (1.17, 4.59); No 1 | (0.99, 1.23) | | (0.82, 2.71); No 1 |
| Hamstring flexibility | 0.99 | N/A | N/A | N/A | 2.41 | **2.36** | 1.11 | N/A | 1.45 |
| | (0.97, 1.01) | | | | (0.86, 6.78); No 1 | (1.19, 4.67); No 1 | (1.00, 1.24) | | (0.81, 2.69); No 1 |
| Beighton Horan Laxity index[a] (normal) | 1.14 | N/A | N/A | N/A | 2.49 | **2.32** | 1.11 | N/A | 1.49 |
| | (0.55, 2.38); Hyperflex 1 | | | | (0.89, 6.97); No 1 | (1.17, 4.59); No 1 | (0.99, 1.23) | | (0.82, 2.72); No 1 |

[a] Normal range 0-3, hyperflexibility 4-9
N/A, Not included in the final model
Statistically significant ($p < 0.05$) findings are indicated with **bold** type.

**Figure 1.** Flow of players in the study ([a] Excluded due to not being official members of the team)

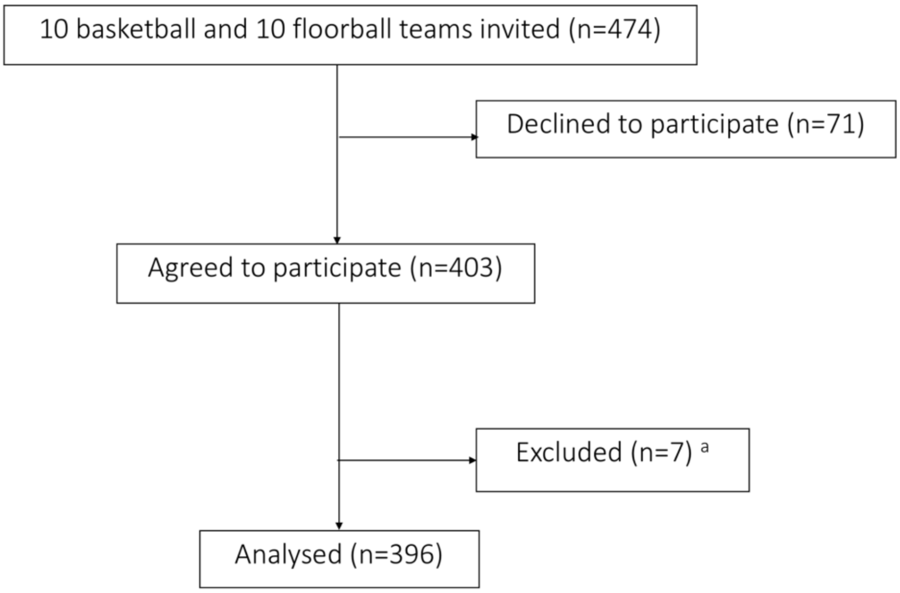
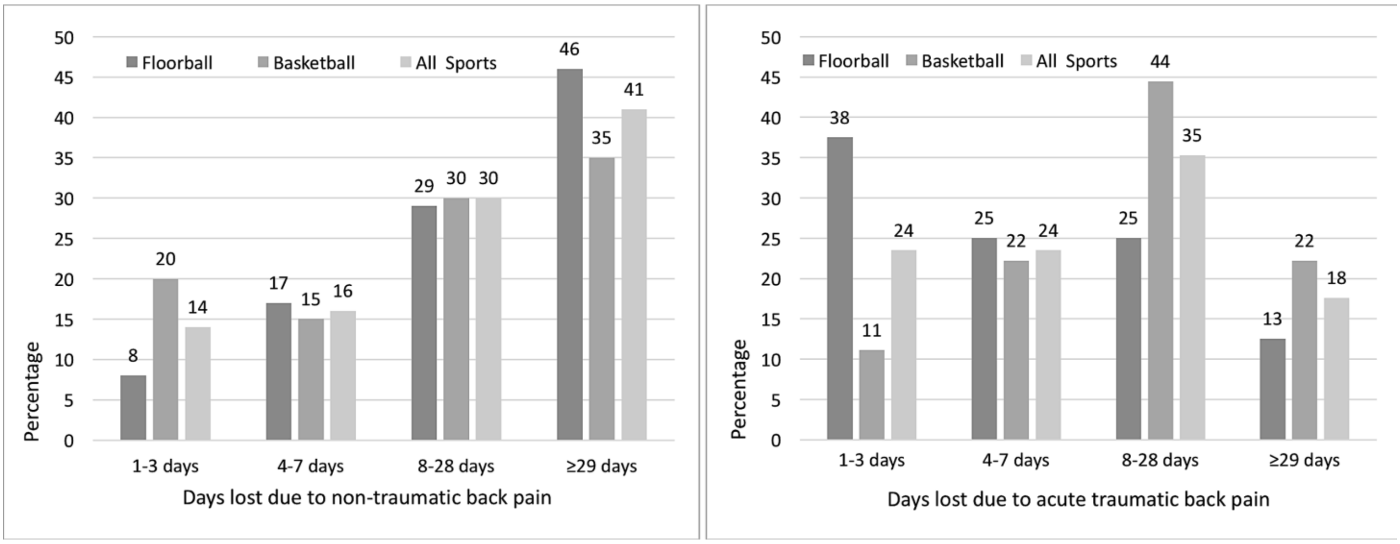


**Figure 2.** Severity of the non-traumatic (left) and acute traumatic (right) back pain (results given as percentage (%) of all back pain according to time-loss days).



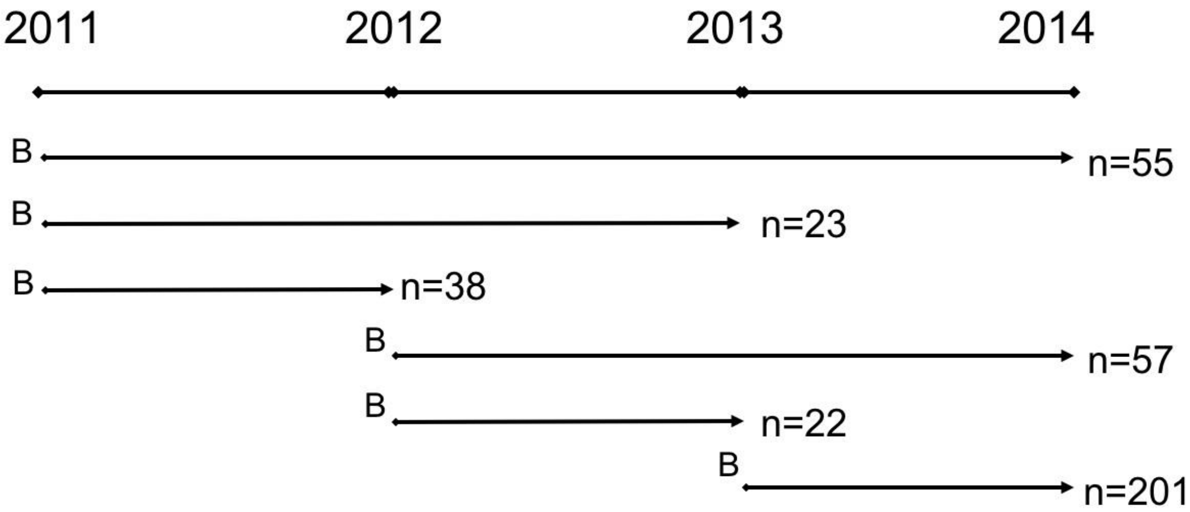
**Supplement 1.** Baseline characteristics of risk factor variables (n (% within sport) or mean (SD)) (n=396)

| | | Basketball | | | Floorball | | | P-value* | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables | | | | | | | | | | Mean | |
| | | All | Female | Male | All | Female | Male | | All | Female | Male |
| **Current nicotine use[a]** | | | | | | | | 0.001 | | | |
| | No | 199 (98.0 %) | 103 (100.0 %) | 96 (96.0 %) | 175 (90.7 %) | 81 (98.8 %) | 94 (84.7 %) | | 374 (94.4 %) | 184 (99.5 %) | 190 (90.0 %) |
| | Yes | 4 (2.0 %) | 0 (0.0 %) | 4 (4.0 %) | 18 (9.3 %) | 1 (1.2 %) | 17 (15.3 %) | | 22 (5.6 %) | 1 (0.5 %) | 21 (10.0 %) |
| **Beighton Horan index (n=383)** | | | | | | | | | | | |
| | Nor-mal range (0-3) | 153 (78.5 %) | 69 (69.7 %) | 84 (87.5 %) | 157 (86.3 %) | 63 (79.7 %) | 94 (91.3 %) | 0.048 | 310 (82.2 %) | 132 (74.2 %) | 178 (89.4 %) |
| | Hy-per-flex (4-9) | 42 (21.4 %) | 30 (30.3 %) | 12 (12.5 %) | 25 (13.7 %) | 16 (20.3 %) | 9 (8.7 %) | | 67 (17.8 %) | 46 (25.8 %) | 21 (10.6 %) |
| **History of LBP** | | | | | | | | | | | |
| | No | 111 (54.7 %) | 59 (57.3 %) | 52 (52.0 %) | 68 (35.4 %) | 29 (35.8 %) | 39 (35.1 %) | ≤0.001 | 179 (45.3 %) | 88 (47.8 %) | 91 (43.1 %) |
| | Yes | 92 (45.3 %) | 44 (42.7 %) | 48 (48.0 %) | 124 (64.6 %) | 52 (64.2 %) | 72 (64.9 %) | | 216 (54.7 %) | 96 (52.2 %) | 120 (56.9 %) |
| **LBP during previous 12 months (n=395)** | | | | | | | | | | | |
| | No | 113 (55.7 %) | 59 (57.3 %) | 54 (54.0 %) | 73 (38.0 %) | 31 (38.3 %) | 42 (37.8 %) | ≤0.001 | 186 (47.1 %) | 90 (48.9 %) | 96 (45.5 %) |
| | Yes | 90 (44.3 %) | 44 (42.7 %) | 46 (46.0 %) | 119 (62.0 %) | 50 (61.7 %) | 69 (62.2 %) | | 209 (52.9 %) | 94 (51.1 %) | 115 (54.5 %) |
| **Family history of back pain** | | | | | | | | | | | |
| | No | 179 (88.2 %) | 90 (87.4 %) | 89 (89.0 %) | 172 (89.1 %) | 71 (86.6 %) | 101 (91.0 %) | 0.768 | 351 (88.6 %) | 161 (87.0 %) | 190 (90.0 %) |
| | Yes | 24 (11.8 %) | 13 (12.6 %) | 11 (11.0 %) | 21 (10.9 %) | 11 (13.4 %) | 10 (9.0 %) | | 45 (11.4 %) | 24 (13.0 %) | 21 (10.0 %) |
| **Sports specific training (hours)** [b] | | 140.0 (68.4) | 112.8 (52.6) | 168.1 (71.5) | 101.9 (46.9) | 97.8 (43.5) | 104.8 (49.3) | ≤0.001 | 121.4 (61.8) | 106.1 (49.2) | 134.8 (68.4) |
| **Condition training (hours)** [b] | | 75.1 (39.1) | 66.6 (31.3) | 83.9 (44.2) | 133.8 (78.6) | 123.2 (50.4) | 141.7 (93.6) | ≤0.001 | 103.7 (68.2) | 91.7 (49.5) | 114.3 (79.7) |
| **Quadriceps extensibility (n=346)** | | 60.1 (9.1) | 60.6 (9.3) | 59.7 (9.0) | 59.6 (10.3) | 64.0 (9.1) | 56.8 (10.1) | 0.649 | 59.9 (9.7) | 62.1 (9.3) | 58.2 (9.7) |
| **Iliopsoas extensibility (n=346)** | | -17.9 (8.4) | -19.4 (9.2) | -16.5 (7.3) | -15.4 (9.8) | -16.4 (9.3) | 1-14.7 (10.1) | 0.012 | -16.7 (9.2) | -18.1 (9.4) | -15.6 (8.9) |
| **Hamstring extensibility (n=382)** | | 142.1 (15.6) | 148.6 (15.2) | 135.5 (13.1) | 139.5 (15.8) | 150. 0 (13.5) | 131.4 (12.2) | 0.104 | 140.9 (15.7) | 149.2 (14.5) | 133.4 (12.8) |
| **Hamstring extensibility asymmetry (n=382)** | | 6.6 (5.4) | 6.5 (4.7) | 6.7 (6.1) | 6.3 (5.1) | 6.4 (5.4) | 6.2 (4.9) | 0.609 | 6.4 (5.3) | 6.4 (5.0) | 6.4 (5.5) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Hip abduction strength asymmetry (n=383)** | | 1.2 (1.1) | 1.0 (0.9) | 1.3 (1.2) | 1.5 (1.3) | 1.4 (1.3) | 1.6 (1.3) | 0.006 | 1.3 (1.2) | 1.2 (1.1) | 1.5 (1.3) |
| **Leg press 1RM (n=364)** | | 165.1 (55.1) | 139.2 (28.2) | 192.6 (62.9) | 186.7 (47.9) | 154.3 (27.9) | 213.9 (44.3) | ≤0.001 | 175.5 (52.8) | 146.0 (29.0) | 203.4 (55.2) |

*p-values shown refer to the t-test/Mann-Whitney test between sports groups
Boys: basketball n=100, floorball n=111
Girls: basketball n=103, floorball n=82
[a] Yes= smoking once a week or more often and/or snuff (suns) every day,
No= Snuff every now and then or not at all and no smoking or less than once a week.
[b] Team practice hours/season

**Supplement 2.** Follow up time between participants (n=396). B=baseline (baseline questionnaire and baseline tests).



**Supplement 3.** Physical tests performed at baseline

| | |
|---|---|
| Flexibility and extensibility | |
| Hamstring extensibility | Hamstring extensibility was measured with the athlete in supine position on a firm surface with a lumbar support. Pelvis and the non-tested leg were stabilized using belts to avoid compensatory movements. The hip of the testing leg was fixed at 120° flexion with a belt, and the athlete prevented further hip flexion by pressing distally against the femur with both hands. The ankle and foot were in relaxed position, and the hip was in neutral rotation, abduction and adduction. Three landmarks were placed on the leg: lateral fibular malleolus, lateral femoral epicondyle and the greater trochanter of femur. The knee was extended passively with a 8kg load (a fish scale, Salter Super Samson, Taylor Precision Products, Inc., Illinois, USA). A goniometer (HiRes, Baseline® Evaluation Instruments, White Plains, NY, USA) was placed to point of knee joint line and extensibility of the muscle was measured as static range of motion. Side-to-side difference was calculated as: Hamstring asymmetry=MAX(left, Right)- MIN(left, right). |
| Iliopsoas and quadriceps extensibility | Modified Thomas' test was used to measure extensibility of iliopsoas and rectus femoris muscles. The athlete was lying supine on an examination table with buttocks on the edge of the table. The athlete was instructed to bend one knee close to the chest. The opposite leg was relaxed and the angle of hip (iliopsoas) and knee (quadriceps) were measured. Extensibility of the iliopsoas muscles: position of the thigh relative to the examination table surface is assessed with an inclinometer (Bubble Inclinometer, Baseline® Evaluation Instruments, White Plains, NY, USA). Quadriceps extensibility: the angle of the knee was measured with a goniometer (starting point with knee straight at 0°) (HiRes goniometer, Baseline® Evaluation Instruments, White Plains, NY, USA). |
| Generalised Joint Laxity | Generalised joint laxity (Beighton-Horan) was measured in standing position. The athlete was measured for excessive joint laxity at the trunk, the fifth fingers, thumbs, elbows, and knees using a goniometer. |
| Lower Extremity Strength | |
| Maximal isometric hip abductor strength | Maximal isometric hip abductor strength was tested with the player in supine position using a hand-held dynamometer (Hydraulic Push-Pull Dynamometer, Baseline® Evaluation Instruments, White Plains, NY, USA). Pelvis and other leg was stabilized with a belt and the dynamometer was positioned approximately 2 cm proximal to the lateral ankle malleolus. With the leg in neutral and extended the athlete abducted the leg against fixed resistance for two seconds until the max contraction was reached. One test performance followed by two trials/leg with 10 sec rest in between was performed. The best result was used from both legs to calculate the side-to-side difference. |
| Leg Press Test | Leg press test (1RM= 1 repetition maximum) was performed after a warm up protocol (5 min ergometer and warm up sets in leg press machine). A seated leg press machine (Technogym®, Gambettola, Italy) was used and feet were placed 20cm apart and the end of the shoes 10 cm superior to the lower edge of the foot platform. The back of the seat was set to 30° angle relative to the floor. A vertical bar was placed at the point where the knees reach the target knee angle (80° measured with a goniometer) (the weight holder of machine touches the bar when the correct knee angle is reached). The 1RM test started from 80-100kg. At the starting point the athlete's legs were extended. Then the athlete lowered the platform until the knees were in the correct angle, and returned the weights back to the starting position. After each successful trial the weights were increased by 10-30 kg (Olympic Iron Weight Plates, Leiko Oy, Tampere, FIN) for the next attempt. Recovery period between the attempts was two minutes. In valid trial the weight holder touched the bar before the athlete pressed the weight platform back up. The test ended when 1RM level was reached. |

**Supplement 4.** Structured injury questionnaire

Date of injury

- Where did the injury occur? (in official game / friendly game / sports specific training / conditioning training / other)

- Questions for game injury
o Playing position

o Game period

o Time of game period
- Surface (wooden / artificial / other, specify)

- Injured body part (according to Fuller et al. 2006)

- Injured body side (right / left / both / not applicable)

- Type of injury (according to Fuller et al. 2006)

- Onset of injury (acute / overuse)

- New / recurrent injury?

- Question for recurrent injury
o Specify date of return to full participation from the previous injury
- Use of protective or supportive equipment (no/yes, specify)

- Was the injury caused by contact or collision? (no / yes, contact with another player / yes, contact with the ball, stick or other object)

- Question for contact injury
o Direct contact to the injured body part / indirect contact
- Describe the injury situation

- Existing video material of the injury situation (no / yes)

- Where the injury was treated?

- Medical investigations (MRI / ultrasound / other, specify)

- Diagnosis

- Orthopedic operations due to the injury (no / yes, specify)

- Time-loss from training (number of days)

- Time-loss from games (number of games)

- Time-loss from school/work (number of days)

- Previous menstruation (date)

- Direct costs of the injury