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### 001 SELF-REPORTED SKILL LEVEL AND INJURY SEVERITY IN SKIERS AND SNOWBOARDERS

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**Background:** It is well documented that the rate of injury is significantly lower for expert skiers and snowboarders than for beginners. A better understanding of the relation between the severity of injury and skill level is also needed for planning of injury prevention strategies.

**Objective:** To examine the severity and location of injuries sustained by self-reported expert and beginner skiers and snowboarders.

**Design and Methods:** A case-control study design was used. Injured subjects had to report their skill level on a 5-point scale. Beginners (1) were compared with experts (5). Two sets of severely injured cases were defined based on the type of injury and ambulance evacuation. Controls were those who did not sustain severe injuries. Logistic regression analyses were performed to relate injury severity to the skill level. All analyses were controlling for age, sex, place of injury (snow-park versus other), helmet use, season and type of activity (skiing versus snowboarding).

**Setting and Participants:** Subjects were 22 078 injured skiers and snowboarders who reported to the ski patrol with an injury sustained on the slopes (including snow-parks) of an alpine ski centre of the Canadian province of Québec from seasons 2001–2 to 2004–5.

**Results:** There was evidence to suggest that expert skiers compared with beginners had an increased risk of experiencing a severe injury (adjusted odds ratio (AOR) 1.88; 95% CI 1.58 to 2.23). Expert snowboarders were more likely to have a severe injury or be evacuated by ambulance (AOR 1.18; 95% CI 1.02 to 1.38). The risk of severe head or neck, trunk and upper extremity injuries was significantly greater for expert skiers and only severe injuries of the lower extremities for expert snowboarders.

**Conclusions:** Results suggest that the type of activities or manoeuvres performed by expert skiers and snowboarders may increase the risk of sustaining a severe injury compared with beginner participants.

### 002 INJURIES AMONG WORLD CUP ALPINE SKIERS

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**Background:** Although the injury risk among world class alpine skiers is believed to be high, there is little research available.

**Objective:** To describe the incidence and pattern of injuries among World Cup alpine skiers during the 2006/7 winter season.

**Methods:** At the final World Cup events in Kvitfjell and Lenzerheide, injuries were recorded retrospectively by interview with athletes and coaches from nine World Cup teams. All acute injuries that occurred from November 2006 until March 2007 and required attention by medical staff were included. Z-tests were used to compare disciplines and genders.

**Results:** Through the interviews, 84 injuries among 260 athletes were reported, ie, the overall incidence was 32.3 injuries per 100 athletes per season. In the FIS World Cup competition, the injury incidence was 8.4 (95% CI 5.7 to 11.1) per 1000 runs; 5.4 (2.2 to 8.6) for women and 11.0 (6.8 to 15.3) for men (relative risk (RR) 2.1 versus women,  $p = 0.047$ ). The injury incidence for the different disciplines was 14.7 (95% CI 7.7 to 21.8) per 1000 runs for downhill, 9.4 (1.9 to 16.9) for super-G, 7.2 (1.9 to 12.5) for giant slalom and

4.3 (1.1 to 7.4) for slalom (RR 0.3 versus downhill,  $p = 0.006$ ). The most common location of injury was the knee ( $n = 32$ , 38%) and the most common type was joint and ligament injuries ( $n = 40$ , 48%). Of all injuries reported, 75 were time-loss injuries (89%) and 31 (37%) resulted in absence from training and competition for more than 28 days.

**Conclusion:** In the FIS World Cup competition, the risk of injury was higher for men compared with women and higher in downhill than slalom. Serious knee injuries were frequent and an identification of risk factors and injury mechanisms for knee injuries is an important goal for further studies.

**Funding:** The FIS Injury Surveillance System has been established through a generous grant from DJO.

### 003 INJURIES TO WORLD CUP SKI AND SNOWBOARD ATHLETES

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**Background:** We have inadequate knowledge regarding the injury profile of skiers and snowboarders competing at the elite level and limited data to suggest how injuries may be prevented. The FIS Injury Surveillance System was therefore established before the winter season 2006–7.

**Objective:** To compare the injury risk and injury pattern between the different FIS disciplines (alpine, freestyle, snowboard, ski jumping, Nordic combined and cross country).

**Design/Setting:** Athletes from nine World Cup teams in the six disciplines were interviewed towards the end of the 2006–7 winter season regarding injuries they had sustained during the season. Questions were asked regarding body part, injury type, severity (number of days out of training/competitions), as well as the specific diagnosis. Coaches and/or physical therapists/physicians were interviewed regarding athletes not available.

**Results:** A total of 296 injuries were recorded among 902 athletes, 47% ( $n = 139$ ) in World Cup events (including official training and World Championships) and 28% ( $n = 84$ ) in other training activities on snow. There was a total of 217 (73%) time-loss injuries, in which 84 (28%) led to an absence of >28 days and 76 (26%) with no time loss from training/competition. Alpine, freestyle and snowboard accounted for 84 (28%), 49 (17%) and 100 (34%) of all injuries, respectively. The number of time-loss injuries per 100 athletes per season was 28.8 (95% CI 23.0 to 36.1) in alpine, 26.8 (19.7 to 36.5) in freestyle and 44.7 (34.9 to 57.3) in snowboard, whereas the Nordic events had 26.3 (15.9 to 43.6) injuries per 100 athletes per season in Nordic combined, 19.4 (11.3 to 33.4) in ski jumping and 5.8 (3.2 to 10.5) for cross country. The knee was the most common injury location with 81 injuries (27%) followed by 36 injuries to the lower back (12%) and 31 head injuries (11%).

**Conclusion:** The injury frequency of elite ski and snowboard athletes is high, particularly in snowboard.

**Funding:** The FIS Injury Surveillance System has been established through a generous grant from DJO.

### 004 EVALUATION OF SKIING AND SNOWBOARDING INJURIES IN TERRAIN PARKS

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**Background:** There are no studies describing injuries in terrain parks, an outdoor area that contains terrain such as rails, fun boxes, jumps and half-pipes.

**Purpose:** To describe characteristics of injury among skiers and snowboarders in terrain parks, an outdoor area that contains terrain such as rails, fun boxes, jumps and half-pipes.

**Methods and Study Design:** Retrospective cohort, using Ski Patrol injury report forms for 2000–5 from two western US ski areas. Population included all skiers and snowboarders who received care from the Ski Patrol for an injury. Logistic regression was performed to examine characteristics of injuries in terrain parks compared with injuries on slopes.

**Results:** From 2000 to 2005, 8 173 622 skier days and 16 944 ski and snowboard injuries were reported. Combined injury rate for ski seasons 2000–5 was 2.1 injuries per 1000 skier days. 8802 (73%) injuries occurred on slopes and 3228 (27%) injuries occurred in terrain parks. Of those individuals sustaining injuries in terrain parks, 2679 (83%) were snowboarders and 2626 (82%) were males; approximately two-thirds were aged 13–24 years. Almost 90% self-reported ability as intermediate or expert and owned their own equipment. Two-thirds were not wearing a helmet. Mechanism of injury in 75% of terrain park injuries was a high fall. There was a higher odds of fracture (OR 1.3, CI 1.0 to 1.7), head injury (OR 1.7, CI 1.2 to 2.5) and transport to a hospital by ambulance (OR 1.9, CI 1.3 to 2.9) for injuries sustained in terrain parks compared with injuries sustained on slopes.

**Conclusions:** The majority of injuries in terrain parks are due to high falls among non-beginner male snowboarders aged 13–24 years. Injuries sustained in terrain parks may be more severe than injuries sustained on slopes.

**Significance:** These findings highlight the need for injury prevention programmes to target this at-risk population at ski areas that contain terrain parks.

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## 005 EFFECTS OF A CORE STABILITY INTERVENTION PROGRAMME ON ABDOMINAL AND LUMBAR MUSCLE SYMMETRY IN ELITE HIGH SCHOOL CRICKETERS

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**Background:** There is a high incidence of lumbar injury and lower back pain in elite schoolboy cricketers. These injuries may be associated with abdominal and lumbar muscle asymmetry.

**Objective:** This study aimed to assess the measurements of the lateral abdominal muscles (LAM), external oblique (OE), internal oblique (OI) and transverse abdominis (TrA) and posterior lumbar musculature (PLM) of elite high school cricketers and determine the effects of a core stability intervention programme.

**Design:** Parallel group intervention study.

**Setting:** High school provincial cricketers.

**Participants:** 46 cricketers were recruited and allocated to the intervention (I; n = 21) or control (C; n = 18) group.

**Interventions:** I underwent an 8-week progressive pre-season core stability programme, whereas C undertook only traditional pre-season training.

**Main Outcome Measures:** PLM cross-sectional area measured by magnetic resonance imaging and total LAM thickness (TLAT; OE + OI + TrA;) measured by ultrasound. Dominance was designated as bowling or batting dominance.

**Results:** Relative cross-sectional area of PLM was no different in both groups, in both dominant (D) and non-dominant (ND) sides either pre or post-intervention. TLAT in I was thicker on the ND versus D sides ( $22.7 \pm 4.7$  mm versus  $26.2 \pm 3.4$  mm;  $p < 0.05$ ); however, this difference was not evident in C ( $26.5 \pm 4.7$  mm versus  $26.2 \pm 3.4$ ; ND versus D;  $p = \text{NS}$ ). Following intervention, TLAT increased on the D side ( $22.7 \pm 4.7$  mm versus  $24.2 \pm 3.9$  mm;  $p < 0.05$ ) and decreased on the ND side ( $26.2 \pm 3.4$  mm versus  $24.1 \pm 4.2$  mm;  $p < 0.05$ ) so that there

was no longer a difference between D and ND. TLAT in both D and ND was unchanged in C over time.

**Conclusions:** Muscle asymmetry of the LAM can occur between the D and ND sides in young elite cricketers and can be reversed by a pre-season core stability intervention programme.

## 006 PACE BOWLERS IN CRICKET WITH HISTORY OF LUMBAR STRESS FRACTURE HAVE INCREASED RISK OF LOWER-LIMB MUSCLE STRAINS, PARTICULARLY CALF STRAINS

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**Background:** It has previously been proposed that lumbar spine pathology (particularly involving the L5 segment) is a risk for hamstring and calf strain, although supportive data for this theory are lacking.

**Objective:** To assess whether history of lumbar stress fracture in pace bowlers in cricket is a risk factor for lower-limb muscle strains.

**Design:** Prospective cohort risk factor study.

**Setting:** Contracted first class pace bowlers in Australia from seasons 1998–9 and 2006–7 inclusive.

**Participants:** 29 pace bowlers with a history of lumbar stress fracture and 148 bowlers without a history of lumbar stress fracture.

**Assessment of Risk Factors:** The independent variable was history (before any muscle strain) of a lumbar stress fracture.

**Main Outcome Measure:** The dependent variables were occurrences of muscle strains (to hamstring, quadriceps, calf and groin muscle groups).

**Results:** Risk of calf strain (expressed as risk ratio of seasonal incidence) was strongly associated with positive lumbar stress fracture injury history (relative risk (RR) 5.61, 95% CI 2.93 to 10.74). Risks of both hamstring strain (RR 1.73, 95% CI 1.08 to 2.75) and quadriceps strain (RR 2.09, 95% CI 1.15 to 3.81) were somewhat associated with history of lumbar stress fracture. Risk of groin strain was not associated with history of lumbar stress fracture (RR 0.69, 95% CI 0.39 to 1.20).

**Conclusion:** Confounders may be responsible for some of the findings. In particular, bowling speed is likely to be independently correlated with risk of lumbar stress fracture and risk of muscle strain. However, as the relationship between lumbar stress fracture history and calf strain was very strong and there is a strong theoretical basis for the connection, it is likely that this is a true association.

## 007 PACE BOWLERS IN CRICKET DEMONSTRATE 3–4-WEEK DELAY BETWEEN HIGH WORKLOADS AND INCREASED RISK OF INJURY

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**Background:** Bowling workload has previously been associated with injury in cricket but the details of the relationship are not well understood.

**Objective:** To assess whether acute high workload leads to increased risk of injury in future matches.

**Design:** Prospective cohort risk factor study.

**Setting:** First class cricket matches involving Australian teams over 9 years (seasons 1998–9 and 2006–7 inclusive).

**Participants:** 125 pace bowlers who bowled in 2467 player matches.

**Assessment of Risk Factors:** The independent variables were numbers of overs bowled in the entire match and in each innings.

**Main Outcome Measures:** The dependent variables were the occurrences of any non-contact bowling injury in various time periods after the match under assessment.

**Results:** Bowlers who bowled more than 50 overs in a match had an injury incidence in the next 21 days of 3.49 injuries per 1000 overs bowled, a significantly increased risk compared with those bowlers who bowled less than 50 overs, relative risk (RR) 1.82 (95% CI 1.06 to 3.11). Bowlers who bowled more than 30 overs in the second innings of a match had an injury incidence in the next 28 days of 4.48 injuries per 1000 overs bowled, a significantly increased rate compared with those bowlers who bowled less than 30 overs, RR 2.29 (95% CI 1.27 to 4.12). Time periods of less than 21 days or greater than 28 days after the match in question did not yield significant differences in injury risk between high and low workload bowlers.

**Conclusion:** High acute workloads may predispose to non-contact (or "overuse") injury by damaging immature tissue, leading to a delayed increased risk of injury 3–4 weeks after the acute overload.

### 008 SELF-REPORTED INJURY HISTORY AND LOWER-LIMB FUNCTION AS RISK FACTORS FOR INJURIES IN FEMALE YOUTH FOOTBALL

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**Background:** Identifying and understanding injury risk factors are necessary to develop and target measures to prevent injuries. As youth teams rarely have healthcare professionals working directly with the team, identifying players at increased risk through elaborate clinical tests is therefore not feasible. Questionnaires may be a possible alternative as screening instruments.

**Aim:** To examine whether injury history and lower-limb function assessed by a self-administered questionnaire represent risk factors for injury.

**Design:** Prospective cohort study; based on a secondary analysis of data from a randomised controlled trial.

**Methods:** At baseline, female players (14–16 years) were asked to complete a detailed questionnaire covering sports participation, history of previous injuries to the ankle, knee, hamstring or groin, as well as present function of these four specific regions. A total of 1430 (71% of the entire cohort) were followed up to record injuries during the subsequent 8 months.

**Results:** A history of a previous injury to the ankle (relative risk (RR) 1.2, 1.1 to 1.3,  $p < 0.001$ ), knee (RR 1.4, 1.2 to 1.6,  $p < 0.001$ ) or groin (RR 1.6, 1.2 to 2.1,  $p = 0.004$ ) increased the risk of new injuries to the same region. Reporting a reduced function (defined as  $< 80\%$  of the maximum score) for the ankle (RR 1.7, 1.1 to 2.7,  $p = 0.021$ ) or knee (RR 3.2, 1.8 to 5.7,  $p < 0.001$ ) were also significant risk factors. However, the sensitivity of previous injuries and lower-limb function in predicting new injuries was low.

**Conclusion:** A history of previous injury and reduced function at baseline were significant risk factors for new injuries to the same region during the following season.

### 009 SELF-REPORTED PSYCHOLOGICAL CHARACTERISTICS AS RISK FACTORS FOR INJURIES AMONG MALE FOOTBALL PLAYERS

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**Background:** There are few studies on psychological characteristics and their possible relation to injuries in football. Knowledge on this area could be important to be able to identify athletes with an increased injury risk.

**Objective:** To investigate if differences in psychological characteristics can predispose players to injuries.

**Design:** Prospective cohort study.

**Setting:** Norwegian amateur men.

**Participants:** 508 players from 31 teams.

**Methods:** All players were asked to complete a detailed questionnaire covering psychological player characteristics. These included perception of success (POSQ), risk-seeking behaviour, life stress (LESCA), coping strategies, anxiety (SAS-n) and motivational climate (PMCSQ). Time-loss injuries sustained throughout the subsequent season were then registered by each team's physiotherapist.

**Results:** A total of 505 injuries were reported, sustained by 283 (55.7%) of the 508 players. There was a significantly higher self-reported level of stress among the players with previous injury to the ankle, knee, hamstring or groin (mean value 9.6 versus 8.5,  $p = 0.048$ ). There were only slight trends indicating covariation between performance climate and previous acute injuries (performance,  $p = 0.12$ ; mastery,  $p = 0.11$ ). When looking at new injuries, no predictive value was found from the self-reported psychological variables. However, there was a tendency towards higher values for the subscales "worry" (SAS-n,  $p = 0.08$ ) and "coping strategies" (Brief Cope,  $p = 0.07$ ).

**Conclusions:** There are higher self-reported levels of stress among players with previous injuries. No other correlations between the psychological variables tested and previous injuries or new injuries were found in this cohort.

### 010 SELF-REPORTED PSYCHOLOGICAL CHARACTERISTICS AS RISK FACTORS FOR INJURIES IN FEMALE YOUTH FOOTBALL

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**Background:** Identifying and understanding injury risk factors are necessary to target the injury-prone athlete and develop injury prevention measures. The influence of psychological factors on injuries in football is poorly documented.

**Objective and Design:** The purpose of this 8-month prospective cohort study was therefore to examine whether psychological player characteristics assessed by a self-administered questionnaire represent risk factors for injury.

**Methods:** At baseline, female football players (14–16 years) were asked to complete a detailed questionnaire covering player history, previous injuries, perception of success and motivational climate, life stress, anxiety and coping strategies. During the 2005 season, a total of 1430 players were followed up to record injuries.

**Results:** A history of a previous injury (odds ratio (OR) 1.9, 1.4 to 2.5,  $p < 0.001$ ) increased the risk of a new injury to the same region. There were significant differences in disfavour for previously injured compared with non-injured players for ego orientation ( $p = 0.007$ ), perception of a performance climate ( $p = 0.003$ ) and experienced stressful life events ( $p < 0.001$ ). However, only high life stress ( $p = 0.001$ ) and perception of a mastery climate ( $p = 0.03$ ) were significant risk factors for new injuries.

**Conclusions:** A perceived mastery climate and a high level of life stress were significant predictors for new injuries in a cohort of young female football players. A coach should avoid and if present buffer high levels of stress among the players by creating a positive motivational climate.

### 011 RISK FACTORS FOR ANKLE, KNEE, HAMSTRING AND GROIN INJURIES AMONG MALE FOOTBALL PLAYERS: A PROSPECTIVE COHORT STUDY

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**Background:** Ankle, knee, hamstring and groin are among the most common injury locations in football, and precise knowledge about their risk factors is important to be able to target players at risk.



**Objective:** To identify risk factors for ankle, knee, hamstring and groin injuries among male football players.

**Design:** Prospective cohort study.

**Setting:** Norwegian amateur football men.

**Participants:** 508 players from 31 teams.

**Assessment of Risk Factors:** Players were tested during the 2004 pre-season for potential risk factors for ankle, knee, hamstring and groin injuries through a questionnaire and clinical tests. The questionnaire included function scores for the ankle, knee, hamstring and groin and information on previous acute injuries. The clinical tests were balance tests (balance mat and floor), hamstring strength, hamstring muscle length, isometric groin strength, 40 m sprint run and clinical examination of the ankle, knee, hamstring and groin. Time-loss injuries occurring during the subsequent season were registered by the team physical therapist.

**Results:** During the 2004 season, 56 acute ankle injuries (46 injured players), 61 acute knee injuries (57 players), 77 acute and overuse hamstring injuries (66 players) and 62 acute and overuse groin injuries (56 players) were registered. Multivariate analyses showed that previous ankle injuries were a significant risk factor (adjusted odds ratio (OR) 1.22, 95% CI 1.06 to 1.41,  $p = 0.006$ ) for new acute ankle injuries. For knee injuries, clinical examination was the best predictor (adjusted OR 1.57, 95% CI 0.97 to 2.54,  $p = 0.056$ ). The number of previous acute injuries was also the best predictor for hamstring injuries (1.29, 95% CI 1.08 to 1.53,  $p = 0.005$ ), whereas increasing age (1.08, 95% CI 1.01 to 1.17 per year,  $p = 0.028$ ) and history of previous acute groin injuries (1.19, 95% CI 0.98 to 1.43,  $p = 0.079$ ) were the most important risk factors for new groin injuries.

**Conclusion:** A history of previous injury is the most important to target players at risk of injury, whereas clinical and fitness tests were of little help.

## 012 WITHDRAWN

## 013 RISK OF FOOTBALL INJURIES ON ARTIFICIAL TURF IN YOUTH FOOTBALL: 3-YEAR DATA FROM THE NORWAY CUP TOURNAMENT

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**Background:** Artificial turf is in common use in youth football worldwide, although little is known about the injury risk on third-generation artificial turf types.

**Objective:** To compare the injury risk on natural grass and third-generation artificial turf in youth football.

**Design:** Prospective cohort study.

**Participants:** Girls and boys (13–19 years) playing the Norway Cup tournament, 2005–7.

**Method:** Referees gave injury registration cards to each team before each match and collected these immediately after. Injuries were defined as all injuries, painful conditions or physical complaints that occurred during the match, even if the player was able to continue to play.

**Results:** A total of 2015 injuries was recorded during 3369 11-a-side matches. This corresponds to an incidence of  $39.6 \pm 0.9$  (SE) injuries per 1000 match hours,  $39.4 \pm 2.8$  (193 injuries, 4902 h exposure) on artificial turf and  $39.6 \pm 0.9$  (1822 injuries, 45 960 h exposure) on natural grass (relative risk (RR) 0.99, 95% CI 0.86 to 1.15). A total of 232 injuries (11.5%) was projected to result in absence from play for at least one day. This corresponds to an incidence of  $4.6 \pm 0.3$  injuries per 1000 match hours,  $4.5 \pm 1.0$  ( $n = 22$ ) on artificial turf and  $4.6 \pm 0.3$  ( $n = 210$ ) on natural grass (RR 0.98, 95% CI 0.63 to 1.52). On artificial turf there was a higher risk of back injuries (RR 2.46, 95% CI 1.41 to 4.27) but a

lower risk of ankle injuries (RR 0.58, 95% CI 0.38 to 0.88) and lower extremity injuries (RR 0.78, 95% CI 0.64 to 0.95).

**Conclusion:** Overall, there was no difference in injury risk between third-generation artificial turf and natural grass in a youth football tournament. However, both surfaces exhibited unique injury patterns that warrant further investigation.

## 014 RISK OF INJURY ON ARTIFICIAL TURF IN ELITE FOOTBALL

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**Background:** Artificial turf is in extensive use in both grassroots and elite football in areas with difficult climatic conditions. Few studies have been carried out on the latest generation of artificial turf. A recent Swedish study found no evidence of increased risk of injury when playing football on third-generation artificial turf compared with playing on natural grass (Ekstrand *et al*, 2006).

**Objective:** To compare the risk of acute injury on artificial turf with natural grass in male elite football.

**Design:** Prospective injury registration in the male Norwegian professional league ( $N = 14$  teams).

**Methods:** Injuries and exposure were registered by team medical staff through the league surveillance system during three seasons (2004–6). An injury was recorded when a player was unable to take part fully in football training or matches.

**Results:** A total of 776 acute injuries was recorded. The injury incidence for matches on natural grass and artificial turf was 16.7 (95% CI 15.1 to 18.3) and 15.1 (11.7 to 18.6) per 1000 match hours, respectively (relative risk (RR) 0.91; 95% CI 0.71 to 1.16). During training the incidence was 1.8 (1.6 to 2.0) per 1000 h on natural grass and 1.7 (1.3 to 2.0) per 1000 h on artificial turf (RR 0.93; 95% CI 0.72 to 1.20). The risk of severe match injuries (absence >21 days) was higher on artificial turf compared with natural grass (5.9 versus 3.6 injuries per 1000 match hours; RR 1.63; 95% CI 1.07 to 2.49). The risk of mild injuries (absence <7 days) was lower on artificial turf compared with natural grass (RR matches 0.62; 95% CI 0.41 to 0.93; RR training 0.64; 95% CI 0.43 to 0.95).

**Conclusion:** No overall difference in the risk of acute injury was observed between artificial turf and natural grass in male Norwegian professional football. Severe injuries, however, appeared to be more common and mild injuries less common on artificial turf.

## 015 INJURY SURVEILLANCE IN MALE NORWEGIAN PROFESSIONAL FOOTBALL: A METHODOLOGICAL STUDY

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**Background:** Since the 2000 season, an injury surveillance system has been established to monitor injury risk and injury patterns in male Norwegian professional football. Injuries have been registered by club medical staff. Despite the frequent use of such systems, the accuracy and completeness of medical personnel registration have not been examined.

**Objective:** To assess the accuracy of routine injury registration performed by medical staff in professional football.

**Design:** Injury survey, comparison of prospective medical staff recording and retrospective player interviews.

**Participants:** 13 of 14 teams in the male Norwegian professional league, 300 of 317 A-squad players were interviewed.

**Methods:** The team physiotherapists completed injury registration forms and submitted these on a monthly basis throughout the 2007 season (January–October). Players were interviewed at the end of the season (October/November) covering all injuries occurring during July–September. An injury was recorded when a player was

unable to take part fully in football training or a match the day after injury.

**Results:** A total of 181 injuries was registered, 137 acute injuries and 44 overuse injuries. Of these, 145 were reported by medical staff and 128 by players. Ninety-two injuries (50.8%) were registered using both methods, 53 (29.3%) by medical staff only and 36 (19.9%) by player interviews only. Of the acute injuries, 18 mild (absence <7 days), four moderate (absence 8–21 days) and two severe (absence >21 days) were registered by player interviews only and of the overuse injuries, eight mild and four moderate were registered by player interviews only.

**Conclusion:** Prospective injury surveillance by medical staff reports the majority of injuries in male professional football. One fifth of all time-loss injuries, however, was not reported by the medical staff.

#### 016 THE NEED FOR INJURY PREVENTION IN ELITE FOOTBALL REFEREES: DATA FROM THE 2006 FIFA WORLD CUP AND THE FIFA WOMEN'S WORLD CUP 2007

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**Background:** Although numerous studies have investigated the injury pattern of football players, there is no research on injuries among referees.

**Objective:** To investigate injuries and musculoskeletal complaints in male and female referees selected for FIFA World Cups.

**Design:** Retrospective and prospective surveys.

**Setting:** 2006 FIFA World Cup, FIFA Women's World Cup 2007.

**Methods:** During the preparation camps before the tournaments, all candidate referees, male (N = 123) and female (N = 81), completed a retrospective questionnaire on injuries and musculoskeletal complaints related to officiating or training. Prospective data on all referees (63 men, 36 women) officiating during the tournaments were collected on a daily basis by a physiotherapist working with the referee team. An injury was defined as any musculoskeletal complaint caused by refereeing a football match or the related training.

**Results:** More than 40% of the male and 49% of the female referees reported at least one time-loss injury during their career. Musculoskeletal complaints were reported by 77 (63%) male and 66 (81%) female referees. The data collected prospectively during the World Cups resulted in an incidence of 20.8 injuries per 1000 match hours (95% CI 4.2 to 37.4) for men and 34.7 (4.2 to 65.1) for women (ns versus men). Injuries during the two World Cups resulted in reduced training but none in time loss. In both groups, the most common injuries were hamstring strains, calf strains and ankle sprains. More than 30% of male and 33% of female referees reported musculoskeletal complaints during the respective tournament, mainly located in the low back, followed by calf and Achilles tendon in men and hip and groin in women.

**Conclusion:** Referees should be regarded as elite athletes performing at high level during the match. The results show that referees have significant injuries and complaints and therefore prevention programmes should be developed for elite football referees.

#### 017 FATAL ACCIDENTS IN SPORT: DATA COLLECTION, ACCIDENT OCCURRENCE AND PREVENTION

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**Background:** The recording of accident occurrences in Switzerland is only fragmentary.

**Objective:** The BFU, the Swiss Council for Accident Prevention, set itself the objective of keeping own statistics on fatal accidents in

sport, so as to have a basis for the planning and assessment of preventative measures. In addition to demographic data, information was also to be compiled on the activity at the time of the accident, events leading to the accident, risk factors, objects involved and the cause of death.

**Methodology:** Since 2000, BFU statistics has collected information from many national institutions (Central Office for Statistics in Accident Insurance, Swiss Institute for Avalanche Research, Swiss Alpine Club Rescue Service, Swiss Lifesaving Society, Swiss Hanggliding Association and others), media releases, professional online search engines and combined this into one overall statistic.

**Results:** In Switzerland, over 200 persons die each year as the result of a sporting accident, of whom 70 are foreign tourists. On a long-term average, 36% of cases occur in mountain sports (mountaineering climbing, mountain hiking), 22% in winter sports (skiing and snowboarding, mainly off-piste), 20% in water sports (swimming, bathing, boating) and 10% in aerial sports (paragliding, hang gliding, parachute jumping). However, an annual three to four fatal accidents also occur in equestrian sports as well as hunting and fishing. It is difficult to estimate the number of cycling and skating accidents, as these are mostly classified under the sector of road accidents.

**Implications on Prevention:** Comparison with other statistics has shown that the BFU data collection is a valid representation of accident occurrence. One important advantage of this data collection is the availability of current information. In prevention, the BFU is working on accident focal points in close cooperation with national institutes, to reduce the annual number of accident fatalities to a maximum of 100 by 2010.

#### 018 COST OF SPORTS ACCIDENTS TO THE SWISS NATIONAL ECONOMY

O Bruegger. Swiss Council for Accident Prevention, Bern, Switzerland

**Background:** In 2003, 318 000 people were injured (incidence rate (IR) of 42 injuries per 1000 inhabitants) and a further 174 lost their lives (IR 0.02 × 10<sup>-3</sup>) during sporting activities in Switzerland.

**Objective:** The study aimed to calculate the cost of all non-occupational accidents (NOA), applying recent standards in economic methodology for the first time. Procedure accident figures are based on various detailed statistics and were processed by the Swiss Council for Accident Prevention BFU. The cost of NOA was calculated using these statistics and details of case costs from insurance companies' statistics. Only those injuries requiring medical treatment and involving insurance claims were included. Intangible costs were based on willingness to pay.

**Main Findings:** In 2003, sports accidents in Switzerland accounted for total material costs of €1.3 billion (16% of the total cost of all NOA). These costs were mainly for medical treatment and lost production due to absence from work. The total economic cost of sports accidents was €8.0 billion, ie, it exceeded the material costs by a factor of 6. Intangible costs accounted for 71% of this. A fatality costs the national economy €1.9 million (174 casualties), a disability case €863 000 (764 casualties), a severely injured person €188 000 (11 099 casualties), a moderately injured person €83 000 (16 822 casualties) and a slightly injured person €12 000 (289 315 casualties). Sports accidents cost 5.6 million working days, corresponding to the workload of over 15 000 employees.

**Conclusion:** The overall cost of accidents in the NOA sector reveals an obvious need for action in this public health field. The BFU's focus is on material costs when evaluating prevention measures.

## 019 SHOULDER PAIN IS A COMMON PROBLEM IN ELITE FEMALE TEAM HANDBALL PLAYERS

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**Background:** The prevalence of shoulder pain among team handball players is unknown.

**Objective:** To describe the prevalence of painful conditions in the shoulder region and assess the relationship between pain and glenohumeral range of motion (ROM), shoulder instability and throwing velocity among female elite team handball players.

**Design:** Cohort study.

**Participants:** All female team handball players competing in the Norwegian elite league and/or national team were invited to participate and 179 players were included in June 2007.

**Methods:** The players completed two questionnaires, an apprehension and a relocation test were performed and glenohumeral internal and external rotations were measured with goniometry. Throwing velocity was measured using radar.

**Results:** Previous or present shoulder pain was reported by 57% of all players and current pain was reported by 36% of the players. Furthermore, the presence of shoulder pain negatively influenced training and competition habits and also affected activities of daily living. The majority of the players had sought medical advice and had been given physical therapy treatment. A positive apprehension test was assessed in 51 players (29%) and was significantly correlated with ongoing pain. A significant difference was found in internal and external rotation between the dominant and non-dominant arm. However, no differences in ROM were found between players with shoulder pain and those without pain. There was no relation between a positive apprehension test and shoulder ROM. No between-group differences were measured in throwing velocity for players with shoulder pain and those without pain, nor between players with or without a positive apprehension test.

**Discussion/Conclusion:** Shoulder pain is an extensive and significant problem among female elite handball players, and for those affected their symptoms influence their training and playing capacity negatively. It is necessary to start focusing on preventing shoulder pain in this group of team handball players.

## 020 EFFECT OF THE SCRUM LAW CHANGE ON INJURIES IN RUGBY UNION

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**Background:** In January 2007 the International Rugby Board implemented a new law for scrum engagement aimed at reducing scrum-related injury by decreasing impact force and scrum collapses.

**Objective:** To determine if the new law reduced scrum-related neck/spine/back moderate to serious injury claims to the Accident Compensation Corporation, the provider of no-fault injury compensation and rehabilitation costs for injuries throughout New Zealand.

**Design:** Ecological cohort study. To determine a rate, neck/spine/back scrum injuries were calculated using player registrations. Injury claims were compiled in December 2007, 4 months after the end of the playing season. Mean delay between injury and claim was 10 days. The scrum claim rate per 100 000 players for 2002–6 was used to predict and compare with the claim rate for 2007 using Poisson regression. To determine safe scrum behaviour at practices, players were surveyed at season end in 2007 (n = 169) comparing with survey results in 2005 (n = 318). Inferences were based on the likelihood of substantial difference.

**Setting:** Rugby-related injuries in the general population.

**Participants:** For the injury claims, all rugby players aged over 12 years. For the behaviour survey, a random sample of players aged over 19 years.

**Intervention:** Annually all rugby community coaches and referees must complete the education-based RugbySmart injury prevention programme, which contains a section on scrum safety and the new 2007 law.

**Results:** The observed and predicted rates of injury per 100 000 players in 2007 were 50 and 79 (rate ratio 0.63, 90% CI 0.38 to 1.04). The likelihood of substantial reduction (rate ratio <0.90) was 88%. Safe scrum behaviour of players at practices was 93% (91 to 95%) in 2005 and 94% (91 to 97%) in 2007.

**Conclusion:** These large effects can be ascribed to the law change as there were no other substantial scrum initiatives in 2007. The law change is evidently highly successful in terms of injury prevention.

## 021 F-MARC 11+: A COMPLETE WARM-UP PROGRAMME TO PREVENT INJURIES IN YOUTH FEMALE FOOTBALL

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**Background:** The incidence of injuries in youth female football is high and injury prevention is needed.

**Objective:** To examine the effect of F-MARC 11+, a complete warm-up programme combining strength, balance and core stability exercises based on The 11 with plyometrics and running exercises, on lower extremity injury risk in female youth football.

**Design:** Randomised controlled trial.

**Participants:** 120 teams, approximately 2000 Norwegian female players, aged 14–16 years.

**Methods:** The intervention teams (n = 60) were asked to use 11+ as their warm-up in training throughout the season (March–October 2007), whereas control teams (n = 60) warmed up as usual. Injuries and player participation were registered weekly by the coaches. An injury was recorded if the player was unable to take part fully in the next training session or match.

**Results:** A total of 376 injuries was registered among the 93 teams (52 intervention, 41 control) who completed the study. This corresponds to an incidence of  $3.9 \pm 0.2$  (SE) injuries per 1000 player hours,  $3.2 \pm 0.3$  (161 injuries, 49 899 h exposure) in the intervention group and  $4.7 \pm 0.3$  (215 injuries, 45 428 h exposure) in the control group. The risk of injury was reduced by 32% in the intervention teams (relative risk (RR) 0.68, 95% CI 0.57 to 0.84). Correspondingly, the intervention teams had a significantly lower risk of acute injuries (RR 0.76, 95% CI 0.60 to 0.95), overuse injuries (RR 0.47, 95% CI 0.30 to 0.74), training injuries (RR 0.62, 95% CI 0.44 to 0.89), match injuries (RR 0.71, 95% CI 0.55 to 0.91), serious injuries (absence >28 days) (RR 0.54, 95% CI 0.38 to 0.78), injuries to the lower extremities (RR 0.70, 95% CI 0.57 to 0.88) and knee injuries (RR 0.55, 95% CI 0.36 to 0.84), compared with the control teams.

**Conclusion:** The F-MARC 11+ programme significantly reduced the risk of injury among adolescent female football players.

## 022 COMPLIANCE WITH F-MARC 11+: A COMPLETE WARM-UP PROGRAMME TO PREVENT INJURIES IN YOUTH FEMALE FOOTBALL

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**Background:** Few published studies provide sufficient information on compliance and barriers associated with implementing injury prevention programmes in sports.



**Objective:** To assess compliance with F-MARC 11+, a warm-up programme designed to prevent injuries in youth female football, and to examine the influence of beliefs and attitudes towards injury prevention among coaches.

**Design:** This study is based on a controlled trial, in which 60 female football teams (14–16 years) were randomly assigned to 11+.

**Methods:** Programme compliance was registered prospectively throughout one football season (March–October 2007). Weekly registration forms were completed by the coach, including individual training and match exposure, injuries and compliance with the prevention programme. After the season, standardised telephone interviews were conducted to assess coaches' beliefs and attitudes towards injury prevention.

**Results:** Of the 60 teams included, 52 completed the study and were included in the compliance analysis. They completed a total of 2281 11+ sessions (mean 44, range 11–104). The 16 most compliant teams (30%; mean session number 70, range 52–104) were compared with the 16 least compliant (30%; mean session number 20, range 11–28). Among high-compliant teams, 93.8% of coaches reported that they thought it was very important to focus on injury prevention, compared with 75.0% of the coaches representing low-compliant teams. All high-compliant coaches (100%) held the belief that the motivation of the coach greatly influences players' motivation, compared with 87.6% of those with low compliance. When using 11+, 43.8% of the high-compliant coaches reported always giving feedback and correcting their players, compared with 18.8% of low-compliant coaches. The prevention programme was reported to be too time consuming by 75.0% of low versus 25.0% of high-compliant coaches.

**Conclusion:** The overall compliance with the injury prevention programme was very good. There was a relationship between coach attitudes and compliance with the programme.

### 023 CAN RISK MANAGEMENT TRAINING IMPROVE THE SAFETY ACTIVITY OF COMMUNITY SPORTS CLUBS? AN EVALUATION OF THE "SAFECLUB" PROGRAMME

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**Background:** Risk management has been identified as a "best buy" in sports injury prevention; however, very few community sports clubs have successfully embraced it in Australia. The effectiveness of risk management training in increasing community sports safety activity has yet to be determined.

**Objective:** To evaluate whether the SafeClub risk management training programme increased the sports safety activities of community football (soccer) clubs.

**Design:** A prospective controlled trial was conducted.

**Setting/Participants:** Seventy-six Australian community football clubs (representing 38 000 players) participated.

**Interventions:** Clubs were allocated either to an intervention group (receiving SafeClub programme) or a control group (no SafeClub) through a matching process. The SafeClub programme provided training in a basic, flexible risk management framework that was adaptable to suit the needs of individual community sports clubs.

**Main Outcome Measures:** A modified version of a validated sports safety audit tool was used to measure sports safety activity (policy, infrastructure and overall safety). Safety scores were compared at baseline, post-season and 12-month follow-up.

**Results:** There was no significant difference in safety scores between control and intervention clubs at baseline. General linear modelling indicated that intervention clubs significantly improved safety-related policy ( $p < 0.001$ ), infrastructure ( $p < 0.001$ ) and overall safety scores ( $p < 0.001$ ) when compared with control clubs at post-season and 12-month follow-up.

**Conclusions:** SafeClub risk management training effectively assisted community football clubs to increase their sports safety activities, particularly the foundations and processes for good risk management practice, in a sustainable way. The public health implications of SafeClub are considerable, as each community sports club participating in the programme will deliver safety benefits to an estimated 1000 Australians each weekend.

### 024 GROIN INJURY PREVENTION PROGRAMME IN PROFESSIONAL SOCCER PLAYERS

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**Background:** Groin injuries represent a significant cause of disability in professional soccer players. Groin injury prevention programmes have been created in an attempt to decrease their incidence in athletes.

**Objectives:** This study was designed to determine the efficacy of a groin injury prevention programme in reducing the incidence of injury in professional soccer players.

**Setting:** Major league soccer (MLS) in the United States.

**Patients:** 315 active players in MLS during the 2005 season were prospectively enrolled into one of two groups. Group 1 (intervention;  $n = 106$ ) participants were exposed to a groin injury prevention programme; group 2 (control;  $n = 209$ ) participants continued their usual training methods. The groin programme involved a combination of modalities: dynamic stretching, strengthening and proprioceptive exercises. Excessive anterior pelvic tilt was addressed and a Pilates method was utilised to establish core and trunk control. Group 1 was exposed to this programme two to three times per week throughout the pre-season period. Groin injuries were recorded via a central database (Sportsware).

**Results:** The overall incidence of groin injuries occurring in the 2005 MLS season was 10.9%. The incidence of groin injuries occurring in group 1 was 0.44 injuries/1000 h. The incidence of groin injuries occurring in group 2 was 0.61 injuries/1000 h. The incidence of athletes requiring groin surgery in group 1 was 0.13/1000 h compared with a group 2 incidence of 0.18/1000 h. The groin injury prevention programme was successful in reducing injury by 28% when compared with the control group ( $p < 0.05$ ). However, there was no significant difference in the number of players requiring surgery between the two groups.

**Conclusions:** The implementation of a groin injury prevention programme focusing on core instability and pathokinematics of the pelvis resulted in fewer injuries in the intervention group. This could potentially result in fewer surgical interventions and fewer missed playing hours.

### 025 THE EFFECTIVENESS OF A NEUROMUSCULAR PREVENTION STRATEGY TO REDUCE INJURIES IN YOUTH SOCCER: A CLUSTER-RANDOMISED CONTROLLED TRIAL

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**Background:** Soccer is one of the leading sports for participation and injury in youth.

**Objective:** To examine the effectiveness of a neuromuscular prevention strategy in reducing injury in youth soccer players.

**Design:** Cluster-randomised controlled trial with blinding of therapists to study group.

**Setting:** Twelve Calgary soccer clubs participating in male or female, U14–U18, tier 1–2 indoor soccer. The 20-week study period was October 2006–March 2007.

**Participants:** Eighty-two soccer teams were randomly approached for recruitment. Twenty teams declined participation and two dropped out. Players from 60 teams completed the study (32

training group teams ( $n = 380$  players), 28 control group teams ( $n = 364$  players)).

**Intervention:** The training group teams were asked to complete a physiotherapist taught and reviewed, coach delivered soccer-specific neuromuscular training programme warm-up, including stretching, eccentric strength, agility, jump technique and balance training components and a home-based balance training programme using a wobble board. The control group was asked to do a standardised warm-up (including static and dynamic stretching and running), in addition to a home-based stretching programme.

**Main Outcome Measures:** Previously validated injury surveillance was used including injury assessment by a study therapist. The injury definition included all soccer injury resulting in medical attention and/or time loss from soccer participation.

**Results:** The overall injury rate in the training group was 2.08 injuries/1000 player hours and in the control group was 3.35 injuries/1000 player hours. The relative risk of all injury and acute onset injury comparing the training group with the control group was 0.62 (95% CI 0.38 to 1.0) and 0.57 (95% CI 0.35 to 0.94), respectively. Point estimates also suggest protection of ankle and knee sprain injuries.

**Conclusions:** A team-based neuromuscular training programme and home-based balance training programme is protective of all injury and acute onset injuries in youth soccer players aged 13–18 years and is recommended.

#### 026 RELATIONSHIP BETWEEN CLINICAL MEASURES OF JOINT LAXITY AND SAGITTAL PLANE JOINT EXCURSION AND STIFFNESS DURING A DROP JUMP LANDING

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**Background:** Greater anterior knee laxity (AKL) has been associated with greater tibiofemoral joint displacement as the knee transitions from non-weight-bearing to weight-bearing conditions. The combined effect of AKL, genu recurvatum (GR) and general joint laxity (GJL) on sagittal plane biomechanics during landing is unknown.

**Objective:** To determine whether GJL, AKL and GR predict lower extremity joint excursions and stiffnesses during landing. Participants with greater joint laxity were expected to use “softer” landing strategies in an attempt to reduce axial loading.

**Design:** Descriptive cohort study.

**Setting:** Controlled laboratory.

**Participants:** Thirty-nine physically active, healthy women ( $21.9 \pm 2.9$  years,  $58.1 \pm 6.1$  kg,  $162.9 \pm 6.8$  cm).

**Assessment of Risk Factors:** During menses, participants were measured for AKL (133 N) using the KT2000, supine GR using a standard goniometer and GJL using the Beighton and Horan joint mobility index. Kinematic and kinetic data were collected during five5 double leg drop jump landings (30 cm box). Stepwise linear regressions examined whether AKL, GJL and GR were predictive of the dependent variables.

**Main Outcome Measures:** Hip (HIPEXC, HIPK), knee (KNEEXC, KNEEK), and ankle (ANKEXC, ANKK) joint excursion (peak – initial angle = °) and stiffness ( $\Delta$ Moment/ $\Delta$ Angle = Nm/deg).

**Results:** GJL ( $1.9 \pm 2.0$ ), AKL ( $6.9 \pm 2.3$  mm) and GR ( $3.7 \pm 3.8^\circ$ ) each entered the model and combined to predict KNEEXC ( $70.6 \pm 11.8^\circ$ ) ( $R^2 = 0.225$ ,  $p = 0.029$ ) and HIPK ( $-0.0391 \pm 0.2040$  Nm/deg) ( $R^2 = 0.230$ ,  $p = 0.026$ ). GJL and GR were also predictors of ANKK ( $-0.0020 \pm 0.0052$  Nm/deg) ( $R^2 = 0.254$ ,  $p = 0.016$ ). In particular, greater GJL and AKL and lower GR were related to greater joint excursion and decreased stiffness. Laxity was not related to HIPEXC ( $40.2 \pm 15.9^\circ$ ), ANKEXC ( $58.3 \pm 7.2^\circ$ ) or KNEEK ( $-0.0015 \pm 0.0008$  Nm/deg).

**Conclusions:** Participants with greater AKL, greater GJL and lower GR appear to adopt landing styles that may attenuate forces at the knee. These findings also suggest that AKL, GJL and GR represent distinct laxity measures that should be considered collectively in future studies.

**Finance:** Supported by NIH-NIAMS grant nos R01-AR53172 and 3R01AR053172-01A1W1.

#### 027 AGREEMENT AND VALIDITY OF OBSERVATIONAL RISK SCREENING GUIDELINES IN EVALUATING ANTERIOR CRUCIATE LIGAMENT INJURY RISK FACTORS

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**Background:** Post-pubescent female athletes have an increased risk of anterior cruciate ligament (ACL) injury partly due to their high-risk landing and cutting strategies. There are currently no scientifically tested methods to screen for these high-risk strategies in the clinic or on the field.

**Objective:** To examine the agreement and validity of using observational risk screening guidelines to evaluate ACL injury risk factors during three different tasks: a drop jump (DJ), side hop (SH) and unanticipated side cut (USC). We hypothesised that observational ratings would demonstrate substantial intrarater and interrater agreement ( $\kappa = 0.61$ ), high sensitivity ( $\kappa = 0.80$ ) and moderate specificity ( $\kappa = 0.50$ ).

**Design:** Methodological study.

**Setting:** Biomechanical research laboratory.

**Participants:** A convenience sample of 40 13–17-year-old competitive female soccer players was tested.

**Assessment of Risk Factors:** Three physiotherapists used observational risk screening guidelines to rate the biomechanical characteristics of participants. The DJ was rated as high or low risk based on the degree of knee abduction observed. The SH and USC were rated on the degree of lower-limb “reaching” observed.

**Main Outcome Measures:** Ratings were evaluated for intrarater and interrater agreement using kappa coefficients. The sensitivity and specificity of ratings were evaluated by comparing results with three-dimensional motion analysis.

**Results:** Intrarater and interrater kappa coefficients ranged from 0.64 to 0.94 for the DJ and SH tasks and from 0.24 to 0.75 for the USC. Sensitivity ranged from 0.88 to 1.00 for the SH and USC tasks and from 0.67 to 0.87 for the DJ. Specificity ranged from 0.60 to 0.72 for the DJ and from 0.08 to 0.79 for the SH and USC tasks.

**Conclusions:** Observational risk screening is a practical and cost-effective method of screening for ACL injury risk. Based on levels of agreement and sensitivity, the SH appears to be a suitable screening task. Agreement was acceptable for the DJ but its validity requires further investigation.

#### 028 IS DYNAMIC LOWER-LIMB ALIGNMENT DURING LANDING A PREDICTOR OF NON-CONTACT ANTERIOR CRUCIATE LIGAMENT INJURY IN HIGH SCHOOL BASKETBALL PLAYERS?

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**Background:** In several videotape analyses, excessive lower-limb alignment was observed at non-contact anterior cruciate ligament (ACL) injury in sports activities.

**Objective:** The purpose of this study was to investigate prospectively the relationship between dynamic lower-limb alignment and the incidence of ACL injury in high school basketball players.

**Design:** Cohort study.

**Settings:** Basketball players belonging to 13 high school basketball teams in Hiroshima City were recruited.



**Participants:** A total of 401 high school basketball players (177 girls and 224 boys) with no history of lower-limb injury participated.

**Assessment of Risk Factor:** The subjects performed a drop vertical jump by dropping directly down off a box and immediately performing a maximum vertical jump. The lower-limb alignment was recorded with a digital video camera system and the image at landing was captured.

**Main Outcome Measures:** The separate distances between right and left hips and knees were measured. The knee separation distances normalised by the hip separation distance (K/H ratio) were used as a parameter representing the valgus/varus lower leg alignment. The subjects were assigned to two groups: the valgus alignment group (K/H ratio < average minus 1 SD) and the neutral-alignment group (K/H ratio > average minus 1 SD). They were followed up for one year to determine the incidence of ACL injury.

**Results:** Four (girls) of 57 players (7.0%) in the valgus alignment group and four (three females and one boy) of 344 players (1.2%) in the neutral alignment group had ACL injury.

**Conclusions:** The valgus alignment group showed a more than five times greater ACL injury rate compared to the neutral-alignment group. However, it is difficult to predict ACL injury based on only the dynamic lower-limb alignment because half of the players who incurred ACL injury were in the neutral alignment group.

## 029 THE COL5A1 GENOTYPE IS ASSOCIATED WITH RANGE OF MOTION MEASUREMENTS

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**Background:** There has been a growing interest in identifying intrinsic risk factors, including musculotendinous inflexibility, which may be associated with musculotendinous injuries. There is a possibility that genetic factors may affect musculotendinous flexibility and this requires investigation. We have recently shown that sequence variants within the COL5A1 gene are associated with chronic Achilles tendinopathy. Furthermore, mutations within this gene have been implicated in Ehlers Danlos syndrome, which is characterised by joint hypermobility.

**Objective:** The aim of this study was therefore to investigate the possible association of single nucleotide polymorphisms within the 3'-untranslated region of the COL5A1 gene and musculotendinous flexibility.

**Methods:** Lower-limb range of motion measurements, including the sit and reach (SR) test and the passive straight leg raise (SLR), were conducted on 119 physically active white subjects. Single nucleotide polymorphisms rs13946 (DpnII restriction fragment length polymorphism (RFLP) C/T) and rs12722 (BstUI RFLP, C/T) were used to genotype these individuals for the C>T transitions within exon 66 of COL5A1.

**Results:** The genotype groups were similarly matched for age, height, body weight, BMI, gender and duration of flexibility training per week. There was, however, a significant difference in the passive left ( $p = 0.037$ ) and right ( $p = 0.036$ ) SLR, as well as SR ( $p = 0.010$ ) measurements between the COL5A1 BstUI RFLP genotype groups, with the heterozygous (TC genotype) group less flexible than the homozygous (TT and CC genotypes) groups. Gender ( $p = 0.015$ ), age ( $p = 0.006$ ) and the COL5A1 BstUI RFLP ( $p = 0.008$ ) genotype contributed significantly to the optimal SLR model, which accounted for 19.2% of the variance. The factors contributing significantly to SR, which accounted for 30.9% of the variance, were weight ( $p = 0.004$ ), age ( $p < 0.001$ ) and the COL5A1 BstUI RFLP genotype ( $p = 0.001$ ).

**Conclusion:** These data suggest that SNP rs12722 (BstUI RFLP) within the COL5A1 gene is associated with lower-limb flexibility within the cohort investigated in this study.

## 030 AN IN-VITRO INVESTIGATION OF THE ROLE OF QUADRICEPS LOAD DURING ONE-LEGGED JUMP LANDING

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**Background:** The reasons why non-contact anterior cruciate ligament (ACL) injuries occur when the injured person has performed the same activity countless times before the eventual injury are not yet known. One suspected mechanism is the aggressive and large quadriceps pull during low knee flexion landing conditions, resulting in excessive anterior tibial translation and ACL injury.

**Objective:** We hypothesise that as the tension in the quadriceps increases before and during the landing stage, the observed strain in the ACL decreases.

**Design:** A jump landing simulator was designed for dynamic loading of cadaveric knee joints (one-legged landings) with the facility to apply dynamic muscle forces using servo-electric actuators. The arrangement also allows for free hip flexion during the landing stage. An impact-lever apparatus is devised to load the tibia impulsively (upward) thus simulating landing ground reaction force. Six knees were tested using similar ground reaction forces and low knee flexion angles (approximately 20°) at various quadriceps load levels extending from zero to approximately 1000 N. A differential variable reluctance transducer was mounted on the ACL to monitor strain before (static) and during (dynamic) landing.

**Results:** In all knees, as the magnitude of the quadriceps load increased, the pre-landing or static component of strain in the ACL increased. However, the dynamic component of strain during the actual landing process decreased with increasing quadriceps load. None of the tested conditions resulted in ACL injury.

**Conclusions:** High quadriceps forces during the landing process are protective of the ACL and will not result in injury during the jump landing process. This protective function is due to two main reasons: (1) increased joint stability as a result of joint compression and (2) reduction in the anteriorly directed component of the force in the patellar tendon as quadriceps force increases.

## 031 NON-CONTACT ANTERIOR CRUCIATE LIGAMENT INJURY RISK IS LINKED DIRECTLY TO FATIGUE-INDUCED CENTRAL PATHWAY DEGRADATION

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**Background:** Dynamic sports landings in a combined fatigued and unanticipated state represent a worst case scenario for non-contact anterior cruciate ligament (ACL) injuries. The extent to which this phenomenon stems from a compromise in central pathways, however, remains unclear. Elucidating this link is critical in developing prevention modalities capable of countering the inherently random nature of sports.

**Objective:** To determine the impact of fatigue on central pathway mechanisms during dynamic lower-limb landings.

**Design:** A single (pre-test–post-test) experimental block design.

**Setting:** NCAA division 1 athletes.

**Participants:** 18 women (19.8 ± 1.2 years) with no history of major lower-limb injury or surgery.

**Assessment of Risk Factors:** Subjects performed randomly ordered anticipated and unanticipated single-leg landings, before and during fatigue. For fatigue trials, subjects performed three single-leg squats immediately followed by an anticipated or unanticipated landing, with this sequence repeated until squats were not possible.

**Main Outcome Measures:** Initial contact three-dimensional hip and knee postures and peak stance phase three-dimensional knee

rotations and moments were calculated across prefatigue trials and for trials denoting 50% and 100% maximal fatigue.

**Results:** Unanticipated landings promoted significant ( $p < 0.01$ ) increases in initial contact hip extension and internal rotation and knee flexion angles and peak knee abduction and internal rotation angles and moments. Initial contact knee extension, the knee abduction angle and peak knee flexion and abduction moments all significantly ( $p < 0.01$ ) increased as fatigue progressed. Fatigue-induced increases in knee abduction mechanics were more pronounced during unanticipated compared with anticipated ( $p < 0.01$ ) landings. Combined fatigue and decision effects were evident in both the fatigued and non-fatigued limb.

**Conclusions:** Neuromechanical adaptations in the non-fatigued limb suggest substantial fatigue-induced central pathway degradation. Fatigue-related ACL injury risk is probably exacerbated during unanticipated landings, in which spinal and supraspinal mechanisms are already compromised. Current prevention methods should act to fine-tune these mechanisms, particularly in the presence of fatigue.

### 032 GENDER DIFFERENCES IN DYNAMIC LOWER-LIMB ALIGNMENT DURING A DROP JUMP TASK IN PUBESCENT CHILDREN

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**Background:** It has been demonstrated that female athletes have larger valgus lower-limb alignment than men during landing and this may contribute to the gender disparity in anterior cruciate ligament injury risks. In early teens, the gender difference in lower-limb alignment has not been elucidated.

**Objective:** The purpose of this study was to examine whether lower-limb alignment changes during the pubertal stage in girls and boys.

**Design:** Cross-sectional study.

**Settings:** We recruited elementary and junior high school students with no lower extremity complaints who lived in a specific school district.

**Participants:** A total of 302 students (162 girls and 140 boys) aged 10–14 years participated in this study.

**Assessment of Risk Factors:** The subjects performed a drop vertical jump by dropping directly down off a box and immediately performing a maximum vertical jump. Images of pre-landing and landing, defined by toe touch to the ground after the jump off the box and the deepest point of the body, respectively, were captured.

**Main Outcome Measures:** The distances between right and left hips and knees were measured in each frame. The knee separation distances normalised by the hip separation distance (K/H ratio) were used as a parameter representing the lower-limb alignment.

**Results:** In 10–12-year-olds, the K/H ratio during landing was  $0.40 \pm 0.11$  in girls and  $0.54 \pm 0.21$  in boys, and in 13–14-year-olds it was  $0.36 \pm 0.10$  in girls and  $0.55 \pm 0.15$  in boys. The K/H ratio at landing in girls was significantly less than in boys in 10–14-year-olds ( $p < 0.05$ ).

**Conclusions:** A significant gender difference in lower-limb alignment during landing was seen in puberty. These results suggest that training for the prevention of anterior cruciate ligament injuries may be needed before the onset of puberty.

### 033 RELATIONSHIP OF CLINICAL LAXITY MEASURES WITH ENERGY ABSORPTION DURING DROP JUMP LANDINGS

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**Background:** Clinical laxity measures have been suggested as potential risk factors for lower extremity injury. Little information is available as to the mechanism by which variations in laxity may influence functional activity.

**Objective:** To determine if clinical laxity measures are predictive of eccentric work demands placed on lower extremity extensor musculature during drop jump landings.

**Design:** Descriptive cohort study.

**Setting:** Laboratory.

**Participants:** Thirty-nine recreationally active women ( $21.9 \pm 2.9$  years;  $162.9 \pm 6.8$  cm;  $58.1 \pm 6.1$  kg).

**Assessment of Risk Factors:** During menses, subjects were measured for anterior knee laxity (AKL) at 133 N using the KT2000TM, supine genu-recurvatum (GR) using a standard goniometer and general joint laxity (GJL) using the Beighton and Horan joint mobility index. Biomechanical data were collected on the stance limb during five double-leg drop jump landings.

**Main Outcome Measures:** Hip (HEA), knee (KEA) and ankle (AEA) energy absorption normalised to bodyweight and height during the first landing phase served as the dependent variables for three separate stepwise linear regressions with AKL, GR and GJL serving as the predictor variables.

**Results:** For KEA ( $-0.052 \pm 0.02$  Nm/(Bw\*Ht)), GJL ( $1.9 \pm 2.0$ ) entered the model first ( $R^2 = 11.8\%$ ; Sig F change = 0.03), AKL ( $6.9 \pm 2.3$  mm) entered next ( $R^2 = 15.6\%$ ; Sig F change = 0.21), with GR ( $3.7 \pm 3.8^\circ$ ) entering last ( $R^2 = 23.5\%$ ; Sig F change = 0.06). In particular, this regression revealed that greater GJL, greater AKL and lower GR predicted greater KEA. Laxity measures were not predictive of HEA ( $-0.072 \pm 0.03$  Nm/(Bw\*Ht)) or AEA ( $-0.079 \pm 0.03$  Nm/(Bw\*Ht)).

**Conclusions:** Women with greater GJL and AKL and lower GR values tend to absorb greater energy with their knee extensors during the first landing phase of a drop jump. This may be a strategy to minimise intersegmental forces on the joint. Future work should consider how these measures act in conjunction to modulate KEA.

**Funding:** Supported by NIH-NIAMS grants R01-AR53172 and 3R01-AR053172-01A1W1.

### 034 FUNCTIONALLY ASSESSING BILATERAL DIFFERENCES AND GENERAL EFFECTS OF FATIGUE DURING A SPORT-SPECIFIC RUNNING PROTOCOL

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**Background:** Assessment of bilateral differences typically involves a static or very short-term test, typically of strength, power or flexibility. For athletes involved in prolonged activities such as football codes, it is not known how these bilateral differences may manifest throughout an entire game.

**Objective:** This research aimed to identify a technique to identify bilateral differences during a prolonged sport-specific running programme.

**Design:** Participants presented for two familiarisation sessions to determine maximal sprinting speed and a third time to complete an 80 minute sport-specific running protocol.

**Setting:** All testing took place in a university laboratory.

**Participants:** Male semiprofessional Australian rules football players volunteered; aged  $19.5 \pm 0.8$  years, body mass of  $83.0 \pm 7.8$  kg and height of  $184.3 \pm 0.7$  m. Exclusion criteria included having had a hamstrings or quadriceps injury within 3 months of the study.

**Assessment of Risk Factors:** Participants completed the protocol on a Woodway Force 3 non-motorised treadmill; this recorded vertical and horizontal force data together with speed and distance data.

**Main Outcome Measures:** The following measures were made: peak velocity, stride frequency, vertical and horizontal force, work and power for each step. Primarily only maximum sprinting efforts were analyzed.

**Results:** From results analyzed to date, there are significant differences between the left and right legs in horizontal force (121 N) and power (635 W) in each step. Neither the magnitude of these differences nor their absolute values changed throughout the running protocol.

**Conclusions:** The literature confirms that imbalances between body sides may be a contributing factor to injuries. The evidence presented here highlights that these bilateral differences persist for an entire simulated game of Australian rules football and that this technique is able to provide a step by step profile describing these bilateral differences.

### 035 THE INFLUENCE OF SEX HORMONES ON ANTERIOR CRUCIATE LIGAMENT LAXITY OF FEMALE HANDBALL PLAYERS

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**Background:** The incidence of anterior cruciate ligament (ACL) injuries is reportedly higher in young female handball players than in male players. Some conflicting results about the possible effect of sex hormones and oral contraceptives on injury prevention calls for further study.

**Objective:** To investigate the relation between sex hormone levels and knee laxity with both usage and non-usage of oral contraceptives (OC).

**Design:** Two-group prospective study (with and without usage of OC).

**Setting:** ACL laxity was measured at 30 lb with a KT1000 arthrometer, just before training sessions and matches; 3271 measures were done on each leg. Estradiol, progesterone, testosterone, relaxin and luteinising hormone levels were determined from blood samples collected in a medical laboratory at the same general hour of day; 184 blood samples were collected.

**Participants:** National-level female handball players with healthy and intact knees were divided into two groups and followed during a menstrual cycle; one group (N = 18) using OC uninterruptedly for 6 months before the testing sessions and one group (N = 25) not subjected to hormonal therapy and being eumenorrheic for the past 6 months.

**Results:** Using cross-correlation techniques for each of the time series we found that, for the group not using OC, estradiol and progesterone have a smaller correlation with ACL laxity variations (average normalised covariance of 6.6 and 4.5, respectively) than relaxin and testosterone (average normalised covariance of 6.7 and 8.0, respectively). However, the group using OC had an increased correlation between ACL laxity and relaxin and testosterone (average relative covariance of 8.8 and 7.4, respectively). There is also a subject-dependent optimal lag between hormonal level changes and subsequent ACL laxity changes, varying between 0 and 2 days.

**Conclusions:** Although the use of OC changes the relation of sex hormones and knee laxity, specific tests between OC and non-OC groups still fail to identify an effect.

### 036 THE EFFECT OF SCHOOL-BASED INSTRUCTION ON THE USAGE OF PROTECTIVE EQUIPMENT IN IN-LINE SKATERS

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**Background:** The use of protective equipment by in-line skaters has been shown to be effective at reducing injuries. However, the use of protective equipment by in-line skaters is relatively low.

**Objective:** To evaluate the influence of an in-line skating instructional unit on the usage of and attitudes towards protective equipment of adolescent in-line skaters.

**Design:** Pre-programme, end-of-programme and 3-month post-programme surveys were administered to the individuals participating in the fall semester in-line skating unit. The control group students attended the same grades in the same school, but did not take the in-line skating unit; they took the initial and final surveys at the same time as the intervention group.

**Setting:** High school physical education class.

**Participants:** The intervention group consisted of 271 students completing the pre-programme survey, 249 completing the programme and end-of-programme survey and 269 completing the 3-month follow-up survey. The control group consisted of 73 students who completed both the initial and follow-up surveys.

**Intervention:** A 2-day, 90-minute course that included basic in-line skating techniques and safety.

**Main Outcome Measures:** Usage of and attitudes towards protective equipment.

**Results:** The intervention group had significant ( $p < 0.05$ ) improvements in the use of helmets (121%) and knee-pads (32%) and in some but not all attitudes towards the use of protective equipment. A significant ( $p < 0.05$ ) improvement in attitudes included importance of the use of protective equipment by self (0.5 points on 5-point Likert scale), by friends (0.3) and desire to obtain protective equipment (0.4) compared with the control group.

**Conclusions:** Instructional intervention appears to have a small but significant increase in the use of protective equipment by adolescent skaters. This is encouraging because previous studies have suggested that convincing even a few skaters to use protective equipment has an exponential effect that leads to an overall greater usage of protective equipment in the community.

### 037 CHANGING BEHAVIOURS OF YOUTH HOCKEY PLAYERS BY INNOVATIVE EDUCATIONAL INTERVENTIONS

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**Background:** Attitudes and behaviours legitimising violence in youth ice hockey are well documented, and although the outcome is usually transient, in some cases it is catastrophic.

**Objective:** To develop an innovative educational intervention using a custom-developed 3 on 3 hockey video game and to determine the effectiveness of the game in changing players' behaviour.

**Design:** We studied game play in an experimental simulated environment in which the possibility to win the game was exaggerated as a consequence of desirable safe behaviours and effectively reduced as a consequence of undesirable behaviour.

**Participants:** 63 youth participants (aged 12–14 years) were randomly assigned to one of three experimental groups.

**Interventions:** In one experimental group (Kep) less aggressive behaviour was rewarded with enhanced player attributes, whereas in the second experimental group (Ken) aggressive behaviour was rewarded with enhanced player attributes. Attributes were not changed in the control group (K0p).

**Main Outcome Measures:** An "internal game variable", which we termed karma, was a composite measure reflecting the aggressive acts during gameplay.

**Results:** The significant correlation in the first experimental condition between karma and goal differential ( $r = 0.73$ ,  $p < 0.05$ ) was consistent with our prediction. Similarly, the predicted negative relationship between karma and goal differential in the second experimental group was also evident ( $r = -0.68$ ,  $p < 0.05$ ). No significant relationship was found in the control condition ( $r = 0.06$ ). A two-way repeated measures on the second factor ANOVA revealed an interaction between condition and session ( $F = 2.862$ ,  $p = 0.026$ ). Follow-up post hoc analysis revealed a significant linear trend ( $p = 0.001$ ) for the Kep group, with increased karma values over session.



**Conclusion:** The results of the assessment study clearly showed that the implicit educational mechanism embedded in the video hockey game resulted in a change in game play behaviour.

### 038 THE RISK OF INJURY ASSOCIATED WITH BODY CHECKING AMONG PAEDIATRIC ICE HOCKEY PLAYERS

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**Background:** Ice hockey has one of the highest participation and injury rates in male youth in Canada. Body checking is the most frequent mechanism of injury.

**Objectives:** To determine if the risk of concussion, concussion severity, all injury, injury severity and mechanisms of injury significantly differ for Pee Wee ice hockey players (11–12 years) exposed to rules that permit body checking (Alberta, Canada) versus players exposed to rules that do not permit body checking (Quebec, Canada).

**Design:** Prospective cohort study.

**Setting:** Pee Wee teams from the top 60% of competitive levels of play in Alberta, Canada and Quebec, Canada. The study period is October 2008 to March 2008.

**Participants:** 90 teams from Alberta and 93 teams from Quebec were randomly approached for recruitment. 16 teams from Alberta and 15 teams from Quebec declined participation or withdrew from the study. Players from 152 teams completed the study (74 Alberta teams ( $n = 1106$  players), 78 Quebec teams ( $n = 1057$  players)).

**Assessment of risk:** Pee Wee ice hockey players are exposed to rules that permit body checking in Alberta and to rules that do not permit body checking in Quebec.

**Main Outcome Measures:** Previously validated injury surveillance was used including injury assessment by a study therapist and physician referral. The injury definition includes any ice hockey injury that requires medical attention and/or results in time loss from hockey. Standardised concussion definitions, return to activity guidelines and follow-up by study physicians are based on international consensus for concussion management (2005).

**Results:** Preliminary univariate analysis is based on injuries sustained before the end of the regular season of play. Incidence rate ratios (IRR), adjusted for clustering by team, suggest a significantly increased risk of concussion (IRR 2.87, 95% CI 1.47 to 5.58), all injury (IRR 1.66, 95% CI 1.12 to 2.46) and all injury resulting in  $\geq$  week time loss (IRR 2.02, 95% CI 1.1 to 3.71) based on exposure to body checking (body checking age 11 years/no body checking until age 13 years). Further multivariate analysis will include play-off injuries and will also examine other risk factors and mechanisms of injury.

**Conclusions:** The preliminary evidence obtained from this study suggests a significantly increased risk of injury by all primary injury definitions in the body checking cohort compared with a non-body checking cohort in 11 and 12-year-old ice hockey players. These findings will have important implications for policy decisions related to body checking in minor hockey.

**Funding:** This study was funded by Canadian Institutes of Health Research, Alberta Heritage Foundation for Medical Research and the Max Bell Foundation.

### 039 DO FOOTBALL (SOCCER) PLAYERS HAVE A HIGHER PREVALENCE OF COGNITIVE DEFICITS COMPARED WITH ATHLETES IN NON-CONTACT SPORTS?

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**Background:** Football is a contact sport with a high risk of experiencing minor head impacts and based on cross-sectional

studies it has been claimed that this causes reduced brain function among footballers.

**Objective:** To assess the effect of previous concussions on neuropsychological performance for elite football players in comparison with elite athletes in non-contact sports.

**Design:** Case-control study.

**Participants:** Football players in the Norwegian elite league 2004–6 ( $N = 401$ ) and Norwegian elite swimmers ( $N = 5$ ), cross-country skiers ( $N = 5$ ) and orienteers ( $N = 43$ ).

**Assessment of Risk Factors:** Questionnaire assessing concussion history as well as age, education, alcohol history and total active years at elite level, etc.

**Main Outcome Measures:** Measures of reaction time from the six subtasks in the computerised neuropsychological test battery, CogSport. “Poor performers” were identified as the athletes who performed poorer (slower) than  $>1$  SD from the participants’ mean performance (sum of Z-scores).

**Results:** The non-contact athletes were significantly older than the footballers. 178 of the footballers (44.4%) and 21 of the non-contact athletes (39.6%) had experienced one or more previous concussions. The non-contact athletes were significantly slower than the footballers on three of the six subtasks. The non-contact athletes had a significantly higher prevalence of “poor performers” ( $N = 9$ , 40.9%) versus the footballers ( $N = 47$ , 11.7%, chi-square;  $p < 0.001$ ). The highest prevalence was found among the previously concussed non-contact athletes ( $N = 9$ , 44.4%). 94.3% of the non-contact athletes and 97.1% of the footballers were within the normal range when compared with the normative data supplied by the manufacturer of the test.

**Conclusion:** Despite the high risk of minor head impacts in football, this study provides no evidence of cognitive deficits among footballers when compared with athletes in non-contact sports. However, there is a possible effect of previous concussions on neuropsychological performance that is unrelated to the sporting activity as such.

### 040 THE INCIDENCE OF MILD TRAUMATIC BRAIN INJURY IN AN AUSTRALIAN NON-ELITE RUGBY COHORT

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**Background:** Mild traumatic brain injury (MTBI), or concussion, is associated with significant adverse long-term sequelae. As a consequence, understanding both the incidence and mechanisms of MTBI in high contact sports, such as rugby, is paramount in order to develop appropriate preventive strategies.

**Objective:** To estimate the incidence of MTBI in non-elite Australian rugby players and to identify differences in the risk of MTBI across competition levels and player age.

**Design:** Prospective cohort study, with three separate cohorts recruited in the pre-season over three consecutive years.

**Setting:** Community level (non-elite) rugby competition in the Sydney metropolitan area.

**Participants:** 3797 male rugby players aged 16–35 years were recruited to the study. Demographic information, history of recent head injury, information concerning potential risk factors and baseline computer-based neuropsychological tests were collected. MTBI events were identified and reported by the designated club contact (ie, physiotherapist). Time played (player exposure) was also collected.

**Assessment of Risk Factors:** Competition level, player age, training hours and experience.

**Main Outcome Measures:** Incidence of MTBI per 1000 player hours.

**Results:** 350 (5.2%) players had sustained an MTBI event. Analysis of players with or without a reported MTBI throughout the season highlighted that both the age of the player (5.7% of adults versus 3.8% of adolescents;  $p = 0.03$ ) and the competition level (11.6% of suburban, 9.1% of grade, 4.9% of school level;  $p < 0.01$ ) were associated with the occurrence of an MTBI injury. These findings, along with the influence of other risk factors, will be explored in the context of player exposure.

**Conclusions:** This study reports on differential rates of MTBI across a number of factors in a large community-based study. This paper will explore the implications of these findings for injury prevention programmes, whereas the strengths and limitations of the research will be outlined.

#### 041 THE NHL-NHLPA CONCUSSION PROGRAMME: A PROSPECTIVE STUDY OF SEVEN REGULAR SEASONS (1997–2004)

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**Background:** In 1997, the National Hockey League (NHL) and NHL Player's Association (NHLPA) launched a concussion programme prospectively to document concussions and identify potential contributing factors.

**Objective:** To explore descriptively post-concussion signs, symptoms, memory dysfunction, loss of consciousness (LOC) and abnormal physical examination findings, as well as determine concussion rates, trends and injury severity among professional ice hockey players.

**Design:** Prospective case series.

**Setting:** NHL regular season games over seven consecutive years (1997–2004).

**Participants:** 9619 professional male ice hockey players from all NHL teams.

**Independent Variables:** Initial post-concussion signs, symptoms, memory dysfunction, LOC and abnormal physical examination findings.

**Main Outcome Measures:** The primary outcome measure was concussion sustained during a regular season game. The secondary outcome measure was concussion severity determined retrospectively using a 10-day time loss cut-point ( $\leq 10$  days versus  $> 10$  days).

**Results:** The absolute number of concussions ranged from 56 to 109 per season, with an overall game concussion rate of 5.8 concussions per 100 players per season. 69% of concussion cases missed  $\leq 10$  days and 31%  $> 10$  days. The most common post-concussion symptom was headache (71%), followed by dizziness (34%), nausea (24%), neck pain (23%), low energy/fatigue (22%) and blurred vision (22%). There appeared to be a trend of increasing median time loss per concussion per season, as well as a significant association between concussion severity and the presence of headache ( $p < 0.01$ ), LOC ( $p = 0.04$ ), fatigue ( $p < 0.01$ ) and light sensitivity ( $p = 0.03$ ).

**Conclusion:** In this prospective series of concussions, headache was found to be the most frequent post-concussion symptom. There is a suggestion that, although concussion rates may be decreasing in the NHL, there was a trend towards a gradual increase in time loss from participation.

#### 042 ANTERIOR CRUCIATE LIGAMENT INJURIES IN FEMALE TEAM HANDBALL PLAYERS: NATIONAL INJURY TRENDS AFTER THE NORWEGIAN INJURY PREVENTION STUDY

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**Introduction:** From 1998 to 2001 an anterior cruciate ligament (ACL) injury prevention programme was developed and introduced

in female team handball in Norway as part of a large intervention study. The intervention consisted of a neuromuscular training programme with exercises on a wobble board, a balance mat and handball-specific exercises, and a gradual reduction in injury rate was observed during this period.

**Objective:** To survey the ACL injury incidence after the intervention to reveal if a recent national information campaign has changed injury frequency.

**Participants:** Norwegian female team handball, top three divisions.

**Methods:** ACL injuries have been recorded prospectively since 1998 until 2007 (except the 2003–4 season). A national information campaign, including coach education and a new DVD was initiated during the 2005 pre-season.

**Results:** During the intervention study period, the injury rate fell gradually from 0.48 ACL injuries per team (1998–9, 29 injuries, 60 teams) to 0.40 injuries per team (1999–2000, 23 injuries, 58 teams) to 0.33 injuries per team (2000–1, 17 injuries, 52 teams). After the intervention, compliance with the intervention programme fell and the injury rate gradually increased to 0.34 injuries per team (2001–2, 20 injuries, 59 teams), 0.47 injuries per team (2002–3, 32 injuries, 68 teams) and 0.55 injuries per team (2004–5, 39 injuries, 71 teams). A reduction in ACL injury rate was observed after the initiation of the information campaign, with 0.17 injuries per team (2005–6, 16 injuries, 93 teams) and 0.26 injuries per team (2005–6, 23 injuries, 90 teams,  $p = 0.0001$  versus the post-intervention seasons 2001–5). During the 2005–7 seasons, compliance with ACL injury prevention training was 83% of teams in the elite division and 60% in the first division.

**Conclusion:** A national campaign appears to have had a favourable effect on ACL injury risk among female team handball players.

#### 043 CHANGE OF WHOLE-BODY REACTION TIME BY PERFORMING AN ANTERIOR CRUCIATE LIGAMENT INJURY PREVENTION PROGRAMME

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**Background:** Neuromuscular function has an important role in the prevention of anterior cruciate ligament (ACL) injuries. We introduced an ACL injury prevention programme to female high school basketball players for a year and investigated whether there was any change in their neuromuscular functioning.

**Objective:** The purpose of this study was to determine whether whole-body reaction times (WBRT) could be shortened after intervention; moreover, to investigate the characteristics of WBRT of ACL-injured athletes.

**Design:** A randomised control trial.

**Setting:** Female high school basketball players.

**Participants:** 200 participants divided into three groups: 70 players as the intervention group (group A), 70 players (group B) in the control group and 60 students as a non-athletic control group (group C).

**Interventions:** The ACL injury prevention programme consisted of strengthening, balance and jump-landing exercises.

**Main Outcome Measures:** WBRT were used for the assessment of neuromuscular function before and after the intervention. For determining WBRT, we measured the time from light stimulus to jump on double legs or on one leg.

**Results:** Before the intervention, WBRT on both legs were  $0.31 \pm 0.04$  s,  $0.32 \pm 0.02$  s and  $0.35 \pm 0.05$  s in groups A, B and C, respectively. After a year, WBRT in group A were significantly shortened; however, there were no changes in groups B or C. Six ACL injuries occurred over the year. Before the intervention, the mean WBRT on both legs was  $0.32 \pm 0.04$  s and there were no significant differences between the ACL-injured and

non-injured athletes in groups A or B. WBRT on the ACL-injured side was longer than that on the other side.

**Conclusions:** WBRT were shortened by performing the programme. Adding to the number of subjects and the characteristics of the ACL injured could clarify this further.

#### 044 NEUROMUSCULAR TRAINING CHANGES THE TIMING OF MEDIAL HAMSTRING MUSCLE ACTIVITY DURING SIDECUTTING IN FEMALE ELITE SOCCER AND HANDBALL PLAYERS

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**Background:** Different neuromuscular training regimes have been shown to decrease the incidence of ACL injuries effectively in female sports such as handball and football. However, little is known about the specific neuromuscular adaptation mechanisms elicited by this type of training.

**Objective:** The present study aimed to implement neuromuscular training during a full soccer and handball league season and experimentally analyze the neuromuscular adaptation mechanisms elicited by this neuromuscular training during a standardised sidecutting manoeuvre.

**Design:** The players were tested before and after a season without implementation of the neuromuscular training and subsequently before and after a full season with the implementation of neuromuscular training (two per week).

**Participants:** 20 female elite soccer and handball players aged  $26 \pm 3$  years at the start of the study.

**Intervention:** The subjects participated in a neuromuscular training programme previously shown to prevent non-contact ACL injury (Myklebust *et al*, 2003).

**Main Outcome Measures:** Onset of neuromuscular activity (electromyography (EMG); gluteus medius, biceps femoris, semitendinosus, vastus lateralis and medialis, rectus femoris and gastrocnemius lateralis and medialis) was recorded during a sidecutting manoeuvre on a force plate.

**Results:** The gluteus medius muscle was always activated first, followed by the hamstrings, then the gastrocnemius muscles and finally the quadriceps muscle group. Neuromuscular training selectively changed the onset of EMG activity for m semitendinosus. Before the intervention, EMG onset of m semitendinosus was  $168 \pm 70$  ms before foot strike compared with  $140 \pm 26$  ms after the intervention.

**Conclusions:** Neuromuscular training selectively induced a change in the onset of m semitendinosus activity to occur closer to the time of landing. It could be speculated that an EMG onset closer to ground contact enables m semitendinosus activity to coincide better with the high tibiofemoral shear forces generated just after initial ground contact, thereby reducing the risk of ACL injury.

#### 045 EFFECT OF AN ANTERIOR CRUCIATE LIGAMENT INJURY PREVENTION PROGRAMME ON DECREASING ANTERIOR CRUCIATE LIGAMENT INJURY INCIDENCE: A 3-YEAR FOLLOW-UP STUDY

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**Background:** Anterior cruciate ligament (ACL) injury prevention is a primary issue in the sports medicine field. Therefore, we developed an ACL injury prevention programme.

**Objective:** The purpose of this study is to demonstrate the effect of the ACL injury prevention programme for a 3-year period.

**Design:** Randomised control trial.

**Participants:** 171, 185 and 160 female basketball players from local high schools participated in this study in the first year, the second year and the third year, respectively.

**Interventions:** The participants were divided into exercise and control groups. The exercise group performed a 10-minute exercise programme before regular practice. The programme consists of strengthening, balance and jump-landing exercises. The visual exercise instruction was given to each high school.

**Main Outcome Measures:** In every 3 months, the participants were asked their exercise attendances and injury profiles. Physical fitness tests were also conducted. The ACL incident rate and the fitness level were compared between two groups in every single year.

**Results:** During the intervention period, two, three and two ACL injuries occurred among the exercise group in the first, second, and third year, respectively. On the other hand, four, five and five ACL injuries occurred among the control groups. The injury rates in the exercise group were 0.039, 0.045 and 0.030 per 1000 practice hours in the first, second and third year, respectively. On the other hand, the injury rates in the control group were 0.081, 0.099 and 0.087 per 1000 practice hours.

**Conclusions:** Although this programme required shorter exercise time than other ACL injury prevention programmes reported previously, great effect on decreasing ACL injury incidence was observed in this study. This finding enhances the current knowledge of ACL injury prevention.

#### 046 STRESS FRACTURE REDUCTION BY EQUIPMENT MODIFICATION IN BORDER POLICE FEMALE FIGHTER RECRUITS: PART I

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**Purpose:** Female fighters have been followed for stress fracture incidence during basic combat training in the border police for the previous 11 years. Both internal and external risk factors were studied and various interventions were implemented in order to reduce stress fracture incidence with only a trend disclosed in their reduction. The aim of this study was to assess whether combat equipment modification, by mildly reducing weight and approximating the gear to the body centre of gravity could reduce stress fracture incidence.

**Methods:** 216 border police female recruits, aged 18–19 years, undergoing basic combat training of 16 weeks, were followed prospectively for stress fracture incidence using modified fighting gear: a short M16 rifle and a lighter and closely fitted combat vest. Follow-up included questionnaires and bimonthly assessment by the research team. Stress fractures were diagnosed by bone scintigraphy when clinically indicated. Incidence of stress fractures in the intervention group was compared with a control group of 1210 recruits who used the traditional equipment and were followed by the same research group in previous years.

**Results:** Equipment modification was associated with a significant reduction in stress fractures from 18.3% in the control group to 7.9% in the intervention group ( $p < 0.001$ ).

**Conclusions:** Stress fractures are common among female fighters. Study results suggest that emphasis should be put on external modifications rather than early screening and preselection of recruits. A significant effect was achieved by reducing equipment weight and changing configuration of the combat gear so as to approximate it to the body centre of gravity. This last intervention is promising and should be evaluated further.



#### 047 IS THE NOVICE RUNNER AT RISK? A PROSPECTIVE COHORT STUDY OF RUNNING INJURIES DURING A 10-WEEK SUPERVISED TRAINING PROGRAMME

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**Background:** Running has gained popularity over the past decades, but as participation increases running-related injuries also increase. To minimise injuries, running programmes for novice runners have been set up all around the world. The number of injuries occurring in these set ups for novice runners and whether they can be prevented is still unknown.

**Objective:** Registration of the incidence and the severity of running-related injuries in a guided training programme for novice runners. Identifying associated risk factors based on baseline characteristics.

**Design:** Prospective cohort study.

**Setting:** A standardised 10-week supervised running programme.

**Participants:** Cohort of 141 novice runners.

**Assessment of Risk Factors:** Baseline characteristics were collected with a questionnaire. The registration, assessment and classification of all the running-related injuries was performed.

**Main Outcome Measures:** Baseline characteristics; injury site; incidence rate, incidence proportion, clinical incidence.

**Results:** Subjects were classified into different subgroups: completed the programme without injury (63%); completed the programme with injury (11%); stopped running because of an injury (13%) and drop out for different reasons (13%). The baseline characteristics of the subgroups did not differ significantly. The most frequent site of injury was the lower leg, the most common injured tissues were tendons and muscles and the most common diagnosis was exercise-induced lower leg pain. The incidence rate was 24.9/1000 h; the incidence proportion was 0.23 and the clinical incidence 0.31.

**Conclusion:** The risk of getting an injury was not significantly related to gender but was significantly related to a previous injury, which is similar to the findings in the existing literature on musculoskeletal injuries.

#### 048 VARIANTS WITHIN THE COL5A1 GENE ARE ASSOCIATED WITH CHRONIC ACHILLES TENDINOPATHY IN A SECOND POPULATION

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**Background:** As much as 30–50% of all sporting injuries involve tendons, of which 6–18% comprise Achilles tendon injuries (ATI). A lifetime prevalence of ATI has been reported as high as 11%. There is a spectrum of pathology that can affect the Achilles tendon and surrounding structures most commonly due to overuse (referred to as “tendinopathy” or “tendinosis”). A number of extrinsic and intrinsic risk factors have been proposed for ATI and recently a polymorphism within the COL5A1 gene has been shown to be associated with ATI in a white population from South Africa. COL5A1 codes for a polypeptide component of type V collagen that is involved in the regulation of the assembly of tendon collagen fibrils.

**Objective:** The aim of this case-control association study was to determine whether the BstUI restriction fragment length polymorphism (RFLP) within the COL5A1 gene was associated with ATI in a second independent white population.

**Methods:** A total of 295 white subjects from Australia composed of 85 individuals clinically diagnosed with chronic Achilles tendinopathy (TEN) and 210 without any clinical history of ATI (CON) were genotyped for the BstUI RFLP within the 3'-untranslated region (UTR) region of the COL5A1 gene.

**Results:** There was a significant difference in the genotype distribution between the TEN and the CON subjects in the Australian population ( $p < 0.0001$ ). Individuals with a CC genotype (12% ATI versus 24% CON) had a significantly decreased risk of developing chronic Achilles tendinopathy than those with a T allele (TC or TT genotype) (odds ratio 0.42, 95% CI 0.20 to 0.86,  $p = 0.017$ ).

**Conclusion:** This confirms our initial association results with COL5A1 in a white South African population. In conclusion, the BstUI RFLP within the 3'-UTR of the COL5A1 gene was associated with symptoms of Achilles tendinopathy in an Australian population. In addition individuals with a CC genotype were protected from developing ATI.

#### 049 ACHILLES TENDON MORPHOLOGY AND BLOOD FLOW CHANGES FOLLOWING AN IRONMAN TRIATHLON: A PROSPECTIVE COHORT STUDY

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**Background:** Achilles tendon overuse injuries are common in Ironman triathletes. The effects of competing in this ultra-endurance event on the development of morphological and/or blood flow changes in the Achilles tendon and surrounding tissue have not been investigated.

**Objective:** The aim of this study was to assess these changes in triathletes competing in the 2006 South African Ironman Triathlon.

**Methods:** During the pre-race period, 109 triathletes complete a questionnaire containing demographics, past injury and training history, medical history including medication use and family history. Subjects then underwent a clinical examination of the Achilles tendons, as well as an ultrasound examination to assess Achilles tendon morphology and blood flow. The clinical assessment and ultrasound examinations were repeated immediately after the race and in 29 athletes 6–8 weeks later.

**Results:** 17% of the triathletes had evidence of Achilles tendinosis before the race. Factors associated with Achilles tendinosis were increased age ( $p < 0.001$ ), faster running times ( $p < 0.05$ ), a past history of Achilles tendon injury ( $p < 0.001$ ) and a history of oral corticosteroid use ( $p = 0.003$ ). Immediately post-race, there was a significant increase in blood flow in the Achilles tendon and surrounding tissues (pre 3.4%, immediately post 14.3%,  $p = 0.007$ ). Furthermore, after 6–8 weeks, this increased flow returned back to pre-race values. The immediate post-race increased blood flow was strongly related to the presence of pre-race Achilles tendinosis (US) (odds ratio 4.7, 95% CI 1.8 to 12.2,  $p = 0.002$ ) and tenderness to palpation ( $p = 0.011$ ) and a positive shift's test ( $p = 0.025$ ).

**Conclusion:** Approximately 17% of the Ironman participants have evidence of Achilles tendinosis and this will result in an increased blood flow in the tendon and surrounding tissues immediately after the race. The increase in blood flow returns to normal at 6–8 weeks post-race, but long-term consequences of repetitive increases in blood flow in the Achilles tendon are not known and require further investigation.

#### 050 THE EFFECT OF ECCENTRIC EXERCISE ON THE INJURED PATELLA TENDON HEALING

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**Introduction:** Clinical studies have suggested that eccentric loading can be beneficial for tendinopathies but the mechanism remains unclear. This study examined the effects of eccentric and

concentric exercise of the quadriceps femoris muscle on the patellar tendon structure.

**Hypothesis:** A loading-induced expression of collagen and collagen-related growth factors in tendon will depend on contraction type.

**Material and Methods:** We made longitudinal incisions into the patellar tendons of 7-week-old female Wistar rats. Each rat was taught to run on a 15° incline uphill and downhill at 15 m/minute for 60 minutes for 14 days. Group N (n = 35) was the non-exercise group, group C (n = 35) was the concentric exercise group and group E (n = 35) was the eccentric exercise group. The patellar tendons were removed 1, 4, 7, 14, 21, 28 and 42 days after injury. Reverse transcriptase PCR was performed for collagen types I and III, transforming growth factor beta (TGF-β) 1 and matrix metalloproteinase (MMP) 13. Histological studies were performed on days 7 and 14.

**Results:** Group E's TGF-β1 gene expression level exceeded that of groups C and N on days 4 and 7 ( $p < 0.05$ ). Group E's collagen type I gene expression level exceeded that of group N on day 4 ( $p < 0.05$ ). Group E's collagen type III gene expression level exceeded that of group N on days 7 and 14 ( $p < 0.05$ ). Group E's MMP-13 gene expression level was less than that of groups C and N on day 21 ( $p < 0.01$ ).

**Conclusions:** Eccentric loading was associated with significant increases in the gene expression levels of TGF-β1 and following increase of collagen types I and III and with a significant early decrease in the MMP-13 gene expression level. Eccentric exercise appears to elicit the remodelling response effectively.

#### 051 DOES PRE-TREATMENT WITH NON-STEROIDAL ANTI-INFLAMMATORY DRUGS PREVENT MUSCLE PAIN AND DAMAGE AFTER UNACCUSTOMED ECCENTRIC EXERCISE?

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**Background:** Athletes often ingest non-steroidal anti-inflammatory drugs (NSAID) before or after unaccustomed exercise to treat or prevent delayed-onset muscle soreness.

**Objective:** To determine the effects of the NSAID, meloxicam, on symptoms of muscle damage and plasma creatine kinase (CK) concentrations after unaccustomed eccentric exercise.

**Design:** Double-blind placebo controlled trial.

**Setting:** Laboratory-based study.

**Participants:** Forty-five healthy male volunteers.

**Interventions:** The biceps muscles of the subjects' non-dominant arms were damaged using an eccentric exercise protocol. Subjects were randomly assigned to treatment with either meloxicam 15 mg immediately before (ME) or 48 h after induced injury (ML) or a placebo (P) and monitored for a total of 168 h.

**Main Outcome Measures:** Pain, arm carrying angle and CK.

**Results:** Subjects in all three groups experienced severe pain ( $2.5 \pm 2.2$  units;  $2.3 \pm 2.1$  units;  $2.4 \pm 2.5$  units versus control;  $p < 0.001$ ) after the eccentric exercise. After 24 h the difference in the elbow joint angle of all three groups had increased significantly from the control arm ( $7.0 \pm 6.5^\circ$ ;  $4.3 \pm 3.4^\circ$ ;  $2.7 \pm 2.7^\circ$ ; ME, ML, P versus control;  $p < 0.05$ ), possibly as a consequence of elbow flexor muscles shortening. CK at 72 h was higher in ME ( $2540 \pm 4230$  U/l) compared with ML ( $671 \pm 953$  U/l) and P ( $675 \pm 1002$  U/l;  $p < 0.05$  versus pre-exercise control).

**Conclusions:** Skeletal muscle damage using the eccentric protocol is not positively influenced by meloxicam. Indeed, it appears that the ingestion of meloxicam immediately preceding injury seems to affect muscle cell membrane permeability, leading to higher peak CK. These findings are likely to have important implications for athletes who ingest NSAID before exercising in an attempt to decrease muscle injury.

#### 052 INCIDENCE AND RISK FACTORS OF RUNNING-RELATED INJURIES IN FEMALE RECREATIONAL RUNNERS

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**Background:** Running is a popular form of recreational exercise. Besides the positive effects of running on health and fitness, the risk of a running-related injury (RRI) has to be considered.

**Objective:** To determine the incidence and to identify predictors of RRI among a group of female recreational runners.

**Design:** Prospective cohort study.

**Setting:** Participants were observed during an 8-week period training for a 4-mile running event. Each training week participants reported running exposure and RRI in a running diary.

**Participants:** 422 female recreational runners.

**Assessment of Risk Factors:** Several potential risk factors were prospectively measured. Participants were observed for any running-related musculoskeletal injuries of the lower limb and back.

**Main Outcome Measures:** A RRI was defined as any self-reported musculoskeletal pain of the lower limb or back causing a reduction in running mileage for at least one day.

**Results:** At least one RRI was reported by 23.2% of the female recreational runners during the 8-week observation period. The incidence of RRI was 27.5 (95% CI 22.0 to 32.9) per 1000 h of running exposure. Multivariate Cox regression analyses showed that lack of running experience was the most important risk factor (hazard ratio (HR) 2.1; 95% CI 1.2 to 3.7). Furthermore, female runners who reported engaging in non-axial sporting activities at baseline were at higher risk (HR 1.9, 95% CI 1.1 to 3.2) of sustaining a RRI. Higher BMI was also a risk factor for RRI in female participants (HR 1.06; 95% CI 1.01 to 1.13).

**Conclusions:** The incidence of running-related injuries in female recreational runners preparing for a 4-mile running event is substantially high. The findings suggest that female runners without running experience are most availed with preventive interventions for RRI.

#### 053 RELIABILITY OF AN ON-FIELD JUMP-LANDING SCORING SYSTEM

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**Background and Objectives:** Landing with great impact forces may be a risk factor for knee injuries. A good landing technique diminishes the impact forces on the knee. Current technologies, enabling jump-landing data to be readily measured non-invasively in a large number of athletes within a relatively short time period, appear necessary in future screening and prevention studies aimed at reducing knee injuries.

**Design:** The jump-landing scoring-system (JLS system) was developed through content validity and a randomised cross-sectional study was set up.

**Setting and Participants:** Eight basketball teams (two women and six men) of the second and third division participated in this randomised cross-sectional investigation.

**Interventions:** The basketball players were asked to perform double-legged maximal counter movement jumps three times while digital video recording from three different angles was performed: frontal view and lateral view (left and right). Consistency, intra and interreliability were determined.

**Results:** Overall, the JLS strategy showed valid findings. The measured angles of knee, hip and ankle showed only for the ankle angle at first foot contact no consistency between the three jumps. This was also true for the displacement of the centre of gravity. The test-retest consistency of the measured angles was high but the intrareliability of the distance between knees (95% CI -4.64 to -1.60), right knee angle at first foot contact (95% CI -3.77 to

−0.22), maximal right and left knee angle at first foot contact (95% CI −3.10 to −0.10), (95% CI 0.58 to 3.29) was poor. These results clarify that measure errors of a few degrees, made at the test–retest, consistently had the same deviations.

**Conclusion:** With the use of a few guidelines, coaches, physical educators and athletes may utilise the JLS strategy to help prevent knee injuries.

**Funding:** This research was sponsored by the Flemish authorities.

#### 054 PREVALENCE AND RISK FACTORS OF ANTERIOR KNEE PAIN IN BASKETBALL

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**Background:** Sports involving running, jump–landing and sudden stops are at high risk of anterior knee pain (AKP). AKP is suggested to encompass all pain-related problems of the anterior part of the knee and is a common overuse injury in basketball. Data on the prevalence of AKP in basketball are limited.

**Objective:** To determine the prevalence and risk factors of AKP in sub-elite basketball players.

**Design:** A randomised cross-sectional study.

**Setting and Participants:** Twenty-nine basketball teams, with a total of 86 female and 115 male athletes of the second and third division participated. A valid self-reported questionnaire was used to determine anthropometric variables, intrinsic risk factors, sports-specific injuries and characteristics associated with AKP.

**Results:** The self-reported 1-year prevalence, according to the definition used, was 36.1%. The 1-year prevalence of AKP diagnosed by a physician was 17.4%. Of all the participants, 42.3% had experienced AKP once in their lifetime. The most common reported pathologies were patellar tendinopathy (9.5%), patellar femoral pain syndrome (4.0%), Osgood–Schlatter (3.0%), quadriceps tendinopathy (2.0%) and stress fracture of a lower extremity (1.5%). Athletes reporting AKP are significantly more likely to have hip/groin, low back and knee injuries. Short hamstrings, genu valgus and orthosis are reported significantly more frequently in athletes with AKP. Movements with great impact on the knees, such as jumping, are positive for pain in athletes with AKP. There was no difference between the athletes with and without AKP concerning physical activity.

**Conclusion:** The results give clear information about the prevalence of the most common knee overuse injuries in basketball. Previous epidemiological studies on the prevalence of AKP are scarce. Evidence exists that the jump–landing technique might play an important role in both the aetiology and prevention of AKP, because it has previously been shown to be an important risk factor.

**Funding:** This study was sponsored by the Flemish government.

#### 055 RISK FACTORS FOR SCUBA DIVING INJURY: A SURVEY

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**Background:** Scuba diving is a popular sport but it is not medically regulated in Greece.

**Objective:** To identify risk behaviours, pre-existing medical conditions, compliance with dive guidelines and injury patterns of recreational scuba divers.

**Design and Setting:** General practitioners from the Health Center of Varda–Ililas carried out an interpersonal interview-based survey that took place in the north-west area of the Peloponnese in Greece during the 6-month tourist period in 2007 (May–October). They examined risk behaviours and diver safety practices.

**Participants and Results:** Responses from 82 of 123 (66.6%) divers revealed that five (6.09%) were certified; 60% of certified divers reported diving injuries versus 62.33% for non-certified divers

( $p < 0.001$ ); suspected decompression symptoms were witnessed by 43 (52.44%) of divers; 28 (34.14%) of non-certified divers reported medical problems including hypertension, asthma, diabetes and epilepsy. No significant percentage was observed in injuries among the two categories of the divers based on dive frequency ( $p = 1.00$ ), medical conditions ( $p = 0.75$ ), smoking ( $p = 0.55$ ), alcohol ( $p = 0.65$ ). Among certified divers, there was a positive association with fewer diving injuries but not with diving frequency, pre-existing medical condition(s), smoking or alcohol.

**Conclusions:** Intensive courses for health education and prevention must be started directly in scuba diving in Greece, at least during the tourist season. That remains one of the great concerns of the general practitioners' association, which has already taken steps in collaboration with the Ministry of Tourism.

#### 056 JOGGERS' INJURIES: THE ASSOCIATION OF ALCOHOL CONSUMPTION WITH THE TYPE AND SEVERITY OF INJURIES AND OUTCOMES

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**Background:** Bicycling has become a way of life in Greeks for the past decade.

**Objective:** To investigate the prevalence of positive alcohol screens and the effect of alcohol level on injury patterns, injury severity and outcomes in joggers.

**Design, Participants, Settings:** The study population included bicyclists older than 19 years, treated in the Health Center of Varda–Ililas in the north-west Peloponnese during the calendar year 2006, who were involved in an injury and had a blood alcohol level measured. The alcohol-negative group was defined as those patients with a blood alcohol level  $\leq 0.05$  g/dl. Low and high alcohol groups were defined as those having blood alcohol levels  $> 0.05$  g/dl to  $< 0.08$  g/dl and  $\geq 0.08$  g/dl, respectively. We compared the three study groups with respect to demographics, injury patterns, injury severity, complications and outcomes. Logistic regression was used to determine if alcohol had an independent association with any outcomes.

**Results:** 98 patients met the study criteria. Overall, 57 patients (58.16%) had a negative alcohol screen, eight (7.84%) had low alcohol levels and 33 (33.67%) had high alcohol levels. The alcohol level was not notably associated with severity of injury, admission hypotension, major complications and injury pattern (head, chest, abdomen or extremity area injury score). The overall complication rate and hospital length of stay were markedly higher in the high alcohol level group than in the negative-alcohol level group.

**Conclusions:** In bicyclists involved in an injury/accident, a high alcohol level is not associated with body area severity of injury and overall severity of injury, but a high alcohol level is notably associated with higher overall complication rates and longer hospital length of stay.

#### 057 DESCRIPTIVE EPIDEMIOLOGICAL SURVEY OF WOMEN'S VOLLEYBALL INJURIES

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**Background:** Volleyball is popular in Greece. Women's participation in volleyball has increased greatly over the past two decades. As with all sports, women participating in volleyball assume an inherent risk of injury each time they practice or participate in games.

**Objective:** In order for clinicians to obtain a better understanding of the risks associated with volleyball, it is critical to gather data



that illustrate injury rates and patterns among volleyball athletes. Furthermore, with knowledge of injury mechanisms and risk factors comes the ability to initiate prevention strategies to minimise future injury.

**Design, Participants, Settings:** We reviewed 2 years of injury surveillance data for women's volleyball in order to identify potential areas for injury prevention initiatives. Data were gathered from the health centre's books in Varda—Ililas in the north-west Peloponnese.

**Results:** Over the past 2 years, the rate of injury in a game situation was slightly higher than in practice (4.61 versus 4.02 game injuries per 1000 athlete exposures, rate ratio 1.1, 95% CI –1.0 to 1.2,  $p < 0.01$ ). A total of 212 injuries from 188 games and 417 injuries from more than 500 practices was reported. The lower extremities accounted for more than 55% of all game and practice injuries, with ankle ligament sprains representing 41.1% of game injuries and 23.9% of practice injuries. 22.4% of all game injuries involved the upper extremities. The majority of injuries during a game situation occurred while athletes were in one of the front three positions. A player landing on another player and contact with the floor each accounted for 26% of game injuries.

**Conclusions:** Ankle injuries appear to be the most common injuries in women's volleyball. Future preventive efforts should focus on preventing first-time ankle sprains and acute traumatic knee injuries, as well as reducing the risk of ankle sprain recurrence.

#### 058 ACHILLES TENDON DISORDERS IN RECREATIONAL RUNNERS

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**Background:** Achilles tendon injury is one of the most common injuries in sports.

**Objective:** To assess the demographics and training characteristics of recreational runners with overuse injuries in the Achilles tendon.

**Design:** A retrospective training and injury questionnaire was distributed to 102 recreational runners.

**Setting:** Recreational runners.

**Patients:** 102 recreational runners, recruited at random in a local race meeting, 78 completed the questionnaire.

**Interventions:** Independent variables were inadequate stretching, training surfacing, alignment of the lower limb, foot arch and training technical.

**Main Outcome Measures:** Dependent variables were injury of the Achilles tendon (tendinosis or rupture) in the previous 2-year period.

**Results:** 23 runners (29%) had some injury in the Achilles tendon. 18 training on rigid surfaces, 17 wearing inadequate sports shoes, 15 inadequate stretching exercises, four had pronated feet and three genu varum.

**Conclusions:** Achilles tendon disorders have a high incidence in runners. It is very important to know the predisposing factors to develop prevention methods.

#### 059 ISOKINETIC EVALUATION FOR THE ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTED PATIENT: DID WE FORGET STRENGTHENING EXERCISES FOR THE QUADRICEPS?

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**Background:** Quadriceps muscle weakness is common after anterior cruciate ligament (ACL) rupture and reconstruction. Quadriceps strength and the hamstring/quadriceps ratio is often correlated with the ACL reconstructed patient's functional status.

Currently, one study has demonstrated that the hamstring/quadriceps ratio at 30° of knee flexion was strongly correlated with the functional score.

**Objective:** We hypothesised that patients with ACL reconstruction would show a quadriceps strength deficit compared with the uninjured side and that strength measured at 30° of knee extension and the first 1/3 work would be significantly lower than other strength measures.

**Design:** Using a cohort study design we reviewed the physical therapy strength records of 43 hamstring autograft reconstructed patients and 74 allograft reconstructed patients (patellar tendon, Achilles or tibialis anterior). Three, six, or 12-month isokinetic results (peak torque, torque at 30°, torque at 0.18 s, total work, first 1/3 work, last 1/3 work) were reviewed for 117 consecutive patients who had received ACL reconstruction for unilateral primary ACL injuries at one institution between February 2006 and January 2007.

**Results:** There are statistically significant differences between the hamstring and allograft groups at 6 months for time to operation and at 3 months for age. Strength of the quadriceps and side-to-side strength deficit was improved until 12 months, but strength of the hamstring did not improve after the third month ( $p < 0.03$ ). Side-to-side strength deficit for torque at 0.18 s, torque at 30°, total work, first 1/3 work and last 1/3 work improved up to 12 months after reconstruction ( $p < 0.04$ ).

**Conclusion:** Side-to-side quadriceps deficit continues to improve until 12 months after reconstruction. These deficits not only occurred in the first 1/3 of knee flexion, but also through the full range of motion.

#### 060 ROCK CLIMBING INJURY RATES AND ASSOCIATED RISK FACTORS IN A GENERAL CLIMBING POPULATION

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**Background:** Worldwide, climbing has increased in popularity in recent years both as a recreational physical activity and as a competitive sport. With the increasing popularity of climbing and due to the nature of the sport, there are reasons for concern regarding a rise in the number of climbing injuries. In light of these conditions, it is unsatisfying that very few epidemiological studies of general climbing populations are available.

**Objective:** To examine the rates and typical injury patterns in a representative sample from a total population of climbers.

**Design and Setting:** A mail survey was distributed to a random sample consisting of 10% of the Swedish Climbing Association membership (597/6067 persons). Altogether 355 climbers completed a self-report questionnaire about their climbing history, safety practices and retrospective accounts of injury events.

**Assessment of Risk Factors:** Descriptive statistics and a stepwise regression method was used to determine the combination of possible independent associated risk factors that best explained individual injury rates.

**Results:** Overuse injuries were 3.9 per 1000 climbing hours, accounting for 93% of all injuries. Inflammatory tissue damage to fingers and wrists were the most common types of injury. Of those climbers reporting overuse injuries, 24% also had an incident or traumatic injury, which most often was associated with human factors, ie, mistakes or lapses in concentration. Noteworthy, in contrast to earlier studies, we found that a higher BMI was related to an increased injury risk for climbers who practised bouldering and sport climbing.

**Conclusions:** Overuse injuries are common among climbers, indicating that a potential for injury prevention lies in teaching climbers to recognise the early signs and symptoms of overuse and systematically increasing climbing hours and loads for beginners. Due to the fact that incidents and traumatic injuries largely occur

because of human factors, mandatory teaching about safety practices, including first aid and climbing rescue techniques is warranted.

### 061 INCREASED EXTERNAL ROTATION AFFECTS HORIZONTAL ADDUCTION RANGE IN SHOULDER KINEMATICS

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**Background:** Increased contracture of the dominant posterior shoulder in throwing athletes has been associated with the development of altered shoulder rotational motion as well as several conditions.

**Objective:** To investigate the relationship with the external rotation to horizontal adduction in the range of motion in American football players who have increased external rotation.

**Design:** 22 American football players were assessed in this study.

**Setting:** The study was conducted in physiology laboratory settings at Ankara University.

**Patients:** 22 football players aged between 18 and 23 years who had been free from upper extremity pathology for 12 months.

**Interventions:** They were assessed for shoulder range of motion with goniometric measurements. Active internal rotation and pectoral tightness tests were done for all players.

**Main Outcome Measures:** Players assessed for shoulder external rotation, internal rotation and horizontal adduction in range of motion both dominant and non-dominant extremities. Active internal rotation was evaluated by measuring the distance between T5 and the thumb for both extremities. Pectoral tightness was tested.

**Results:** Increased external rotation and decreased internal rotation were seen in all American football players. There was a significant relationship with external rotation to horizontal adduction (right side:  $r = 0.66$ ;  $p = 0.001$ /left side  $r = 0.63$ ,  $p = .002$ ), respectively. Increased external rotation was seen with increased horizontal adduction. There was no significant relationship between internal rotation and horizontal adduction (right side  $r = 0.33$ ;  $p = 0.13$ /left side  $r = 0.28$ ;  $p = 0.22$ ).

**Conclusions:** Based on the results of this study, we found that measuring glenohumeral horizontal adduction with the player who has decreased internal rotation due to increased external rotation in American football, horizontal adduction has increased.

### 062 THE EFFECTS OF WEIGHT ANKLE STABILITY IN ADOLESCENT BASKETBALL PLAYERS

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**Background:** Ankle stability is very important for the prevention of injuries in basketball and is affected by posture, which changes with the weight loaded.

**Objective:** To investigate the effects of weight to ankle stability in adolescent basketball players.

**Design:** Descriptive with repeated measures.

**Setting:** The study was performed in the school gym-hall.

**Participants:** Twenty healthy primary school students aged between 10 and 12 years (age  $11.0 \pm 1.5$  years) who had been free from lower extremity pathology for 12 months and had no previous history of ankle sprain served as subjects.

**Interventions:** Each subject had a warm-up period for 15 minutes by running or riding a stationary bike. The star excursion balance test (SEBT), single-leg balance test (performed with eyes open and eyes closed) and vertical jump test.

**Main Outcome Measures:** The SEBT, single-leg balance test (performed with eyes open and eyes closed) and vertical jump test were performed with dominant lower extremity. One week later, the same tests were performed with a schoolbag. The schoolbag

contained weights corresponding to 20% of the player's own body weight. The tests were also performed with the dominant lower extremity. Absolute average error (in cm) and the standard deviation of the average error were calculated.

**Results:** All parameters in the SEBT showed a significant difference between non-weight measurement and weighted measurement except the posteromedial direction ( $p = 0.004$ ). The single-leg stance test performed with eyes open showed no significant difference between non-weight measurement and weighted measurement ( $p = 0.006$ ). Also the single-leg stance test performed with eyes closed showed no significant difference between non-weight measurement and weighted measurement ( $p = 0.001$ ). The vertical jump test showed no significant difference between non-weight measurement and weighted measurement ( $p = 0.001$ ).

**Conclusion:** In adolescent basketball players, carrying 20% of their own body weight has a harmful effect on their ankle stability. Therefore, this can cause serious ankle instability problems and should be prevented.

### 063 PREVENTIVE BRACE, TAPING OR BAREFOOT: DO THEY SHOW ANY CHANGE ON MULTI-JOINT COORDINATION AND KINESTHETIC POSITION SENSE IN CLOSED KINETIC MECHANISM

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**Background:** Ankle bracing and taping are widely used by sports participants in order to prevent ankle sprains.

**Objective:** The aim of this study was to assess the effects of taping and preventive brace on multi-joint coordination and kinesthetic position sense and to compare with barefooted subjects who never had an ankle injury in order to reveal if there is any effect or superiority one over the other.

**Design:** The dependent variable was the test condition with three trials: control (barefooted), preventive brace and taping.

**Setting:** The Sports Physiotherapy Research Laboratory at Hacettepe University, Faculty of Health Sciences.

**Participants:** Twenty physically active male university students aged between 20 and 28 years who had been free from lower extremity pathology for 12 months and had no previous history of ankle sprain served as subjects.

**Interventions:** They were assessed for multi-joint coordination and kinesthetic joint position sense in three conditions randomly: barefooted, with preventive brace and taping with monitored rehabilitation systems, functional squat system machine.

**Main Outcome Measures:** Absolute average error (in cm) and the standard deviation (SD) of the average error were calculated. Both average and SD were independently quantified as a function of the action mode (concentric versus eccentric) and of the tested lower limb (dominant versus non-dominant).

**Results:** Right concentric and eccentric, left eccentric, right first visible deviation results were significantly higher for the barefoot ( $p < 0.05$ ). According to a paired t-test between groups there was no difference between brace and tape ( $p > 0.05$ ).

**Conclusions:** No superiority of brace over tape or vice versa was shown. As the deviation is higher in the barefoot position, brace and taping may have an effect on improving perception and neuromuscular input in the closed kinetic chain position.

### 064 CORRELATION BETWEEN PATELLAR ANATOMICAL ALIGNMENT AND PATELLAR TENDINOSIS

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**Background:** Clinically, the McConnell and Arno angles are used to measure patellar rotations. Some authors have suggested that an increase in the Q angle is related to an increase in the lateralising

forces acting on the patella, predisposing to patellofemoral dysfunction.

**Objective:** The purpose of this study was to compare the biomechanical patellar alignment between a group of subjects with patellar tendinosis and a control healthy group.

**Design:** Cross-sectional study.

**Setting:** The evaluation was promoted by the Sports Excellence Centre of the Federal University of Minas Gerais, Brazil, carried out in the Laboratory for the Prevention and Rehabilitation of Sports Injury.

**Participants:** Fourteen subjects with a clinical diagnosis of patellar tendinosis were paired with 14 healthy subjects (eight women and six men for each). Intraclass correlation coefficients (ICC) were 0.73 for angle Q, ICC 0.82 for angle of McConnell, ICC 0.91 for angle of Arno.

**Assessment of Risk Factors:** Analysis of variance with a factor of repeated measure (inferior member) and a factorial (group) was used to compare the following dependent variables: Q angle, McConnell angle and Arno angle.

**Results:** The group with patellar tendinosis had a significantly greater Arno angle when compared with the control group ( $p = 0.0125$ ). This higher angle in the tendinosis group was found bilaterally. No differences in the Q-angle and McConnell angle were found between groups.

**Conclusion:** The measurement of the Q angle perhaps is not an efficient predictor of injuries developed from dynamic alterations of the body. The position of  $30^\circ$  of knee flexion for the McConnell measurement would generate more tension on the patellar retinaculum. The overload in the medial region of the tendon leads to a degenerative process. It is important to emphasise that alignment alterations should not be evaluated separately because the origins of all musculoskeletal pathology are multifactorial.

#### 065 ISOKINETIC MUSCLE STRENGTH RATIO EVALUATION OF SHOULDER EXTERNAL AND INTERNAL ROTATORS

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**Background:** The shoulder is one of the most commonly injured areas in judo. These injuries have been associated with inadequate throwing techniques and falls on the ground. Because muscle strength and dynamic stability are related to the execution of the correct movement technique and with success in judo performance, these factors should be considered in this sport.

**Objective:** To evaluate the isokinetic muscle strength ratio between shoulder lateral and medial rotators in athletes of the Brazilian female judo team.

**Design:** Cross-sectional study.

**Setting:** The evaluation was performed by the Sports Excellence Centre of the Federal University of Minas Gerais in the Laboratory for the Prevention and Rehabilitation of Sports Injury.

**Participants:** Thirteen athletes of the Brazilian female judo team were tested.

**Assessment of Risk Factors:** The isokinetic dynamometer Biodex 3 System Pro was used to assess the lateral and medial rotators ratio at  $60^\circ/\text{s}$  and  $360^\circ/\text{s}$ . The protocol used consisted of five maximum repetitions of shoulder medial and lateral rotation, in the concentric-concentric mode. The antagonist/agonist ratio was calculated through the division of shoulder lateral rotators muscles peak torque by medial rotator muscles peak torque multiplied by 100.

**Results:** The average was 68.2% in the dominant limb and 65.4% in the non-dominant limb at  $60^\circ/\text{s}$  and 52.6% in the dominant and 50.2% in the non-dominant limb at  $360^\circ/\text{s}$ .

**Conclusion:** These results indicate a possible muscular imbalance of the shoulder joint that may increase the risk of injury. However, these results could be due to adaptations to sports specificity and further clarifications are needed.

#### 066 ISOKINETIC ANALYSIS OF HAMSTRINGS AND QUADRICEPS MUSCLES IN THE BRAZILIAN MALE AND FEMALE TAEKWONDO TEAM

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**Background:** Gable *et al* showed a high prevalence of hamstrings muscle injury in martial arts and the risk factors are: muscular weakness, fatigue and inadequate previous warm-up. Isokinetic evaluation promotes a dynamic, objective and reproducible muscle evaluation.

**Objective:** Analyze the ratio and peak torque of hamstrings (H) and quadriceps (Q) muscles in male and female athletes of the Brazilian taekwondo team.

**Design:** Cross-sectional study.

**Setting:** The evaluation was performed by the Sports Excellence Centre of the Federal University of Minas Gerais in the Laboratory for the Prevention and Rehabilitation of Sports Injury.

**Participants:** Six women and six men of the Brazilian taekwondo national team were evaluated.

**Assessment of Risk Factors:** The isokinetic dynamometer Biodex 3 System Pro was used to assess H/Q ratio at  $60^\circ/\text{s}$  and  $300^\circ/\text{s}$ . The protocol used included five maximum repetitions of extension and flexion of the knee in the concentric-concentric mode at  $60^\circ/\text{s}$  and 30 repetitions at  $300^\circ/\text{s}$ . The H/Q ratio was calculated as the percentage of the peak torque produced by hamstrings relative to the peak torque of the quadriceps.

**Results:** All athletes presented the H/Q ratio below 60% at  $60^\circ/\text{s}$  and below 75% at  $300^\circ/\text{s}$ . Also, the dominant limb had the lowest ratio H/Q values and of flexor peak torque compared with the non-dominant limb at both speeds.

**Conclusion:** This ratio at  $60^\circ/\text{s}$  may indicate a hamstring weakness or quadriceps increased strength in relation to the hamstrings. In addition, the lower ratio at  $300^\circ/\text{s}$  could be related to a lack of muscular strength at high speeds of hamstring in comparison with quadriceps and is reported to be associated with knee overuse injuries. The taekwondo athletes performed lower flexor peak torque (% body weight) at  $60^\circ/\text{s}$  compared with non-athletes. Therefore, it is important to carry out specific muscular resistance and strength training for the hamstrings to prevent injuries.

#### 067 ISOKINETIC ANALYSIS OF MEDIAL AND LATERAL ROTATORS RATIO OF THE GLENOHUMERAL JOINT IN THE BRAZILIAN MALE VOLLEYBALL TEAM

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**Background:** The efficiency of spike movements is a determinant element that allow players to reach a high level of performance in volleyball. Strength imbalances among shoulder muscles have been highlighted as important risk factors for joint injuries. Isokinetic parameters can be used as injury predictors, especially the ratio between lateral and medial rotators (LR/MR).

**Objective:** The purpose of this study was to analyze the ratio of medial and lateral rotators of the glenohumeral joint in players of the Brazilian male volleyball team under 19 and 21 years of age.

**Design:** Cross-sectional study.

**Setting:** The evaluation was performed by the Sports Excellence Centre of the Federal University of Minas Gerais in the Laboratory for the Prevention and Rehabilitation of Sports Injury.



**Participants:** Twenty athletes of the Brazilian male volleyball team under-19 and 15 athletes under-21 were evaluated.

**Assessment of Muscle Performance:** The dynamometer isokinetic Biodex 3 System Pro was used to assess the lateral rotation/medial rotation (LR/MR) ratio at 60°/s and 360°/s. The protocol carried out was five maximum repetitions of lateral and medial rotation of shoulder in concentric–concentric mode at 60°/s and 30 repetitions at 360°/s. An ANOVA with one factorial level (categories) and another of repeated measures (limb) was used to evaluate the variable antagonist/agonist ratio at the two speeds.

**Results:** A significant difference was found in the LR/MR ratio among the categories, on the dominant limb ( $p = 0.001$  at 60°/s and  $p = 0.012$  at 360°/s) and on the non-dominant ( $p = 0.001$  at 60°/s and  $p = 0.002$  at 360°/s).

**Conclusion:** Only the under-21 volleyball athletes have presented values below the reference for the LR/MR ratio, showing a lateral rotator strength deficit and/or a medial rotator strength increase. Several authors recommend correcting the lateral rotator weakness and LR/MR imbalance, as a decreased LR/MR ratio is associated with shoulder injuries.

#### 068 ISOKINETIC HAMSTRING/QUADRICEPS MUSCLE STRENGTH RATIO IN BRAZILIAN VOLLEYBALL ATHLETES

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**Background:** Volleyball demands great lower-limb strength, mainly in the quadriceps muscle, which may cause an overloading on the structure of tendons and knee muscles. Several studies have reported a 40% incidence of patellar tendinopathy in elite volleyball players.

**Objective:** To assess the isokinetic hamstring/quadriceps ratio in high level male volleyball athletes of the Brazilian team.

**Setting:** The evaluation was performed by the Sports Excellence Centre of the Federal University of Minas Gerais in the Laboratory for Prevention and Rehabilitation of Sports Injury.

**Participants:** Twenty under-19 and 16 under-21 athletes of Brazilian national volleyball team.

**Assessment:** The isokinetic dynamometer Biodex 3 System Pro was used to assess the hamstring/quadriceps (H/Q) ratio. The athletes performed five maximal knee flexion and extension repetitions in the concentric–concentric mode at 60°/s and 30 repetitions at 300°/s.

**Results:** The H/Q ratio average found in under-19 and under-21 athletes, respectively, was 49% and 53.7% for dominant and 47.2% and 49.3% for non-dominant. In addition, there was a statistical difference between dominant and non-dominant limbs, only in under-21 athletes ( $p = 0.043$ ).

**Conclusions:** This study performed the measurement of H/Q ratio in the concentric–concentric mode, because hamstring action as an antagonist is directly proportional to its ability to generate concentric strength. The low H/Q ratio indicates quadriceps predominance or hamstring muscle weakness. These results can be used for comparisons for assessing the isokinetic muscle function in volleyball athletes in future studies.

#### 069 PROSPECTIVE STRENGTH AND FLEXIBILITY TRAINING FOR INJURY PREVENTION IN PROFESSIONAL SOCCER

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**Background:** The incidence of muscle injuries in professional soccer players is high, but evidence-based information on injury-prevention strategies in this sport is limited.

**Objective:** To define the incidence associated with hamstring and quadriceps muscle injuries in professional soccer players and to determine whether the use of strengthening and stretching exercises reduces the incidence and severity of these injuries.

**Design:** Prospective study. Quasi-experimental intragroup with pre-test and post-test design was developed.

**Setting:** Soccer elite division.

**Participants:** 23 professional soccer players were thoroughly supervised during the season 2006/7.

**Interventions:** Total muscular injuries were counted by using a computerised register. During the winter break an additional strength and flexibility training programme was initiated. Furthermore, strength (countermovement jump and isokinetic) and flexibility were evaluated. Data were analyzed with descriptives, Friedman test and paired t-test.

**Results:** All evaluated fitness results increased significantly: CMJ  $45 \pm 6$  cm versus  $41 \pm 8$  cm ( $p < 0.05$ ), quadriceps isokinetic concentric power dominant and non-dominant leg (60°), respectively ( $275 \pm 74$  Nm versus  $261 \pm 87$  Nm,  $274 \pm 41$  Nm versus  $266 \pm 32$  Nm, both  $p < 0.05$ ), hamstrings isokinetic eccentric power dominant and non-dominant leg (60°), respectively ( $225 \pm 84$  Nm versus  $212 \pm 67$  Nm,  $231 \pm 91$  Nm versus  $218 \pm 62$  Nm, both  $p < 0.05$ , flexibility dominant and non-dominant hamstring ( $56 \pm 11^\circ$  versus  $44 \pm 10^\circ$  and  $55 \pm 9^\circ$  versus  $43 \pm 10^\circ$ ,  $p < 0.05$ ). Muscular injuries decreased considerably, with significant differences (20 versus 7,  $\chi^2$  5.34,  $p = 0.007$ ).

**Conclusion:** After initialising the strength and flexibility training, the resulting incidence of muscle injuries was reduced significantly by 300%. Regarding the reduced incidence of muscular injuries in elite soccer players, further studies have to be performed to elucidate the value of this training intervention.

#### 070 BIOMECHANICAL ANALYSIS OF AN INCITING EVENT OF ANKLE SPRAIN ON BASKETBALL PLAYERS

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**Background:** Lateral ankle sprains are very common among basketball players and are responsible for a significant loss of practice time. Nevertheless, having the same exposure to risk while playing basketball, some athletes never sprain their ankles whereas others do.

**Objective:** This study's aim was to understand the main kinematics and electromyography differences in basketball players during jumping.

**Design:** 24 asymptomatic elite basketball players, 12 women and 12 men, underwent the same test procedures consisting of five consecutive jumps in unipodal support. Barefoot athletes with healthy ( $n = 17$ ) and already sprained ankles ( $n = 28$ ) were asked to jump from the floor to an unstable surface in all directions (round Freeman board) placed 50 cm in front of them. This design aimed to reproduce the most common mechanism of ankle sprain in Portuguese basketball players, landing on another player's foot, which temporarily becomes an unstable surface.

**Main Outcome Measures:** Electromyography data of four lower-leg muscles (tibialis anterior, peroneus longus, lateral and medial gastrocnemius) were recorded. Motion data were recorded using an electromagnetic tracking device with three sensors located on each segment (foot, shank and thigh) of the lower limb. Data were analyzed in four phases of movement for phase duration, muscle activity and segment position.

**Results:** During jumping, athletes with already sprained ankles showed less flying time, probably leading to less preparation time for contact and load. They also had their knee more extended and

the ankle in a more plantar flexed position while landing, which creates a dangerous position for the ankle. We found higher muscle activity for all muscles with the exception of the tibialis anterior, contraction of which is significantly different in both groups on landing.

**Conclusions:** Different movement behaviours of the lower leg of healthy and already sprained ankles during the jump can lead to ankle sprain.

## 071 INJURIES IN PORTUGUESE BASKETBALL

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**Objective:** Epidemiological analysis to determine the rate of injuries and their characteristics during basketball.

**Design:** Retrospective cohort study.

**Setting:** Standardised data were collected with a validated instrument from 642 athletes from all competitive basketball categories.

**Participants:** All individuals within the age groups under-14 to seniors who practised federated basketball during at least one of two seasons studied and agreed to participate.

**Results:** A total of 330 athletes sustained 599 injuries (51.5% injured players). The greatest number of injuries occurred in the lower leg followed by the fingers. The most common injury mechanism was contact with another player, especially during a jump. The most frequent injury was ankle sprain. There are statistically significant differences in injury frequency per 1000 h of exposure with regards to sex, competitive level, position played and limb dominance. Female athletes demonstrate higher values (women  $1.46 \pm 2.21$ ; men  $2.03 \pm 2.59$ ) of injury frequency as do higher competitive levels. Forward players have the lowest injury frequencies per 1000 h of exposure, followed by guards, point-guards, post players and finally power forwards. Athletes with undefined positions have the lowest injury frequency (0.56/1000 h). When the left leg is dominant, injury frequency is significantly higher than when the right leg is dominant. Higher values in age, weight, height, BMI, years of basketball practice, years at competitive level, playing time, number of weekly practices and practice volume tend to correspond to higher injury frequencies per 1000 h in both sexes.

**Conclusions:** Injury type, lower-limb dominance (limb used for jumping) and competitive level affect injury occurrence in the sample population studied. The importance of lower-limb injuries compared with injuries of other body segments (upper limb, head and spine) must be emphasised, as well as the fact that most lower-limb injuries occur on the dominant side.

## 072 THE EFFECT OF A PROXIMAL TO DISTAL MOVEMENT STRATEGY IN DECREASING ANTERIOR CRUCIATE LIGAMENT INJURY RISK FACTORS IN FEMALE ADOLESCENT SOCCER PLAYERS

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**Background:** There is a need to investigate the effect of specific movement strategies in reducing the biomechanical risk factors for anterior cruciate ligament (ACL) injury in young female athletes.

**Objective:** To examine the effect of a proximal to distal (PD) movement strategy on biomechanical risk factors at the knee during side-cut, unanticipated side-cut and side-hop movements. It was hypothesised that instruction of a PD movement strategy would result in an increase in flexion angles and a decrease in abduction moments.

**Design:** Prospective intervention study.

**Setting:** Biomechanical research laboratory.

**Participants:** A convenience sample of 10 14–16-year-old female, club-level soccer players entered the study. Six subjects completed all three test sessions.

**Interventions:** The PD strategy was instructed by a physiotherapist immediately after baseline testing and during a 4-week training programme consisting of a 20-minute warm-up, two times per week. No instructions or corrections related to the position of the knee were included in the intervention.

**Main Outcome Measures:** Maximum knee flexion angles during stance and external abduction moments at 20% of stance were measured using three-dimensional motion analysis and inverse dynamics at baseline, after immediate instruction and after 4 weeks.

**Results:** After the immediate instruction, there was a significant increase in knee flexion angle for the side-cut (mean  $+5.7^\circ$  (SD 3.9),  $p = 0.003$ ), unanticipated side-cut (mean  $+3.0^\circ$  (SD 1.9),  $p = 0.002$ ) and side-hop (mean  $+6.0^\circ$  (SD 2.9),  $p = 0.001$ ). Abduction moments decreased across all tasks but were not statistically significant. After the 4-week training programme, there were significant decreases in abduction moments for the side-cut task (mean  $-0.17$  nm/kg (SD 0.15),  $p = 0.043$ ). There were no other statistically significant improvements although most measures demonstrated trends towards improvement.

**Conclusions:** A PD movement strategy may reduce biomechanical risk for ACL injury. Replication with a larger controlled trial is warranted to investigate the effectiveness of this movement strategy.

## 073 SURVEY OF INJURY PREVENTION PROGRAMMES AMONG BASKETBALL, VOLLEYBALL AND HANDBALL COACHES IN CENTRAL ITALY

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**Background:** Ankle and knee ligament injuries occurring in basketball, handball and volleyball players are a big concern. The effectiveness of prevention programmes in lowering the incidence of injuries has been described by several authors but we do not know their diffusion among teams.

**Objective:** To assess the knowledge and the application of prevention methods.

**Design:** Retrospective survey.

**Setting:** Youth sport and amateur elite teams.

**Participants:** Coaches of 150 basketball, handball and volleyball teams (in total 2120 players, 805 men and 1315 women: average age 16.7 years) in the Umbria region (central Italy) answered an anonymous questionnaire regarding injury prevention methods. Additional information on training methods (warm-up, muscle strengthening and stretching) was obtained.

**Results:** Quantitative evaluations by functional tests were performed in 30.6% of the teams; video analysis of sport-specific movements and playing situations were used in 59.3% of the teams to improve their performance but not to prevent injuries (assessing at-risk situations or reviewing the injuries); balance training with a wobble board was performed by 64.6% of the teams (an additional 12% use the board only during rehabilitation after injury); sport-specific at-risk movements such as rapid deceleration and crosscut manoeuvre were reproduced during training in 58% and 49.3% of the teams, respectively, whereas the correction of jump landing strategies as a prevention measure was not applied. 42.6% of the coaches declare they are aware of and use prevention methods.

**Conclusion:** Surveys are important to determine the extent and the way prevention measures are used in each sport in each country. The knowledge of at least basic intervention methods to prevent ligament injuries and their use in 100% of the teams is an ambitious

target that should be reached by special courses for both coaches and athletes.

#### 074 STUDY REGARDING SPECIFIC ALPINE SKIING INJURIES (INITIATION LEVEL) ON STUDENTS IN PHYSICAL EDUCATION AND SPORT

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**Background:** Alpine skiing is a popular sport, included in the university curricula for students in physical education and sport—SPES, which requires medical attention due to the possible injuries.

**Objective:** To describe the features of specific skiing injuries (initiation level for SPES) and the associated risk factors.

**Design:** Retrospective cohort study.

**Setting:** Data were collected during the ski courses for SPES, for five winter seasons (2003–7).

**Participants:** The research included 750 SPES (sex ratio 3 : 1 for men, average age 20.6 years) participants in the ski courses (initiation level). The courses lasted 7 days for each student, during their first year of study.

**Assessment of Risk Factors:** We analyzed the following ski injuries risk factors: gender, age, anxiety, motor skills/experience, context (environmental factors: snow type, slope inclination, climatic features), temporal localisation (during 7 days).

**Main Outcome Measures:** We evaluated the incidence of ski injuries using a scale with two criteria: type of major injuries (fractures, sprains/dislocations, contusions/wounds) and injury localisation (lower/upper limb and trunk).

**Results:** We recorded 33 major injuries (0.62 injuries per 1000 skier days). The most frequent injuries were contusions/wounds (66.6%), especially of the lower limb ( $p \leq 0.05$ ). Regarding sprains, the most common location was the knee (anterior cruciate ligament). Gender did influence the injury rate: girls seem to be at higher risk than boys, independent of age and motor skills. Also, the environmental factors determined the injury pattern, which occurred especially on icy slopes with high inclination; 75% of injuries occurred during the first 3 days of the ski courses.

**Conclusions:** The rate of injuries is lower than other reported data, probably due to the high level of motor skills and physical fitness of the subjects. Also, the ski initiation was conducted using modern learning techniques, with specialised teachers, under medical surveillance.

#### 075 EFFECTS OF THE APPLICATION OF KINESIO-TAPE AND TRADITIONAL TAPE ON MOTOR PERCEPTION

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**Background:** The application of various types of tape is usually to provide functional support for injury prevention and protection. However, the efficiency of traditional tape has been debated in past studies. Kinesio-tape, developed by Kenzo Kase, is currently applied for the rehabilitation of an injury.

**Objective:** The purpose of this study was to investigate the accuracy and the variability for the ability of position match knee joints through the intervention of kinesio-tape and traditional tape for soccer players with an injured knee.

**Participants:** Nine male and eight female college soccer players (aged  $20.9 \pm 2.0$  years; height  $177 \pm 6$  cm; weight  $70.4 \pm 3.3$  kg) served as participants in this study.

**Interventions:** Every participant was asked to tape the knee in three conditions: non-taping, kinesio-tape and traditional tape.

**Measurements and Setting:** The perceptual motor abilities were measured and analyzed for accuracy and variability using a KIN-COM dynamometer system in which the participant performed

tasks of knee positioning to reproduce the positions of  $29^\circ$ ,  $39^\circ$  and  $49^\circ$ .

**Results:** The results showed that the position matching variability for kinesio-tape was significantly less than traditional tape ( $p < 0.05$ ) and the condition of kinesio-tape is subservient to the accuracy of position matching. The variable error at  $29^\circ$  for kinesio-tape was smaller than non-taping ( $p < 0.05$ ).

**Conclusions:** The finding indicated that kinesio-tape could enhance the perceptual motor sensitivity of proprioception to perform small angle movements in the knee, but the enhancement of the variable error for the small angle movement caused by traditional tape affected the constraint of the knee. Kinesio-tape had a positive effect on the knee in  $39^\circ$  that is a mechanical stationary state for perceptual-motor sensitivity.

#### 076 CAN THE CUE OF BREATHING IN DECREASE LANDING FORCES IN THE MAXIMAL VERTICAL JUMP?

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**Background:** The training in dance programmes always requires a person to jump with lower impact sounds by the technique of breathing in and holding breath to reduce the rate of injury and to dance with more grace.

**Objective:** The purpose of this study was to examine the effect of instructional cue of breathing in and holding breath to lower the peak ground reaction forces (GRF) during landing from the countermovement jump occurring naturally in athletes.

**Participants:** Fourteen physical education students (eight men and six women) were recruited as the participants for this study. Participants' mean age, body weight (BW) and height were  $19 \pm 0.9$  years,  $64.5 \pm 9.7$  kg and  $169.4 \pm 9.1$  cm, respectively.

**Interventions:** Every participant was asked to perform the natural maximal vertical jumps barefoot in the condition of breathing in and holding breath to land following one's inherent pattern.

**Measurements:** A Kistler force platform (type 9287BA; sampling rate 1000 Hz) was used to acquire vertical jumps and to assess the landing forces. The analysis of flight height for pre-intervention ( $52.2 \pm 8.6$  cm) and post-intervention ( $52.0 \pm 8.6$  cm) showed no difference ( $p > 0.05$ ).

**Results:** The results indicated that there were no significant differences ( $p > 0.05$ ) in first peak GRF (PK1) (pre  $2.12 \pm 0.63$  BW; post  $2.00 \pm 0.71$  BW), second peak GRF (PK2) (pre  $5.60 \pm 1.75$  BW; post  $4.89 \pm 1.52$  BW), time to PK1 (pre  $15.9 \pm 6.4$  ms; post  $15.6 \pm 4.7$  ms), time to PK2 (pre  $64.6 \pm 11.1$  ms; post  $67.2 \pm 12.6$  ms), load rate of PK1 (pre  $156.17 \pm 80.13$  BW/s; post  $148.00 \pm 109.20$  BW/s) and load of PK2 (pre  $93.66 \pm 49.59$  BW/s; post  $77.17 \pm 33.35$  BW/s).

**Conclusions:** Most participants were accustomed to landing in their own patterns and the temporary instruction of breathing in and holding breath did not seem to decrease landing force.

#### 077 SPORTS INJURY PREVENTION: A MULTIDISCIPLINARY APPROACH

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**Background:** The methodology for studies designed to perform sports injury prevention research carefully has received a lot of attention and has been proposed through different models. Concerning the van Mechelen model, the content of the different sequences has been well discussed; however, the methodology to fulfil step 2 in particular is lacking. The model does not mention the important role fundamental sports science research such as biomechanics may play.



**Objective:** To emphasise the role of fundamental sports science research into sports injury prevention and to fit this research area into the sequence of prevention.

**Design:** This model is designed within the sequence of prevention but also fits in the TRIPP framework. As presented in model 2, background steps are added and the model is proposed in a three-dimensional framework. Background step 2 explains the process necessary to establish the aetiology and mechanism of sports injuries, which is the development of valid and reliable measuring instruments. Background step 2 also reflects the different methodological approaches to describe the inciting event for sports injuries. A second background step has been added to clarify the effect a preventive intervention has, not only on the extent of the injury problem, but also on the risk factors associated with these injuries. The features of the investigations performed within those two background steps involve different research areas and can be defined as the multidisciplinary approach in sports injury prevention (MASIP model).

**Conclusion:** The MASIP model emphasises the multidisciplinary approach necessary to achieve effective prevention strategies in sports. It not only measures the outcome of an intervention in terms of the injury extent but also the effect on the underlying risk factors that have previously been identified. Investigators of different research areas focusing on the prevention of sports injuries can now fit their research into the sports injury prevention models.

#### 078 AN INNOVATIVE APPROACH TO CONCUSSION PREVENTION IN HELMETED SPORTS: A PILOT INVESTIGATION

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**Background:** Research has indicated that head displacement resulting from rapid change in velocity may be a factor in the development of concussion. Helmets are worn in several sports to help reduce the risk of head injury. Unfortunately, these protective devices cannot limit head displacement and the resulting changes in velocity or acceleration that occur after impact.

**Objective:** The objective of this pilot investigation was to determine if a collar-like device, used in conjunction with a helmet, could help reduce the risk of concussion by controlling head displacement, velocity and acceleration.

**Design:** A prospective, single-case experimental design (with withdrawal component) was employed to ascertain the effectiveness of the collar-like device.

**Setting:** Biomechanics laboratory.

**Participants:** A human surrogate (ie, Hybrid III, 95th percentile, crash test dummy) wearing a helmet and equipped with angular rate sensors was used to collect displacement, velocity and acceleration data.

**Interventions:** To determine the effectiveness of the test collar, a swinging pendulum impactor was used to deliver concussive-type forces. The helmeted dummy was struck several times with and without the collar in place. Impacts were delivered from both the front and side of the head.

**Main Outcome Measures:** To evaluate the effectiveness of the collar-like device three dependent variables were examined and compared: head displacement (degrees), angular velocity (degrees/s) and angular acceleration (degrees/s/s) of the head.

**Results:** Wearing a collar-like device resulted in a 40% reduction in head displacement, approximately 15% reduction in angular velocity and no change in acceleration when impacted from the front. There were no notable changes when the head was struck from the side.

**Conclusions:** To minimise concussion risk, a collar-like device must be able to minimise head acceleration after impact; therefore additional research is needed to identify appropriate design

modifications that can help improve the overall effectiveness of the device.

#### 079 EFFECTS OF A CORE STABILITY INTERVENTION PROGRAMME ON SHOULDER COUNTER-ROTATION AND TRANSVERSE ABDOMINAL MUSCLE FUNCTION IN ELITE HIGH SCHOOL FAST BOWLERS WITH LOWER BACK DISCOMFORT

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**Background:** Increased shoulder counter rotation (SCR) of greater than 20° has been associated with lower back injury in cricket fast bowlers. The effects of a core stability intervention programme on SCR and transverse abdominal (TrA) function are unknown.

**Objective:** The aim of the study was to evaluate SCR and TrA thickness and function and determine the effects of an intervention programme.

**Design:** Parallel group intervention study.

**Setting:** High school provincial level pace bowlers.

**Participants:** 15 elite pace bowlers with mild lower back discomfort were recruited and allocated to an intervention (I; n = 7) or control group (C; n = 8).

**Interventions:** I underwent an 8-week progressive pre-season core stability programme, whereas C undertook only traditional pre-season training.

**Main Outcome Measures:** SCR as determined by two-dimensional biomechanical analysis, ultrasound measurement of TrA thickness and function during abdominal hollowing. Significant injury was excluded before intervention by magnetic resonance imaging scanning.

**Results:** Pre-intervention SCR was high but no different between I and C at pre-intervention assessment ( $49 \pm 160$  versus  $39 \pm 130$ ;  $p = \text{NS}$ ). Furthermore, SCR at this assessment was significantly correlated with functional dominant TrA values ( $r = -0.61$ ;  $p < 0.05$ ) and relative non-dominant TrA muscle thickness. SCR was significantly reduced during fast bowling following I ( $49 \pm 160$  versus  $34 \pm 80$ ;  $p < 0.05$ ; pre versus post-I) compared with C ( $39 \pm 130$  versus  $44 \pm 110$ ;  $p = \text{NS}$ ; pre versus post-C).

**Conclusions:** These findings suggest that an 8-week cricket-specific progressive core stability intervention programme proved to be successful in decreasing SCR in young pace bowlers with lower back discomfort. This effect could possibly be related to functional alterations of the prime abdominal stabilising muscle, TrA.

#### 080 TECHNIQUE INFLUENCES ON CO-CONTRACTION AT THE KNEE DURING SIDESTEPPING

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**Background:** Previous work identified sidestepping techniques that produce high moments with the potential to stress the anterior cruciate ligament. Co-contraction of the hamstring and quadriceps protects the joint during sidestepping.

**Objective:** The aim of the study was to identify if, after training, techniques known to increase knee loads during sidestepping would produce a concomitant increase in co-contraction.

**Design:** Cross-sectional study.

**Setting:** Testing took place in a university laboratory.

**Participants:** Fifteen male team sport athletes (aged 21 years; height 1.83 m; mass 73 kg) volunteered to take part in this study. No participants had any history of major lower-limb injury.

**Assessment of Risk Factors:** Subjects performed a normal sidestep and this was compared with three side-step techniques known to increase knee loads (foot wide, torso leaning away and torso rotating away). Electromyography was collected from vastus medialis, vastus lateralis, rectus femoris, biceps femoris, medial hamstrings, medial and lateral gastrocnemius and tensor fascia latae. Total activation (TA) and co-contraction ratio (CCR) were calculated for hamstring: quadriceps and medial group: lateral group. CCR were expressed as 0 perfect co-contraction, 1 quadriceps or medial dominant, -1 hamstring or lateral dominant.

**Main Outcome Measures:** Average TA and CCR were calculated for pre-contact (PC) before heel strike and weight acceptance (WA). Four-way repeated measures ANOVA were performed.

**Results:** Based on data analyzed to date there were no significant differences between techniques in TA or CCR during either phase of the sidestep. CCR ranged from 0.01 to 0.30 (PC) and 0.19 to 0.58 (WA). TA ranged from 2.88 to 4.11 (PC) and 3.52 to 4.59 (WA). Imposed techniques producing higher loads than a normal sidestep had no increase in co-contraction, adding weight to the argument that poor technique can increase the risk of injury. As subjects had limited practice time they may not have developed appropriate activation patterns for the imposed sidesteps.

#### 081 SMITH MACHINE JUMP SQUATS VERSUS FREE WEIGHT JUMP SQUATS: WHICH IS SAFER?

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**Background:** Lower body power assessment typically requires athletes to perform jumping tasks; overloading athletes with jump squats is often performed in a Smith machine with the thought being that this is safer than free weight jump squats. However, no literature suggests that this is the case. In fact, by asking athletes to perform a Smith machine jump squat we may be increasing their injury risk by asking them to perform what is an uncommon activity.

**Objective:** To determine differences or similarities between Smith machine jump squats and free weight jump squats.

**Design:** Participants presented for one testing session. After a warm-up they performed one set of five repeats of a volleyball block jump and two sets of Smith machine and free weight jump squats; performing load conditions of 35% (low) and 70% (high) of 1 RM squat.

**Setting:** A national sports institute biomechanics laboratory.

**Participants:** Six national-level volleyball players.

**Assessment of Risk Factors:** Standard outputs from the Vicon lower body plug-in gait marker set were assessed. The standard block jump was used as the standard against which to compare the two jump conditions.

**Main Outcome Measures:** Peak ankle, knee and hip joint angles and powers were of primary interest in this initial analysis of the results.

**Results:** All joint powers were significantly different between the block jump and Smith machine. Whereas for the free weight jumps only the high condition was different from the block jump for the left ankle and knee and both hips, the hip peak angle was different for both jumps in the high condition.

**Conclusions:** From these preliminary results it appears that the free weight jump squats are most similar to the standard volleyball block jump. From an injury perspective we would be better to ask athletes to perform more commonly practised skills than those that are dissimilar to their normal practice.

#### 082 EFFECTIVENESS OF EMERGENCY RESPONSE PLANNING FOR SUDDEN CARDIAC ARREST IN UNITED STATES HIGH SCHOOLS WITH AUTOMATED EXTERNAL DEFIBRILLATORS

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**Background:** The presence of on-site automated external defibrillators (AED) in United States high schools is a growing trend, but little is known about the effectiveness of early defibrillation programmes to treat sudden cardiac arrest (SCA) in schools.

**Objective:** To analyze emergency response planning and the effectiveness of AED utilisation for SCA in a large cohort of US high schools with on-site AED programmes.

**Design:** A cohort of US high schools with on-site AED programmes was identified from the National Registry for AED Use in Sports. A school representative completed a comprehensive survey on emergency response planning and provided details of any AED utilisation for SCA.

**Setting:** US high schools with AED.

**Main Outcome Measures:** Survival to hospital discharge following SCA.

**Results:** 1710 high schools with an on-site AED programme were studied. 83% of schools have an emergency action plan for SCA, but only 40% practice their plan at least annually. 47/1710 (3%) schools reported a case of AED utilisation for SCA. All cases were reported between December 2006 and November 2007 and occurred within 6 months of when the survey was completed. Of the 47 SCA victims, 17 were high school athletes, five student non-athletes, and 25 non-students on campus such as spectators, teachers, staff and athletic officials. 43/47 (91%) SCA cases were witnessed. An on-site AED deployed a shock in 36/47 (77%) cases. 26/47 (55%) victims survived to hospital discharge, including 9/17 (53%) high school athletes, 4/5 (80%) student non-athletes and 13/25 (52%) non-students on campus.

**Conclusions:** High schools with on-site AED programmes demonstrated a high survival rate for both students and non-students on campus who have SCA, with survival rates comparable to public access defibrillation studies in other public settings. This is the largest study to date of emergency planning for SCA in US high schools. Schools should be encouraged to implement on-site AED programmes to treat SCA.

#### 083 DETAILS AND OUTCOMES OF RESUSCITATION FOLLOWING SUDDEN CARDIAC ARREST IN HIGH SCHOOL STUDENT ATHLETES FROM THE UNITED STATES

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**Background:** Survival following sudden cardiac arrest (SCA) in young athletes is historically very low.

**Objective:** To examine the potential survival benefit of automated external defibrillator (AED) programmes and the details of resuscitation in high school student athletes with SCA.

**Design:** A cohort of SCA cases in high school student athletes was identified from the National Registry for AED Use in Sports. A school representative involved in the resuscitation was asked to complete a comprehensive questionnaire on the details and outcomes of the event. All cases were reported between December 2006 and November 2007 and occurred within 6 months of when the survey was completed.

**Setting:** US high schools.

**Main Outcome Measures:** Time from collapse to cardiopulmonary resuscitation (CPR), time from collapse to first defibrillation and survival to hospital discharge following SCA.

**Results:** Twenty cases of SCA in a high school student athlete were analyzed (mean age 16 years, range 14–19; 18/20 cases males).

All cases of SCA were witnessed. Brief seizure-like or myoclonic activity was reported in 10/20 (50%) cases following the athlete's collapse. An AED was available on-site at the school and was utilised in 16 cases and provided by arriving emergency medical services in three cases (one case did not specify). The average time from collapse to CPR was 61 s (median 15 s, range 0–6 minutes) and the average time from collapse to first shock was 2.8 minutes (median 1.75 minutes, range 0.75–12 minutes). An AED deployed a shock in 85% (17/20) of cases. 65% (13/20) of athletes were successfully resuscitated at the scene of the arrest and 55% (11/20) survived to hospital discharge.

**Conclusions:** Early defibrillation accomplished primarily through on-site school AED programmes achieves a high survival rate in student athletes who have had SCA. This is the first study demonstrating a survival benefit from early defibrillation in young athletes. On-site AED programmes should be encouraged in high schools.

#### 084 INFLUENCE OF RUGBY ON SHOULDER INTERNAL AND EXTERNAL ROTATOR STRENGTH

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**Background:** In rugby, shoulder injuries are frequent like shoulder instability. Muscular imbalance and/or muscular deficit of shoulder internal (IR) and external (ER) rotators are potential risk factors for shoulder injury.

**Objective:** To compare IR and ER isokinetic shoulder strength between male rugby players and non-athletic subjects and to determine muscular imbalance and/or muscular deficit of the rugby player's shoulder.

**Design:** Cross-sectional controlled study.

**Setting:** Rugby players at national division level (4–7 days/week) were compared with subjects with no history of shoulder injury who had not played overhead sports with isokinetic strength evaluation.

**Participants:** 39 subjects participated in this study: 21 rugby players ( $24 \pm 4$  years;  $181 \pm 6$  cm;  $91 \pm 11$  kg) and 18 non-athletic non-injured controls ( $21 \pm 2$  years;  $180 \pm 8$  cm;  $72 \pm 5$  kg).

**Interventions:** Isokinetic shoulder IR and ER strength was evaluated with a CON-TREX dynamometer, in the seated  $45^\circ$  abducted test position in the scapular plane (Davies position). Angular velocities chosen were  $60^\circ \text{ s}^{-1}$  and  $240^\circ \text{ s}^{-1}$  in concentric mode, and  $60^\circ \text{ s}^{-1}$  in eccentric mode for both shoulders.

**Results:** In rugby players, the comparison between dominant and non-dominant side showed higher IR values for the dominant side and higher ER values for the non-dominant side. In absolute strength, the comparison between rugby players and controls showed higher values for the rugby players ( $p < 0.05$  at all angular speeds). In strength relative to body weight, the comparison between rugby players and controls showed higher ER/IR ratios of the dominant side for the rugby players and higher ER/IR ratios of the non-dominant side for the controls.

**Conclusions:** Shoulder strength was higher in the rugby player group. In this group, IR strength was higher on the dominant shoulder and ER strength was higher on the non-dominant shoulder. This study did not find any deficit of rugby player shoulder strength. These results raise questions about the influence of sports discipline on the ER/IR ratio and their role as risk factors for injury.

#### 085 ISOKINETIC ANKLE STRENGTH IN ATHLETICS

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**Background:** Lateral ankle sprain is a frequent injury in sports. In spite of a codified initial treatment, after-effects are frequent and

often incapacitate. Evertor weakness may be hypothesised as one of the causes of ankle dysfunction after injury. Indeed, ankle stability requires co-activation of the antagonists and there is a possible relationship between muscular imbalance, pain, instability and injuries.

**Objective:** To test evertor and invertor muscle weakness in lateral ankle sprains in athletes of different athletic disciplines.

**Design:** Retrospective and cross-sectional study.

**Setting:** Athletes with a regional, a national or an international level in long distance running ( $n = 18$ ), jumping ( $n = 14$ ) and sprinting ( $n = 8$ ).

**Participants:** 40 athletes, 34 men and six women, aged between 15 and 36 years, 28 with a previous history of lateral ankle sprain, were included.

**Methods:** After a medical questionnaire, all athletes were evaluated with a CON-TREX dynamometer: invertor and evertor strength in concentric at  $30^\circ \text{ s}^{-1}$  and  $120^\circ \text{ s}^{-1}$  and evertor strength in eccentric at  $30^\circ \text{ s}^{-1}$ .

**Results:** In the whole group, on the dominant foot, evertor strength was higher than invertor. In jumpers, the evertor strength was lower on the non-dominant than on the dominant foot, whereas in runners and sprinters there were no differences between the dominant and non-dominant foot. In athletes with ankles previously injured and/or with functional signs of discomfort, the evertor strength was lower in the non-dominant foot.

**Conclusions:** This study illustrates the major role of the evertors in athletics both on the foot dominance and on ankle sprains. In sports, evertor strength increases mainly in the dominant foot.

#### 086 FUNCTIONAL MOVEMENT TRENDS AS INDICATORS FOR INJURY PREVENTION

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**Background:** Florida Southern College's (FSC) softball team has finished ranking nationally but has not yet won the national championship. Movement trends were identified as a potential source in identifying performance barriers and injury mitigators.

**Objective:** The purpose of this research study was to establish a physical profile of players on the team in order to develop injury prevention and performance enhancement programmes.

**Design:** This study was a prospective mixed-methods design combining qualitative survey data with empirical data from several postural and movement analyses, vertical jump and BMI. The study sample comprised six randomly selected individuals using [www.randomizer.org](http://www.randomizer.org).

**Setting:** An NCAA division II softball team was studied.

**Participants:** Six team members were randomly selected with all completing the study.

**Assessment:** Data were collected from a survey as well as from postural analysis and video motion analysis of standardised gait and movement patterns (independent variables). Players were instructed before being video-recorded with AllSportsTec.com video capturing system/motion analysis software. Three observers recorded findings to ensure trustworthiness in data collection.

**Main Outcome Measures:** Assessing the ability to perform at an elite level was formulated before data collection, with functional movement trends and injury mitigators being the dependent variables.

**Results:** Half of the players' BMI results indicate overweight/obesity, whereas all of the vertical jump scores were below those of the average college female athlete. Analysis revealed excessive lordosis, weak abdominals, genu valgus and pes planus. Loss of balance and poor technique due to strength deficits emerged during movement patterns. Results were consistent among most of the players.



**Conclusions:** BMI and vertical jump findings evidence poor levels of fitness, whereas the movement patterns revealed functional deficits. In light of their softball experience, it appears the players do not possess appropriate functional strength. Programmes could be developed to improve the functional movement deficits thus preventing potential injuries.

#### 087 ECCENTRIC EXERCISES FOR THE PREVENTION OF PATELLAR TENDINOPATHY IN SOCCER PLAYERS

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**Background:** There is a growing number of lesions caused by sport exercises. For researchers the most immediate and worrying aspect here is the treatment and prevention of these lesions. The aim of this research is to evaluate the effectiveness that a set of eccentric training exercises can have on patellar tendons with the purpose of increasing their physiological properties and acting on a causal risk factor.

**Methods:** The sample was two third division football teams, which had carried out some inclusion and exclusion criteria. A quasi-experimental design was used with a pre-test and post-test evaluation and a control group, in which the area, circumference, width and thickness of the patellar tendon was measured to 5, 10 and 15 mm from the kneecap. The information was assessed by means of a scan and was analyzed using the statistical programme SPSSv.13.0 for Windows.

**Results:** A sample was obtained of 20 footballers (40 tendons) who had passed the exclusion criteria (22 years ( $\pm 2$ ), 178 cm ( $\pm 5$ ), 74 kg ( $\pm 7$ )). Significant differences were only found to within 10 mm of the kneecap;  $p = 0.013$  for area,  $p = 0.0018$  for circumference and  $p = 0.17$  for width, with a decrease in each variable in the control group. Relating to thickness, significant differences ( $p = 0.0029$ ) were found in the experimental group as a result of an increase in thickness between initial and final measurements.

**Conclusion:** The eccentric training exercises have achieved positive results in the experimental group's tendons maintaining and increasing their physiological aptitudes and preventing their degeneration.

#### 088 BICYCLE ADJUSTMENT: RISK FACTORS INJURIES IN CYCLING

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**Background:** In cycling there are risk factor injuries specifically derived from the use of the bicycle, which requires an appropriate adjustment to the cyclist. Indeed, an inappropriate adjustment can turn into overuse injuries.

**Objective:** To know whether cyclists carry out the adjustment of the mobile elements of the bicycle correctly and to know if an incorrect adjustment is related to the appearance of specific pathologies.

**Design:** This is an observational, transverse and analytical study of a randomised sample carried out by a previously validated survey to determine the appearance of specific risk factors.

**Setting and Participants:** From a population of 750 male cyclists officially registered with the Cycling Federation of Murcia (Spain), a sample of 267 was established.

**Selection Criteria:** Randomly selected male cyclists owning a registered licence who want to participate in the study and belong to one of the UCI established categories.

**Assessment of Risk Factors:** We used a questionnaire containing 98 items and based on risk factor injuries and on the injuries experienced throughout the season. We selected those making reference to the moveable basic adjustment of the bicycle: saddle and handlebars.

**Results:** Saddle height adjustment: 75% used incorrect methods, 21.7% used a mathematical formula. Saddle fore/aft position: 69% used incorrect methods and 27.3% used the plumb-line test. Handlebars width: 33.7% adapted it to the width of the shoulders, whereas 38.6% used inappropriate methods. Distance handlebar stem-peak of the saddle: 84% adjusted it incorrectly and the same occurred with the adjustment of the handlebar height, badly performed by 84.3%. There is also a positive relationship between an incorrect adjustment of the saddle height and back and knee pain and between an incorrect adjustment of the handlebar height and cervical and dorsal pain. Likewise, back pain seems to be related to the distance handlebar stem-peak of the saddle. An incorrect adjustment of the saddle fore/aft position may be related to ulnar and median neuropathies.

**Conclusions:** These data let us conclude that the cyclists did not carry out the adjustments of the bicycle correctly, which seemed to result in different ailments.

#### 089 WHEN IS WEARING A HELMET BAD FOR YOUR HEALTH? HURLING INJURIES AND RISK COMPENSATION

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**Background:** The use of protective equipment is fundamental to injury prevention. Risk compensation describes a potentially counterproductive effect of this equipment. Hurling is a high-speed, high-contact field sport played in Ireland. A number of authors have documented a sharp decline in head injury in this sport since the advent of head and facial protection. This has been matched by a rise in hand injury.

**Objective:** To prove the hypothesis: increased helmet usage is a causative factor in hand injury when playing hurling.

**Design:** A retrospective telephone questionnaire.

**Setting:** A university hospital emergency department.

**Participants:** 199 adult hurling players, who had had a confirmed hurling-related injury. The study group ( $n = 100$ ) who had had an upper-limb injury and a control group ( $n = 63$ ) who were injured elsewhere.

**Main Outcome Measures:** Information gathered included site of injury, mechanism of injury, protective equipment in use at the time of injury, previous injury and previous use of protective equipment.

**Results:** Helmet usage in the study group was 82%, in the control group 64% ( $p = 0.008$ ). On univariate analysis the odds ratio (OR) for upper-limb injury between the two groups when wearing a helmet was 2.69 (95% CI 1.27 to 5.4;  $p = 0.009$ ). On multivariate analysis, this relationship persisted OR 3.15 (95% CI 1.51 to 6.56;  $p = 0.002$ ) and was independent of other potential causal factors (age, level of competition, mechanism of injury, foul play).

**Conclusions:** Wearing a helmet while playing hurling is an independent risk factor for hand injury. The benefits of head and facial protection while playing hurling are documented, they may, however, indirectly increase the risk of hand injury. Behaviour modification due to perceived increased safety should be considered when designing and recommending safety equipment.

#### 090 PRESSURE-PLATE EVALUATION OF WALKING GAIT OVERESTIMATES BIOMECHANICAL ABNORMALITIES OF THE FOOT

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**Background:** Lower-limb injury is common among athletes and its causation is multifactorial. Pressure-plate evaluation of gait has

been used to investigate the causative role of abnormal biomechanics. Although pressure-plate analysis while walking or running has been studied, a comparison of the two movements has not been made.

**Objective:** To disprove the null hypothesis: there is no difference in gait assessment between running and walking gait assessment.

**Design:** A prospective clinical cohort study. Activity patterns were assured and those who were injured were precluded from participation. Power calculations were performed to determine the sample size with  $\alpha = 0.05$  with 80% power. Barefoot plantar pressure data were collected at both walking and running gait, over a 1 m Footscan pressure plate five times with each foot. Statistical analysis was performed using the SPSS statistical package version 13.0.

**Setting:** An Australian university sporting population.

**Participants:** 60 university students were recruited with human ethics approval and informed consent obtained.

**Main Outcome Measures:** The captured data were analyzed using the Footscan system 7.2 software. This identifies four potential areas of correction on each foot (forefoot, midfoot, lateral and rearfoot), from analysis of the plantar pressure data. We compared orthotic prescription in walking versus running.

**Results:** An orthotic prescription was generated in 64.7% of feet when walking and 35.2% when running. A midfoot antipronation wedge was prescribed for excessive medial mobility of the midtarsal joint when walking in 42% and when running in 4% of cases.  $\chi^2$  analysis confirmed significance ( $p < 0.01$ ).

**Conclusions:** Analysis of plantar pressures running versus walking gait reduced the orthotic prescription rate by half. When using D3D software orthotic, prescription should be made from a dynamic assessment.

## 091 A FASCIAL ORIGIN FOR UNDIAGNOSED POSTERIOR THIGH PAIN

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**Background:** Posterior thigh pain is common and significant in terms of morbidity and time lost from sport. The majority of acute posterior thigh injuries involve the hamstring muscle group. A review of the literature shows that 15–20% of acute presentations of posterior thigh pain are imaging negative for hamstring muscle trauma. This non-muscle-related pathology is generally regarded as being neuromeningeal in origin. Damaged fascia is subject to inflammation and fibrosis. Innervation of fascia has been demonstrated, making it a plausible pain-generating structure in this area.

**Objective:** To investigate the clinical anatomy of the posterior thigh, to challenge the view that non-muscle-related posterior thigh pain is predominantly neuromeningeal in origin, proposing alternative pain-generating structures.

**Design:** The configuration, fibre alignment, bony anchors and related structures of the deep fascia of the thigh were examined on the posterior thigh of 20 adult, formalin-fixed cadavers. Neural structures of significance in the area were identified and their relations noted.

**Setting:** Department of Anatomy, University of Melbourne.

**Main Outcome Measures:** Gross anatomical and microscopic studies were conducted on areas examined.

**Results:** The fascia of the posterior thigh is morphologically dissimilar to that seen elsewhere in the proximal lower limb. The homogenous, smooth texture of fascia seen elsewhere is replaced with a more friable structure, which is firmly tethered to the skin, especially at the buttock crease. Histological specimens show that “digitations” link the fascia to skin through subcutaneous fat. The proximity of the posterior femoral cutaneous nerve and its

perforating branches to the overlying fascia expose it to injury when haemorrhage or inflammation occurs.

**Conclusions:** Damage to, inflammation of, or traction on the posterior fascia of the thigh may generate pain in itself, or irritate the posterior femoral cutaneous nerve or its branches. This is a proposed alternative aetiology of posterior thigh pain when muscular trauma has been excluded.

## 092 SPORTS AND RECREATION INJURY, FROM THE PLAYING FIELD TO THE HOME: OUT OF THE FRYING PAN AND INTO THE FIRE

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**Background:** The beneficial effects of sporting activities and active recreation are numerous; potential complications, such as injury, may detract from these favourable effects. These complications need to be adequately understood if they are to be minimised.

**Objective:** To quantify the toll of sports and recreation-related injury (SRI) on Irish emergency department attendees.

**Design:** Prospective cohort study.

**Setting:** A large regional emergency department in Ireland.

**Participants:** All patients over 4 years of age attending, during a 6-month period.

**Main Outcome Measures:** The nature and circumstances of SRI, including subsequent investigation and management.

**Results:** Over the 6 months, SRI caused 3172/22 465 of emergency department attendances. Fracture rate was highest in the 4–9-year-old age group (44%), steadily reducing to 20% in those aged 52–63 years. On multivariate logistic regression the adjusted odds ratio (OR) of fracture was higher for children (versus adults) at 1.21 (95% CI 1.0 to 1.45) and showed no gender difference (females versus males) 0.99 (0.8 to 1.2). The adjusted OR was higher for upper-limb 5.8 (4.5 to .6) and lower-limb injuries 1.87 (1.4 to 2.5) versus axial injury and for fall 2.2 (1.6 to 2.9) and external force 1.59 (1.2 to 2.1) versus an overextension mechanism of injury. In the same model, “play” was independently associated with fracture risk, adjusted OR 1.98 (1.2 to 3.0;  $p = 0.001$ ) versus low-risk ball sports 1.0 (reference); an effect size similar to that seen for combat sports 1.96 (1.2 to 3.3;  $p = 0.01$ ) and greater than for presumed high-risk field sports 1.4 (0.9 to 2.0).

**Conclusions:** Fall and subsequent upper-limb injury was the commonest mechanism underlying SRI fracture. Increased supervision, especially for several specific “play” activities such as home play with a trampoline or a “bouncy castle” and measures to prevent and reduce the severity of falls may attenuate the occurrence of potentially disabling SRI.

## 093 INJURIES IN THE FIRST GERMAN FOOTBALL LEAGUE

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**Background:** Epidemiological studies on football injuries are the basis for the implementation of prevention programmes. Recently, considerable regional variability in injury incidence was reported. No injury statistics from German male football are available so far.

**Objective:** To analyze injuries in the first German football league by means of media information.

**Design:** Prospective epidemiological study.

**Setting:** Season 2004/5 (including preparation).

**Participants:** 471 male players participating in at least one regular match.

**Data Assessment:** All available information on time-loss injuries (localisation, diagnosis, duration of absence) and on exposure time

in regular matches were collected from print and online media ("Kicker Sportmagazin") regularly reporting about injuries of first league players.

**Results:** 392 players had 1187 injuries. 37% of injuries occurred during regular matches, leading to an incidence of 37 injuries per 1000 playing hours. 76% of all injuries occurred at the lower extremities, with thigh ( $N = 222$ ), knee ( $N = 197$ ) and ankle ( $N = 166$ ) being the most frequent locations. 12% of all injuries ( $N = 144$ ) led to a duration of absence of more than 28 days, resulting in an average of two players of each team missing the complete season due to severe injuries. 45% of these injuries occurred at the knee. The most frequent diagnoses were contusions (16%), strains (14%) and sprains (13%). Goalkeepers (1.9 injuries per player) had fewer injuries ( $p = 0.006$ ) than field players (defenders 2.6; midfielders 2.5; strikers 2.7). Injury frequency was increased at the end of the first and second leg. No significant correlation was observed between injury frequency and team success.

**Conclusions:** Injury incidence in the German national league during the season 2004/5 was in the upper range of values reported by previous prospective studies in other countries. A limitation of this approach is that media-based injury statistics seem almost complete but an exact diagnosis was not possible in all incidents.

#### 094 HAMSTRING STRETCHING USING A WHOLE-BODY VIBRATION PLATFORM

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**Background:** Only two whole-body vibration-related studies have looked at measures of hamstring flexibility; however, neither study has used the platform as the stretching modality.

**Objective:** To compare 4 weeks of hamstring stretching (static versus static on a whole-body vibration platform) and to compare residual effect.

**Design:** Randomised, single-blind, repeated measures.

**Setting:** University.

**Participants:** 34 active college-aged students (15 female, 19 male) ( $22.7 \pm 1.7$  years, range 21–27) completed the study (five did not finish). Participants were required to have "tight" hamstrings, defined as less than  $70^\circ$  on a straight-leg-raise test.

**Intervention:** Subjects were randomly assigned into one of three groups (control, static stretch only, or static stretch on a whole-body vibration platform). All subjects stretched five times per week for 4 weeks for five repeats for 30 s each leg. Following the stretching intervention subjects returned once a week for 3 weeks for follow-up flexibility measurements to monitor retention. All flexibility measurements were made by a researcher who was blinded to group assignment. Both legs were measured before the start of stretching (baseline), after 4 weeks of stretching and for 3 weeks after intervention.

**Outcome Measurements:** Flexibility of the hamstrings using the passive knee extension method, as measured in degrees.

**Results:** A significant difference existed over in group\*time for the right leg ( $p < 0.0001$ ,  $F(8,124) = 12.591$ ) and left leg ( $p < 0.0001$ ,  $F(8,124) = 9.993$ ). Post-hoc analysis ( $p < 0.05$ ) revealed both interventions had significantly greater flexibility than control after 4 weeks of stretching and at 1 week post. Static stretch only returned to baseline after the second week post-intervention but whole-body vibration did not return even after 3 weeks (still significantly different from control).

**Conclusions:** Static stretching of the hamstrings while undergoing whole-body vibration (26 Hz at 4 mm) improves hamstring flexibility better than static stretching alone. Flexibility gains are also retained for a longer period of time than static stretching alone.

#### 095 REGISTERING INJURIES AMONG WORLD CUP SKIERS AND SNOWBOARDERS: A METHODOLOGICAL STUDY

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**Background:** The International Ski Federation (FIS), in cooperation with the Oslo Sports Trauma Research Centre, has established an injury recording system, the FIS Injury Surveillance System, to monitor injuries to World Cup athletes in skiing and snowboarding.

**Objective:** The purpose of the current study was to compare three different methods for recording injuries in this setting.

**Design/Setting:** Injury information regarding injuries sustained by World Cup athletes in alpine, freestyle, snowboard, ski jumping, Nordic combined and cross-country skiing during the 2006–7 winter season were recorded through three separate and independent recording systems; prospective recording by technical delegates from FIS, prospective recording by the medical staff of six World Cup teams and retrospective interviews with athletes (or in their absence, coaches/physical therapists/physicians) from the same six nations. The injury definition was "all injuries that occurred during official training or competition and required attention by medical personnel". Injuries occurring to athletes from the selected nations in World Cup/World Championship events have been used to compare the different recording methods.

**Results:** A total of 100 unique injuries to 623 World Cup athletes were identified from World Cup/World Championships events during the 2006–7 winter season from any of the three recording methods. Of these, 91% were registered through the interviews, 47% by the medical staff and 27 % by the technical delegates. Only 20 injuries (20%) were captured by all three methods. A total of 64 time-loss injuries (leading to absence from training/competition for at least one day) were registered. The interviews captured 60 (94%) of these, the team medical staff 39 (61%) and the technical delegates reported 23 (36%) time-loss injuries, whereas 18 (28%) were registered by all three systems.

**Conclusion:** Retrospective interviews with athletes/coaches regarding injuries during the past 6 months give the most complete picture of injuries to World Cup athletes in skiing and snowboarding.

**Funding:** The FIS Injury Surveillance System has been established through a generous grant from DJO.

#### 096 HIGH-SPEED VIDEO ANALYSIS OF AN ACCIDENTAL SUPINATION ANKLE SPRAIN: A CASE REPORT

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**Background:** Ankle sprain injury is the most common single type of sports injury; however, its mechanism was only presented qualitatively but not quantitatively in the literature.

**Objective:** This study quantitatively presents an accidental supination ankle sprain injury case.

**Design:** Case report.

**Setting:** A biomechanics laboratory setting.

**Participant:** One male athlete (aged 23 years, height 1.75 m, body mass 62.6 kg).

**Case Report:** The participant performed a series of cutting motions. In each trial, the subject ran forward for 6 m at his maximum speed, stepped with his right foot and changed his moving direction to the left in the shortest time he could. In the fourth trial, the participant accidentally sprained his ankle with a supination mechanism. The injury was immediately diagnosed as a grade one anterior talofibular ligamentous sprain by an orthopaedic biomechanist. The motion was captured by three high-speed cameras at 100 Hz. The major anatomical positions at the lower limb were manually digitised with a motion analysis system. Ankle



kinematics was calculated with a standard biomechanics method. A standing trial served as the offset position. The same procedure was performed for the three successful normal trials before the injury trial for comparison. Ankle angles and angular velocities were presented in the three orthogonal anatomical planes.

**Results:** For the injury trial, the ankle was internally rotated for 20° and inverted for 17° at landing. After landing, the ankle plantarflexed, lifted and laterally swung the rearfoot and shifted the foot contact to the forefoot region. This introduced a sudden explosive kinematic change in 0.04 s, which reached a maximum inversion of 103°. The peak inversion velocity was 2267°/s, which was approximately six times that in normal trials.

**Conclusion:** This study quantitatively reported the ankle kinematics during an accidental supination ankle sprain injury case.

#### 097 CAN THE RSSCAN FOOTSCAN D3D ORTHOTIC REDUCE THE INCIDENCE OF LOWER-LIMB INJURIES IN INITIAL MILITARY TRAINING?

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**Background:** Lower-limb injuries are common in initial military training. Causation of injury is recognised as multifactorial but abnormal biomechanics are contributory. Previous work has demonstrated that the Footscan system and D3D software can predict a risk of lower-limb injury. No studies have assessed whether an in-shoe orthotic can have an effect on injury reduction.

**Objective:** This study is designed to assess the injury risk reduction of the D3D in-shoe orthotic.

**Design:** A prospective, non-blinded, randomised controlled trial. Subjects walked over a 1 m Footscan pressure plate five times at a natural cadence. Power calculations gave  $n = 400$  for a power of 0.80 with  $\alpha = 0.05$ . Plantar pressure data were recorded and the subjects allocated to one of two risk groups. Subjects in the at-risk group were randomly assigned to receive an orthotic insole prescribed using the D3D system or no orthoses. The low-risk group had no intervention. Injury rates were followed prospectively for 14 weeks.

**Setting:** Military initial training establishment.

**Participants:** 400 male subjects (17–34 years) were recruited and gave informed consent with ethical approval from the MOD Research Ethics Committee.

**Interventions:** The D3D orthotic is a bespoke computer designed EVA insole, prescribed and worn throughout the new entry course.

**Outcome Measures:** Lower-limb injuries considered attributable were defined by withdrawal from training for more than 2 days.

**Results:** Injuries were compared in both groups and in the background group. Injury rates in the D3D group were 19% and in the non-D3D group 62%, the control group rate of injury was similar to the background rate from previous work of 21%. This gave an adjusted relative risk of 0.43 and a number needed to treat of 2.32 (Fisher's test  $p < 0.01$ ).

**Conclusions:** The D3D orthotic can reduce injury risk in initial military training. This has significant implications for wider injury prevention in sport and recreational activity.

#### 098 CHANGES IN TIBIAL ROTATION DURING LOCOMOTION: EFFECTS OF SHOE TYPE

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**Background:** Tibial rotation that accompanies foot pronation has been proposed as a key factor of running-related injuries such as patellofemoral pain syndrome, shin splints and stress fractures.

Precise analysis of locomotion is difficult and the effect of shoe type on tibial rotation during locomotion is unknown.

**Objective:** To determine the effect of shoe type on reducing tibial rotation during locomotion.

**Design:** Experimental comparative study under three conditions: barefoot, shoe A (Adidas adiStar Control) and shoe B (Adidas Response Cushion).

**Setting:** 24 markers were secured on the left limb of each subject. Three-dimensional kinematic data were collected using motion analysis. The data were processed using the point cluster technique.

**Participants:** Ten healthy subjects (seven men, three women) participated in this study.

**Interventions:** Subjects were required to walk and run while barefoot and wearing two types of athletic running shoes. The greatest difference between the shoes was the design of the heel structure; shoe A allows the rearfoot to move freely, whereas shoe B provides a secure heel fit.

**Main Outcome Measurement:** The 6 degrees of freedom motion of the tibia with respect to the femur was calculated in the stance phase. The internal/external rotation of the tibia was analyzed after foot strike.

**Results:** In all three conditions, all subjects experienced internal rotation of the tibia after foot strike. Both shoes reduced the amount of tibial rotation during running; however, shoe B had a greater effect than shoe A (barefoot  $13.5 \pm 6.2^\circ$ , shoe A  $11.1 \pm 4.7^\circ$ , shoe B  $9.7 \pm 5.0^\circ$ ). While barefoot, internal tibia rotation after foot strike had a bimodal waveform pattern. The pattern of tibial rotation changed to unimodal with shoes, especially with shoe A.

**Conclusions:** Tibial rotation that accompanies foot pronation can be reduced by wearing the appropriate type of shoe.

#### 099 EPIDEMIOLOGY OF ACUTE HEAD INJURIES IN YOUTH SOCCER

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**Background:** Limited studies have been done to assess head injury characteristics for youth soccer players in Canada.

**Objectives:** To investigate head injury characteristics of youth soccer players and the relationship between demographic and injury characteristics with severe injury.

**Design:** Descriptive epidemiological study, using the Canadian Hospitals Injury Reporting and Prevention Programme.

**Setting:** Competitive and non-competitive Canadian youth soccer players.

**Patients (or Participants):** 32 149 patients with soccer-related injuries, aged 5–19 years, presenting to emergency departments of participating hospitals from 1994 to 2004.

**Interventions (or Assessment of Risk Factors):** Demographic and injury-related variables included age, sex, nature of injury, body regions injured, type of soccer and mechanical factors.

**Main Outcome Measures:** If patients required hospital admission.

**Results:** Head injuries constituted 14.7% of all emergency department visits. Across all age groups males constituted a higher proportion of head injuries, the highest in the 5–9 year age group (23%). The proportion of patients with head injuries who required hospital admission was 3.5%. Compared with patients with head sprains/strains, the odds of hospital admission was highest for patients with concussions followed by those with fractures (odds ratio (OR) 4.8, 95% CI 2.2 to 10.7 and OR 4.7, 95% CI 2.0 to 11.0, respectively). Logistic regression analysis revealed that significant correlates of head injuries associated with hospital admission were: being male (OR 1.5, 95% CI 1.0 to 2.3), aged 15–19 years (OR 2.2, 95% CI 1.4 to 3.6) compared with the reference age of 5–9 years and playing unorganised soccer (OR 1.6, 95% CI 1.1 to 2.3). Furthermore, injuries due to contact with structures, surfaces or objects were significantly at higher odds for hospital admission

when compared with injuries due to contact with balls (OR 2.1, 95% CI 1.2 to 3.7).

**Conclusions:** Head injuries constituted a significant proportion of soccer-related injuries presenting to emergency departments. Injuries requiring hospital admission due to contact with structures, surfaces or objects on/or around the field of play should be reconsidered for injury prevention efforts.

## 100 STRESS FRACTURE OF THE FIFTH METATARSAL BONE IN ATHLETES

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**Background:** Stress fractures of the fifth metatarsal bone is common in athletes. Non-operative treatment has a high incidence of delayed healing and refracture.

**Objective:** Internal fixation with a solid AO cancellous screw leads to healing and rapid return to athletic activity.

**Design:** Retrospective study of patients treated from 1995 to 2006 at Volvat Medical Centre.

**Patients:** The group consists of 37 patients with 40 metatarsal stress fractures (two female and 35 male athletes). 36 patients with 39 fractures were available for an interview. 29 were soccer players, four team handball players, one basket player and two long distance runners. The average age was 23.7 years (17–32) and average follow-up time was 64.7 months (10.1–146.2). 33 of the 39 fractures were previously treated conservatively (84.6%).

**Interventions:** All patients were treated with a solid 4.5 mm AO cancellous screw.

**Results:** To this date there has been no recurrence of fractures. Treatment was rated successful if the patient was able to return to the previous level of activity. The time from operation until the patient returned to full activity varied from 1.4 to 5.3 months, median 2.0 months. Three patients did not return to their previous level of activity. All fractures were radiologically healed. There were no infections. Only one of the 33 cases with the screw in situ has pain, limiting some of the patient activity. 10 patients have experienced tenderness of the area when kicked or stepped on. 38 out of 39 operations resulted in patient satisfaction and they would have gone through the treatment again.

**Conclusions:** Patients with incomplete osteosynthesis due to conservative treatment of stress fracture of the fifth metatarsal bone in athletes achieve satisfying results using operative intramedullary AO cancellous screw fixation. This treatment is associated with few complications, early return to full sports activity and a low rate of refractures.

## 101 WEIGHTLIFTER'S KNEE: A DIFFERENT PATHOLOGY, A DIFFERENT PREVENTION PROGRAMME?

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**Background:** The Spanish weightlifters' medical follow-up found up a high prevalence of quadriceps pathology, defined as tendinosis. The question is whether this should be the focus of prevention in the same way as patellar tendinosis.

**Objective:** To determine the prevalence of overload pathology in the quadriceps tendon in the Spanish weightlifting national team by means of ultrasound and its treatment.

**Materials and Methods:** 12 elite weightlifters from the national team were included in the study. Their clinical records were collected and an ultrasound study was performed in longitudinal and transversal planes with a Philips 3500 HDI system in supine and with the knee flexed in 120°. Tendon echographic morphology and patella superior enthesis structure were checked and anteroposterior diameter in both planes was measured.

**Results:** The age was 18.1 years (19.4 for men and 16.2 for women) and weight was 65.9 kg (67.9 for men and 63.1 for women). The average career on the national team was 5.1 years, with five out of 12 in their second year and the remainder with more than 4 years in the team. Nine weightlifters had clinical symptoms (75%). Ultrasound showed moderate bilateral tendon degeneration in two male weightlifters (16%) and mild degeneration in five (42%). Hypoechoic intratendinous areas with linear hyperechoic deposits inside were found. In other cases, hyperechoic images and irregularity at the patella superior rim were detected. The power Doppler application did not show significant neovascular formation.

**Conclusions:** Quadriceps tendinosis in weightlifters is different from the classic jumper's knee, hence the former should be termed "weightlifter's knee". The biomechanical demands are completely different with extension knee movements from maximally flexed positions and with very high axial loads. This means that an eccentric prevention programme ought to be designed in a different way.

## 102 DEVELOPMENT AND PRELIMINARY VALIDATION OF THE TEAMMATE SUPPORT FOR INJURY SCALE

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**Background:** A serious injury is a major life event that can leave many athletes feeling highly distressed because it threatens a valued identity and associated goals. The psychological and physical recovery of injured athletes may be hastened by two types of support that are best provided by teammates, namely identity and motivational support. Moreover, a voluminous literature reveals that appropriate and well-timed support can serve a preventive function by buffering stress and promoting desirable health behaviours.

**Objective:** The current study aims to develop a psychometrically acceptable multidimensional measure of teammate support for injury that can be used as a screening tool to assess the availability and provision of different types of support following injury, as a research tool in studies examining stress moderators among athletes and as an outcome measure in interventions to improve support for athletes.

**Design:** Cross-sectional surveys and qualitative interviews.

**Setting:** Participants were recruited and interviewed at four community sports injury clinics.

**Participants:** The 26-item teammate support for injury scale (TSFI) was administered to a sample of 112 young male and female competitive athletes (mean age 21 years), including 49 varsity players, who had been sidelined by an injury for at least a week.

**Main Variable:** The TSFI taps injured athletes' perceptions of the frequency of their receipt of emotional, tangible, informational, motivational and identity forms of support in the past month from the teammate or training partner with whom they have the closest relationship, using five to six items that are rated on a 7-point scale for each type of support.

**Results:** A factor analysis with oblique rotation of the 26 items did not confirm the hypothesised five-dimensional structure, yielding a simple structure with three interpretable factors corresponding to identity, emotional and practical support that accounted for 59.2% of the variance in the data and with acceptable alphas of 0.82, 0.89 and 0.86, respectively. Mean levels of support were 4.76 for identity support, 4.73 for emotional support and 4.18 for practical, rehabilitation support. Preliminary validation of the TSFI did not support its hypothesised relationships with validated measures of perceived availability of support, mood and athletic identity.

**Conclusion:** Further validation work and psychometric testing of the TSFI are needed.

# 103 THE EFFECT OF THE F-MARC 11 INTERVENTION PROGRAMME ON ANTERIOR CRUCIATE LIGAMENT INJURY PREVENTION IN FEMALE RUGBY PLAYERS

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**Background:** Female athletes experience a higher incidence of anterior cruciate ligament (ACL) injuries than their male counterparts. Reasons for this are explained by various factors that contribute to the risk of ACL injury. The main factor found through evidence in research is gender differences. Injury prevention has become a new tool in the female sporting field and there are many studies ongoing to see whether intervention programmes can in fact reduce the risk of injury and lower incidence levels.

**Purpose:** The aim of this study is to determine whether the F-MARC 11 intervention programme can be used as an injury prevention tool and decrease valgus angles in female rugby players over a period of time, which will in turn reduce the risk of ACL injury.

**Method:** The female rugby union participants from the University of Hull will be randomly assigned to two groups: experimental or control. Both groups will attend three testing sessions over the course of 4 weeks to record valgus and flexion angles and the difference, if any, shown over time. The experimental group will partake in an intervention programme called the F-MARC 11 in which 10 exercises will be carried out three times a week for a month. The results will be analyzed using two three-dimensional programmes in order for the valgus and flexion change in time to be seen. Three specific moments in time will be analyzed in order for comparisons to be made between the experimental and control groups.

**Results:** With regard to the valgus angle values shown in the drop jump test over time and the valgus angle for the three moments in time found in the pre, mid and post-testing sessions, no significance was found. In relation to the flexion angle that was not the primary focus of this study, it showed a correlation between the groups with an increase in flexion for the experimental group over time. There was significance in initial landing for flexion over time ( $p=0.024$ ) but with regard to the other moments in time, no significance could be found.

**Conclusion:** Although most results were not significant, decreases in valgus angle and increases in flexion angles could be seen within the results, but due to a small sample size these results cannot be conclusive. The F-MARC 11 programme seemed to have no significant effect on the experimental group, which in turn leads to the conclusion that this intervention programme does not prevent ACL injury among women and may not reduce the incidence of ACL injury within the female population. Several factors may have hindered the validity of the results, but it can be seen that there is potential to rectify these factors and hopefully show that the F-MARC 11 programme can be used as a successful injury prevention tool in the future.

# 104 THE TIBIAL PLATEAU GEOMETRY: IMPACT ON BIOMECHANICS OF THE TIBIOFEMORAL JOINT AND ANTERIOR CRUCIATE LIGAMENT INJURY

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**Background:** The geometry of the tibial plateau is complex and asymmetric. Previous research has characterised subject-to-subject differences in tibial plateau geometry in the sagittal plane with a single parameter, the posterior slope, whereas the actual medial tibial slope (MTS) and the lateral tibia slope (LTS) of the plateau may be different. The lateral-to-medial directed coronal tibial slope

(CTS) of the plateau has not been studied. We hypothesise that when considering the tibial plateau, the MTS is different to the LTS in each subject and there exist sex-based differences in the slopes of the tibial plateau in the sagittal and coronal planes.

**Design:** In a blinded study, the MTS, LTS and CTS of the tibial plateau were measured using sagittal and coronal magnetic resonance images obtained from the knees of 33 female and 22 male subjects. Student's t-tests were performed to assess the significance of any differences in MTS, LTS and CTS between sexes. Paired t-tests were performed to assess the significance of any differences between MTS and LTS within each subject. MTS and LTS were compared between sexes using a t-test.

**Results:** The MTS and LTS were different in each subject. In addition, the MTS and LTS of the female subjects were significantly greater than those of the male subjects ( $p<0.05$ ). In contrast, the CTS of female subjects were significantly less than those of the male subjects ( $p<0.05$ ).

**Conclusions:** The higher tibial slope values in women suggest that, at low flexion angles, the anterior shear component of the joint contact force will be larger and could therefore contribute to higher levels of anterior tibial translation during load-bearing activities. The male-to-female differences in the tibial plateau geometry could be essential considerations in knee injury risk assessment and reconstruction procedures.

# 105 INJURIES IN PROFESSIONAL FOOTBALL: EPIDEMIOLOGY AND PREVENTION MEASURES

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**Background:** Many clubs are faced with financial problems. Performance enhancement and success in championships and cup competitions will only be possible if the teams' players stay uninjured.

**Objective:** The question arises as to what injury prevention in professional football should focus on and which measures should be taken.

**Design, Setting and Participants:** For statistical analysis the following datasets of one season were surveyed: (1) Personal, sports-specific and sociodemographic data of the 1953 professional football players from the first, second and third German professional football leagues. These players represent the population. (2) Type, severity and costs of 5361 sports injuries sustained by the German professional football players. (3) Mechanisms, situations and circumstances of 448 out of the 5361 injuries were recorded in a special survey.

**Results:** Each professional football player sustains an average of two injuries per season, one of these resulting in an absence from sports and the other causing only medical costs. No player has not sustained at least one injury per season. Approximately 13.5% of the players are constantly sidelined due to injuries. Knee injuries are by far the most serious injuries in German professional football. They cause costs of nearly €33 million per season, which is equivalent to 37% of all injury costs. Injuries of the lower extremities cause two-thirds of all injury costs. Approximately 25% of the knee injuries are non-contact injuries.

**Conclusions:** This study provides information about how the problem of injuries in professional football can be approached and which preventive measures may be successful, especially concerning the serious problem of knee injuries. With respect to other studies and own experiences, proprioceptive and coordinative exercises seem to be most promising in this area. Examples of preventive training measures are presented for the sectors mobilisation, warm-up, coordination and proprioception, strength training and regeneration.



## 106 MUSCULOSKELETAL INJURIES AND PAIN IN DANCERS: A SYSTEMATIC REVIEW

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**Objective:** To assemble and synthesise the best evidence on the epidemiology, diagnosis, prognosis, treatment and prevention of musculoskeletal injuries and pain in dancers.

**Data Sources:** We searched MEDLINE, CINAHL, PsycINFO, EMBASE and other electronic databases from 1966 to 2004. We also examined the reference lists of relevant studies, hand-searched specialised journals and scanned the websites of major dance associations for relevant information.

**Study Selection:** Citations were screened for relevance using a priori criteria and relevant studies were critically reviewed for scientific merit by the best-evidence synthesis method. After screening 1865 abstracts, we reviewed 103 papers and accepted 32 of these, representing 29 unique studies, as scientifically admissible.

**Data Extraction:** Data from accepted studies were abstracted into evidence tables relating to the prevalence and associated factors, incidence and risk factors, diagnosis, treatment, economic costs and prevention of musculoskeletal injuries and pain in dancers.

**Data Synthesis:** The scientifically admissible studies consisted of 15 (52%) cohort studies, 13 (45%) cross-sectional studies and one (3%) validation study of a diagnostic assessment tool. The dance medicine literature is young and heterogeneous, limiting our ability to draw consistent conclusions. There is evidence that musculoskeletal injury is an important health issue for dancers at all skill levels. There is a high prevalence and incidence of lower extremity and back injuries, with soft tissue and overuse injuries predominating. Several potential risk factors for injury are suggested by the literature, but conclusive evidence for any of these is lacking. There is preliminary evidence that comprehensive injury prevention and management strategies may help decrease the incidence of future injury.

**Conclusions:** Better quality research is needed in this specialised occupational health area. Future research would benefit from more collaboration between clinical content experts and research methodologists, clear and relevant research questions being addressed with appropriate study designs and the use of conceptually valid and clinically meaningful case definitions of injury and pain.

## 107 WHOLE-BODY VIBRATION DOES NOT ALTER DYNAMIC RESTRAINT CHARACTERISTICS OF THE PERONEUS LONGUS

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**Background:** Whole-body vibration (WBV) is theorised to enhance muscle spindle sensitivity. Short latency reflex responses, important to ankle stability, may be positively altered by enhanced peroneal spindle sensitivity.

**Objective:** To identify changes to peroneus longus activation due to WBV after ankle inversion perturbation.

**Design:** A 2 × 3 pre-post factorial design.

**Setting:** Human performance research laboratory.

**Participants:** 22 (aged 22.1 ± 1.8 years, height 168.8 ± 8.2 cm, weight 65.5 ± 11.2 kg) physically active male and female students with no recent history of lower extremity injury.

**Interventions:** Participants were positioned on a WBV platform (Galileo 2000) where treatment was administered over five sessions of 60 s with intermittent 60 s rest intervals.

**Main Outcome Measures:** Peroneus longus electromechanical delay (EMD), reaction time and muscle activation were collected from two groups (WBV and control) over three time intervals (pre-treatment, post-treatment and 30 minutes post-treatment). The

EMD of the peroneus longus was determined by the onset of force contribution after active eversion, as measured by electromyography (EMG) and force plate (intersession reliability, ICC (2,k) 0.972). Reaction time was measured after an inversion perturbation during walking (intersession reliability, ICC (2,k) 0.918). Two-way ANOVA were used to compare groups over time for all dependent variables.

**Results:** No group times time interactions were detected ( $p < 0.05$ ) for any of the dependent variables (peroneus longus reaction time: WBV pre 71.9 ± 7.35 ms, post 70.4 ± 6.66 ms, post 30 67.0 ± 7.75; control pre 71.4 ± 4.59, post 68.3 ± 4.14, post 30 68.6 ± 4.36). Peroneus longus EMG: WBV pre 0.27 ± 0.12, post 0.26 ± 0.11, post 30 0.27 ± 0.12; control pre 0.25 ± 0.10, post 0.23 ± 0.09, post 30 0.21 ± 0.10. Peroneus longus EMD: WBV pre 30.3 ± 13.3 ms, post 42.4 ± 37.1 ms, post 30 30.0 ± 15.2 ms; control pre 29.3 ± 10.0 ms, post 35.0 ± 12.8 ms, post 30 31.3 ± 10.3 ms).

**Conclusions:** WBV did not alter peroneus longus EMD, reaction time, peak EMG or average EMG. The use of WBV for enhancing ankle dynamic stability was not supported by this study. These data were not consistent with the hypothesis that WBV enhances muscle spindle sensitivity.

## 108 COMPLIANCE WITH A 2-MONTH HOME-BASED UNSUPERVISED PROPRIOCEPTIVE TRAINING PROGRAMME

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**Background:** Despite extensive medical treatment of ankle sprains, recurrences are high in the first year after an initial sprain. Perhaps usual care after an ankle sprain needs to be enhanced with an established effective method, ie, proprioceptive training.

**Objective:** To evaluate the compliance with a 2-month home-based unsupervised proprioceptive training programme, which is given in addition to usual care after an ankle sprain.

**Design:** A total of 259 recently injured Dutch athletes were randomly assigned to the unsupervised proprioceptive training programme as part of a randomised controlled trial. They were prospectively followed for 2 months. Compliance was measured through validated questionnaires sent to the athlete each month.

**Patients:** Athletes with an ankle sprain, sustained up to 2 months before enrolment, were included in the study. Athletes with a history of vestibular or neurological complaints were excluded from the study. After one month 209 athletes returned their questionnaires and after 2 months 200 questionnaires were returned.

**Preliminary Results:** Preliminary results show that more than half of the athletes (54%) performed the training programme as scheduled in the first month and almost 40% during the entire 2 months. Non-compliers and compliers with the programme were predominantly involved in high injury risk sports (both groups between 65% and 70%). Almost all compliant athletes played their sports in an organised way, whereas 75% of the non-compliers did.

**Preliminary Conclusions:** From these findings the preliminary conclusion can be drawn that compliance with a home-based unsupervised training programme is acceptable. High injury risk sport participants in an organised setting are more likely to comply with the unsupervised proprioceptive training programme.

## 109 A CRITICAL REVIEW ON THE EFFECTS OF PROPRIOCEPTIVE TRAINING ON STRUCTURAL AND FUNCTIONAL CHARACTERISTICS OF THE ANKLE

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**Background:** Proprioceptive training is effective in preventing ankle sprain recurrences but the pathway through which this effect

occurs is unknown. Biomechanical analyses of the pathway of structural changes leading to functional changes of the ankle are needed to establish this pathway. This critical review focussed on the pathway through which a training programme reduces re-injury risk.

**Objective:** To determine the effect of proprioceptive training on structural (ie, joint position sense, muscle reaction times and strength) and functional (postural sway) characteristics of the ankle.

**Design:** A MEDLINE computerised literature search was conducted to search for relevant articles. Nine out of an initial 47 studies passed the five selective criteria of relevance and quality. Two reviewers conducted the analysis of criteria independently.

**Results:** Results on joint position sense and muscle reaction times showed a learning effect of repeated measures and not a training effect and effects on strength were not found. Decrements of postural sway after proprioceptive training were also mainly attributable to a learning effect.

**Conclusions:** Evidence for an effect of proprioceptive training on structural and functional characteristics is limited, if present at all. The pathway of proprioceptive training thus remains unclear. Future studies need to focus on: (1) differentiating between morphological, physiological and functional changes; (2) larger sample sizes with a priori sample size calculations; (3) correspondence between training and test method; (4) using "time to stabilisation" as a functional measure of stability and (5) using a longer follow-up period than 6 weeks.

## 110 INJURIES AMONG WORLD CUP SNOWBOARD ATHLETES

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**Background:** Snowboarding is constantly developing as a sport, with more extreme tricks and demanding snow installations. Previous studies indicate that injury incidence is high, with a high share of knee and back injuries.

**Objective:** To describe the incidence and pattern of injuries among FIS World Cup snowboarders.

**Design/Setting:** Athletes from nine World Cup teams were interviewed retrospectively at the end of the 2006–7 season. Injuries that required attention by medical personnel from November to April were recorded.

**Results:** A total of 141 athletes in the disciplines half-pipe and snowboard-cross were interviewed, 50 women and 91 men. The total injury incidence was 70.9 injuries per 100 athletes per season (44.7 for injuries leading to absence from the sport of one day or more). The athletes participated in 614 World Cup/World Championship events with an estimated total of 9939 runs (based on exposure factors from Torjussen and Bahr, 2006). This corresponds to an incidence of 3.7 (95% CI 1.9 to 5.2) per 1000 runs, 4.2 (2.1 to 6.2) for women and 3.4 (1.9 to 4.9 for men; relative risk 1.2 versus women,  $p = 0.58$ , Z-test). The injury incidence in half-pipe was 3.5 (95% CI 1.9 to 5.2) per 1000 runs and in snowboard cross 4.6 (2.3 to 6.9; relative risk 1.3 versus half-pipe,  $p = 0.45$ ). The knee was the most common body part injured (19%), followed by the back/pelvis (14%) and the head/face (13%). The most common injury type was joint and ligament injuries (34%). 22% of the injuries led to absence from training and competition for >28 days.

**Conclusion:** The injury incidence in FIS World Cup half-pipe and snowboard cross is high and knee injuries are the most common. No significant sex or discipline differences were detected.

**Funding:** The FIS Injury Surveillance System has been established through a generous grant from DJO.

## 111 IS THE PAIN IN PATELLOFEMORAL PAIN SYNDROME NEUROPATHIC?

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**Background:** Adolescents participating in sports seem to be particularly vulnerable to develop long-lasting anterior knee pain diagnosed as patellofemoral pain syndrome (PFPS). In addition, patellofemoral pain is reported to be one of the main complaints at sports medicine clinics. There is no consensus among experts regarding the aetiology or management of PFPS. Several observations indicate dysfunction of the peripheral nervous system around the patellae. To what extent these sensory abnormalities cause pain has so far not been investigated.

**Objective:** The aim of this study was to assess whether a subgroup of patients with unilateral PFPS may have neuropathic pain related to the painful knee.

**Design and Participants:** Non-experimental, descriptive study. The study included a total of 91 subjects with unilateral PFPS, between 18 and 40 years of age, and a comparable group of 23 healthy subjects aged 18–44 years. The level of knee function, pain intensity and qualities were assessed. Somatosensory assessments were carried out by bedside neurological tests and quantitative sensory testing, assessing thermal, tactile and vibration thresholds.

**Setting:** Subjects with unilateral PFPS were recruited from the orthopaedic outpatient department at local hospitals, from private physiotherapy clinics and by advertisements in local newspapers.

**Results:** The assessments showed ample signs of sensory aberrations with considerable heterogeneity and overlap regarding the degree and type of dysfunction of the nervous system in the painful area of the PFPS subjects. No clear subgroup of subjects with neuropathic pain or clustering of features related to neuropathic pain was identified. In this study considerable heterogeneity and overlap regarding signs and symptoms of neuropathic pain made subgrouping even more difficult.

**Conclusion:** A mechanism-based understanding of the pain is, however, essential for the selection of adequate treatment strategies in this painful musculoskeletal disorder.

## 112 THE EPIDEMIOLOGY OF INJURIES IN AMERICAN FLAG FOOTBALL: INITIAL PILOT STUDY RESULTS

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**Background:** Although American flag football (AFF) is considered a non-tackle sport, many serious contact-type injuries are reported annually worldwide. No previous studies have investigated the epidemiology or the prevention of injuries in this sport.

**Objective:** To examine the epidemiology of sports injuries in the AFF league in Israel.

**Design:** Descriptive epidemiology study.

**Setting:** Sports field, amateur AFF league.

**Participants:** 743 amateur male players.

**Methodology:** All time-loss injuries sustained in game sessions were recorded by the off-the-field medical personnel over a one-season period. Detailed phone questionnaires were carried out 7–14 days after the injury.

**Results:** 329 games were played in the 2006/7 season. The number of athlete exposures was 245 434. Although 70 injuries were reported over this period, 50 detailed questionnaires were fully completed, representing 44 individual players in total. Six of the 70 injuries involved players with multiple injuries. Overall, this represents an injury rate of 0.29 per 1000 athlete exposures (95% CI 0.35 to 0.22). The estimated incidence amounted to 8.6/100 players (95% CI 6.5% to 10.5%). All the injuries were traumatic. 14 (28%) of the injuries occurred to the hand, 11 (22%) to the knee and 10 (20%) to the head/face. Only three (6%) of the players wore any

type of protective equipment. Six (12%) occurred not in accordance with regular game rules. 37 (74%) were moderate to severe in nature, whereas only two (4%) were recurrent in nature.

**Conclusions:** These initial pilot study results reflect both the high number of moderate to severe type injuries in this so-called “non-tackle” sport. Despite the fact that most of the injuries resulted from either direct contact with the ground or another player, very few players used any form of protective equipment. These results have accentuated the urgent need for protective measures to reduce injuries in the AFF league and have formed the basis of the consecutive two-season epidemiological study that is currently underway. A randomised controlled injury prevention trial will thereafter be introduced.

### 113 PREVENTION OF ANKLE SPRAINS IN SPORT: A SYSTEMATIC LITERATURE REVIEW

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**Background:** Ankle sprains are the most common musculoskeletal injuries that occur in athletes. Their frequent nature and the persistent disability that often ensues has led to considerable medical costs. The importance of finding ways to prevent these injuries is therefore of paramount importance to athletes, their teams and the medical system as a whole.

**Objective:** To review the published evidence on the effectiveness of various methods in the prevention of ankle sprains in the athletic population.

**Design:** A literature search was conducted using multiple databases, including the Cochrane Musculoskeletal Injuries Group's specialised register, the MEDLINE, PUBMED, EMBASE and CINAHL search registers. The search included articles published between 1980 and December 2007. Only prospective, levels 1 and 2, randomised and quasi-randomised trials (RCT) were reviewed. Keywords used in the search were “prevention” in combination with “ankle sprains”.

**Results:** Overall, 19 RCT were reviewed consisting of a total of 12 233 participants. The studies showed a significant reduction in the number of ankle sprains in individuals allocated to an external ankle support group. This reduction was greater for those with a previous history of ankle sprains. Braces seemed to be more effective in preventing ankle sprains than tape. Appropriately applied braces, tape or orthoses do not adversely affect performance. Proprioceptive training reduced the incidence of ankle sprains in athletes with recurrent ankle sprains to the same level as subjects without any history of ankle sprains.

**Conclusions:** Semi-rigid orthoses or aircasts are more effective than taping to reduce the incidence of sprains. Sensorimotor control can seemingly be improved in previously injured ankles, such that the risk equals that of healthy ankles. Rules must be changed to limit contact between players and possibly harsher penalties introduced. When the above interventions are utilised effectively, ankle sprains can be significantly prevented.

### 114 A COMPARISON BETWEEN CONSERVATIVE TREATMENT AND PLYOMETRIC EXERCISE IN THE REHABILITATION OF PATIENTS WITH PATELLAR TENDINOPATHY (JUMPER'S KNEE)

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**Introduction:** Patellar tendinopathy (jumper's knee) is common in sports involving much jumping, such as volleyball, basketball and high jumping and is characterised by pain and tenderness below the kneecap and over the patella tendon. Excessive jumping, jumping onto a hard surface and inappropriate footwear are common triggers.

**Methods:** 27 male elite volleyball players (weight 92.3 kg, age 24.6 years) were included, all clinically diagnosed and with imaging confirming patellar tendinopathy and were divided into two groups: (1) conservative treatment group receiving conservative treatment including rest, ice, non-steroidal anti-inflammatory drugs, hot showers and swimming ( $n = 12$ ) and (2) a plyometric exercise group, training 5 days a week for 8 weeks—a programme of specific plyometric exercise ( $n = 15$ ). The relative effectiveness of the treatment was compared by assessing pain, range of motion, tenderness and power. The results were analyzed by ANOVA and the significance was set as  $p < 0.05$ .

**Results:** Both groups were positively helped by their treatment; pain decreased, tenderness decreased and range of motion increased. However, in contrast to the conservative treatment group, in which there was no change in power, in the plyometric exercise group we observed a statistically significant increase in power.

**Discussion/Conclusion:** Plyometrics refers to exercises characterised by powerful, muscular contractions in response to rapid dynamic loading or stretching of the involved muscle. In fact, plyometrics is skipping, hopping, bounding and jumping. The key in all these movements is lengthening of the muscle during loading in the muscle groups responsible for generating power.

### 115 STUDY ON CONFIGURATION OF THE LATERAL TIBIAL CONDYLE IN NON-CONTACT ANTERIOR CRUCIATE LIGAMENT-INJURED KNEES

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**Background:** We already reported that anterior cruciate ligament (ACL)-injured patients have a larger convex index (CI) of the lateral tibial condyle.

**Objective:** To measure the posterior slope of the lateral tibial condyle and study the correlation of the CI and the posterior slope.

**Patients:** We studied 65 outpatients who visited our hospital with knee disorders. Among 37 women, the non-contact ACL-injured group had six women with injury of both sides and 17 women with injury of one side and the control group had 14 women. Among 28 men, the non-contact ACL-injured group had 10 men with injury of one side and the control group had 18 men. The posterior slope of the lateral tibial condyle was x rayed when the mediolateral femoral condyle was congruent to measure the angles of the perpendicular line of the tibia and the articular surface.

**Results:** The average posterior slope of the lateral tibial condyle of women with injury to both sides was  $12.3^\circ$ , that of women with injury to one side was  $12.2^\circ$ , that of women of the control group was  $9.5^\circ$ , that of men with injury to one side was  $12.1^\circ$  and that of men of the control group was  $9.4^\circ$ . The significant difference between women with injury to both sides and the control group, between women with injury to one side and the control group and between men with injury to one side and the control group was recognised. The statistically significant correlation between CI and the posterior slope of the lateral tibial condyle was recognised.

**Conclusions:** This study proves our hypothesis that the ACL is injured because the lateral condyle of the femur easily slips down at the back of the centre of the lateral tibial condyle.

### 116 GENDER MATTERS: SUPERIOR ACHILLES TENDON MICROCIRCULATION IN TENDINOPATHY AMONG SYMPTOMATIC FEMALE VERSUS MALE RECREATIONAL SPORTSMEN

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**Background:** Higher oestrogen levels in women seem to play a role regarding an increased ligament and tendon injury rate. However,



gender differences of tendon microcirculation have not yet been reported.

**Objective:** Female patients with Achilles tendinopathy have worse tendon and paratendon microcirculation than symptomatic male patients.

**Design:** Cross-sectional study; level of evidence, 2.

**Setting:** Clinical setting with recreational sportsmen.

**Patients:** A total of 139 Achilles tendinopathy patients (58 women, 81 men) was analyzed according to their gender for tendon and paratendon microcirculation by mapping at 12 positions (four tendons, eight paratendons) in each limb.

**Main Outcome Measures:** Tendon and paratendon capillary blood flow, oxygen saturation and postcapillary venous filling pressures were measured at 2 mm and 8 mm tissue depths (Oxygen-to-see, laser Doppler and spectrophotometry system).

**Results:** Symptomatic women had similarly elevated tendon capillary blood flow as men at four Achilles tendon positions. However, distal medial ( $83 \pm 40$  versus  $105 \pm 74$ ,  $p < 0.05$ ) and lateral ( $98 \pm 49$  versus  $121 \pm 74$ ,  $p < 0.05$ ) paratendon capillary blood flow was significantly lower among men. Symptomatic female patients had superior tendon and paratendon oxygen saturation at 11 of 12 positions ( $p < 0.05$ ) as well as reduced postcapillary venous filling pressures at the proximal midportion tendon ( $55 \pm 17$  versus  $63 \pm 20$ ,  $p < 0.05$ ) and paratendon ( $69 \pm 19$  versus  $77 \pm 26$ ,  $p < 0.05$ ) location. The pain level was no different between female ( $5.3 \pm 2.2$ ) and male ( $5.4 \pm 2$ ,  $p = 0.864$ ) patients. Female patients had significantly higher foot and ankle outcome sports scores ( $71 \pm 22$  versus  $64 \pm 23$  in the men,  $p = 0.041$ ), whereas four out of five other foot and ankle outcome score items were no different.

**Conclusion:** Symptomatic female patients have similarly elevated tendon capillary blood flow compared with symptomatic male patients with Achilles tendinopathy, but superior tendon and paratendon oxygen saturations and reduced postcapillary venous filling pressures indicate better tendon and paratendon Achilles tendon microcirculation in women.

# 117 CRYOTHERAPY AND COMPRESSION VERSUS SOLE CRYOTHERAPY FOR ACHILLES TENDON MICROCIRCULATION: A RANDOMISED CLINICAL TRIAL

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**Background:** Cryotherapy and compression have been shown to decrease pain and improve function. Whether sole cryotherapy exerts differential effects to combined cryotherapy and compression is unknown.

**Objective:** We hypothesised that standardised CryoCuff changes mid-portion in the Achilles tendon microcirculation were different to sole cryotherapy using a frozen gel (KoldBlue).

**Design:** Randomised prospective clinical trial.

**Setting:** Clinical setting with healthy recreational sportsmen.

**Patients:** Sixty healthy sportsmen ( $33 \pm 12$  years, 33 men, BMI  $25 \pm 5$ ) were randomly assigned and included. All patients fulfilled the entire study.

**Main Outcome Measures:** Mid-portion Achilles tendon microcirculation was determined using continuous real-time assessment with a laser Doppler spectrophotometry system (O2C, Germany) regarding capillary blood flow, tendon oxygen saturation and postcapillary venous filling pressures in 2 mm and 8 mm tendon depth simultaneously in real-time throughout the entire 60 minutes study period.

**Intervention:** Intermittent  $3 \times 10$  minutes application of either CryoCuff (Aircast,  $n = 30$ ) or KoldBlue (TLP Industries, UK,  $n = 30$ ).

**Results:** Both, CryoCuff and KoldBlue significantly reduced superficial and deep capillary tendon blood flow within the first minute of application ( $p = 0.0001$ ) without a significant difference throughout all three applications. However, during recovery superficial and deep capillary blood flow was re-established significantly faster using CryoCuff ( $p = 0.023$ ). Tendon oxygen saturation was reduced in both groups significantly with much stronger effects using CryoCuff ( $p = 0.014$ ). Throughout all recoveries, CryoCuff led to significantly higher tendon oxygenation in superficial and deep tissue. Postcapillary venous filling pressures were significantly reduced in both groups during application; however, CryoCuff led to significantly lower pressures (CryoCuff  $41 \pm 7$  AU versus baseline  $51 \pm 13$  AU,  $p = 0.0001$  and KoldBlue  $46 \pm 7$  AU versus baseline  $56 \pm 11$  AU,  $p = 0.026$  for CryoCuff versus KoldBlue).

**Conclusions:** Intermittent Cryo/Cuff administration of  $3 \times 10$  minutes combining cryotherapy and compression is superior to cryotherapy alone regarding significantly increased tendon oxygen saturation during recovery and superior reduction of postcapillary tendon venous filling pressures facilitating Achilles tendon clearance of metabolic products. Combined cryotherapy and compression is superior to cryotherapy alone for the Achilles tendon.

# 118 RUNNER'S TENDINOPATHY AMONG MASTER RUNNING ATHLETES

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**Background:** Preventive measures for acute sport injuries as well as for overuse injuries have to be based on a thorough injury analysis based on exposure data. Studies have consistently noted the high incidence and prevalence of injuries in competitive runners, with incidence rates being positively correlated with training volume, intensity and age; however, exposure data are often pending.

**Objective:** To determine running-associated tendinopathy depending on exposure and to identify risk factors.

**Design:** Prospective cohort study.

**Setting:** Elite runners competing at the national and international level.

**Patients:** 291 master runners ( $42 \pm 9$  years,  $65.2 \pm 28.3$  km/week) were included, with an overall exposure of 9 980 852 km ( $34\ 416$  km/athlete).

**Main Outcome Measures:** Injury rates depending on exposure, descriptive statistics with  $\chi^2$  test, Fisher's exact test and Mann-Whitney test to calculate relative risks (RR).

**Results:** Overall injury rate was 0.0815/1000 km (2.93/athlete). Overuse injuries (0.067/1000 km) were more frequent than acute injuries (0.014/1000 km). Achilles tendinopathy was the predominant injury (0.0159/1000 km, 62 772 km) followed by anterior knee pain (0.013/1000 km, 73 932 km), shin splint (0.0104/1000 km, 95 969 km), Achilles tendon rupture was rarely encountered (0.0009/1000 km, 1 247 606 km). 56.6% of the athletes had an Achilles tendon overuse injury, 46.4% anterior knee pain, 35.7% shin splint and 12.7% had a plantar fasciitis. Mid-portion Achilles tendinopathy was more common (0.008/1000 km) than insertional (0.0048/1000 km). Asphalt decreased mid-portion tendinopathy risk (RR 0.47,  $p = 0.019$ ). In contrast sand increased the relative risk for mid-portion Achilles tendinopathy 10-fold (RR 10, CI 1.12 to 92.8,  $p = 0.011$ ). Runners with more than 10 years experience had an increased risk (RR 1.6,  $p = 0.041$ ) for Achilles tendinopathy. 65% of the 291 athletes knew about eccentric training, with 46% performing it at a mean 4.2 times per week for 38 weeks. 33% of the athletes performed stretching every day, 17% three to five times per week, 22% one to two times per week and 19% once a week.

**Conclusion:** Achilles tendinopathy is the most common running-associated tendinopathy before runner's knee and shin splints among master runners.

# 119 200–400 M BREASTSTROKE EVENTS ARE ASSOCIATED WITH A FOURFOLD INCREASED RISK OF KNEE OVERUSE INJURIES: A PROSPECTIVE TRIAL AMONG 341 ELITE SWIMMING ATHLETES

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**Background:** Swimming is supposed to be a reasonably safe sport; however, detailed data on acute and overuse injuries according to the exposition time and the relative risk are pending.

**Objective:** To determine swimming-associated injury data.

**Design:** Prospective cohort study.

**Setting:** Elite swimmers competing at the national and international level.

**Patients:** 341 elite swimmers ( $19 \pm 11$  years, BMI  $20.3 \pm 3$ ) were enrolled. Swimming was performed with 3.8 units every week (swimming distance at mean 27.8 km). Overall swimming exposure was 988 551 h.

**Main Outcome Measures:**  $\chi^2$  Test and Fisher's exact test were used to calculate relative risks (RR) based on injury rates per 1000 h exposure.

**Results:** The overall injury rate was 0.387/1000 h. Overuse injuries (0.22/1000 h) were more frequent than acute injuries (0.174/1000 h). The upper extremity was involved more frequently (0.106/1000 h) than the trunk (0.067/1000 h) or the lower extremity (0.085/1000 h). Knee pain was predominant (0.172/1000 h), followed by shoulder overuse injuries (0.106/1000 h). A quarter had knee pain following breaststroke, 4% freestyle, 5% butterfly and 2% backstroke. Breaststroke increased the relative risk by 4.4 ( $p=0.01$ ) for knee pain. In particular, the 200–400 m breaststroke event had a fivefold higher risk of knee pain ( $p=0.001$ , RR 5.061). Freestyle had a reduced relative risk of knee pain (RR 0.457,  $p=0.03$ ), in which shoulder overuse syndromes were predominant. Butterfly increased shoulder overuse syndromes with RR 4.4 ( $p=0.004$ ), cervical spine injuries (RR 3.99,  $p=0.03$ ) and lower back pain (RR 2.49,  $p=0.011$ ). Swimmers with more than 8 years of experience had a threefold higher risk of shoulder overuse injuries. Swimming for more than 2200 h increased the RR for knee injuries to 3.0, shoulder overuse (RR 7.0) and hip pain (RR 4.76).

**Conclusion:** Swimming is a safe sport, with overuse injuries dominating. 200–400 m breaststroke events are prone to lead knee overuse injuries. Training for more than four times a week increases the risk of knee and shoulder overuse injuries.

# 120 REHABILITATION PROGRAMME FOR THE PREVENTION OF RE-INJURY AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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**Background:** Our study examined the postoperative outcomes after anterior cruciate ligament (ACL) reconstruction and re-injured cases after the introduction of a rehabilitation programme, which was established according to the level of competitive sports.

**Objective:** The rehabilitation programmes were divided into three levels according to the level of competitive sports: level 1, professional and semiprofessional; level 2, the student competition level; level 3, all other competition levels. The times for returning to

playing in games were established as 4, 6, and 12 months postoperatively. We examined methods to advance patients to the next step in muscle strength and goal-oriented rehabilitation programmes based on the functional evaluation of movement by physical therapists.

**Patients:** The patients were athletes in whom ACL reconstruction had been performed since 2005. There were 115 patients at levels 1 and 2 in whom 6 months or more had passed since surgery. There were 31 patients at level 3 in whom 1 year or more had passed since surgery.

**Results:** The patients were 41 men and 105 women with a mean age of 19.5 years. Four months postoperatively, 14% of the patients at levels 1 and 2 were able to return to playing competitive sports; 64% and 96% were able to return 6 months and one year postoperatively. One year postoperatively, 94% of the patients at level 3 returned to playing competitive sports. No patient had a re-rupture. One patient ruptured the contralateral ACL and five patients had a meniscus injury requiring re-operation.

**Conclusion:** We achieved a graded return of athletes to playing in competitive sports through muscle strength evaluation and post-operative rehabilitation, in which progression was decided by their level of competitive sports. In addition, movement was evaluated by physical therapists. We were able to attain satisfactory outcomes and to decrease the number of re-injured cases.

# 121 COMPARISON OF BODY MASS INDEX BETWEEN UNIVERSITY AND PROFESSIONAL SOCCER PLAYERS

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**Background:** Transitioning from university level soccer to professional level requires increased technical skill and understanding of the game. Physiological measurements are often not considered if an individual can successfully compete at a higher level.

**Objective:** The purpose of this research is to compare the body mass index (BMI) of university and professional level soccer players.

**Design:** Height and weight was retrospectively gathered for each 2007 professional major league soccer (MLS) player ( $N=366$ ) and 2007 Big East university soccer player ( $N=411$ ). BMI was calculated by team and positions (defenders, goalies, midfielders and forwards).

**Setting:** Team rosters made available by the MLS organisation and the university level Big East Conference were used to gather data. Teams are located in the United States and Canada.

**Participants:** All participants were listed as active members of one of the 13 professional MLS teams or 16 university teams and were purposefully categorised by position (defenders, forwards, goalies and midfielders).

**Interventions:** Standardised and internationally accepted formula to calculate BMI was used.

**Main Outcome Measures:** The variables measured included height and weight and each calculated formula was descriptively grouped by team and position.

**Results:** League-wide BMI was 23.60 and the average BMI of position players were calculated as 23.61 (defenders), 23.63 (forwards), 25.16 (goalies) and 23.16 (midfielders). University-wide BMI was 23.5 (+0.43%) and the average BMI of position players were calculated at 23.3 (defenders, +1.33%), 23.5 (forwards, +0.55%), 23.9 (goalies, +5.27%) and 23.5 (midfielders, -1.45%).

**Conclusions:** BMI for professional soccer players in the MLS is slightly higher for defenders, forwards and goalies and slightly lower for midfielders. Although the comparable calculations were minimal, the overall BMI by position is in the "normal" category for each position, with the exception of MLS goalies who are classified as overweight.

## 122 BODY MASS INDEX FOR PROFESSIONAL SOCCER PLAYERS

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**Background:** Body mass index (BMI) is a relatively simple screening tool for obesity, but one of the inaccuracies of using BMI as a screening tool for obesity is that it does not take into account lean body mass versus adipose tissue. Despite this challenge, it remains a popular and widely used screening tool.

**Objective:** To establish baseline BMI data for all players in major league soccer (MLS). No studies have previously explored this population for BMI labelling.

**Design:** Height and weight were retrospectively gathered for each 2007 professional MLS player. A total of 366 players from 13 teams was assessed for BMI. BMI was calculated by team and positions (defenders, goalies, midfielders and forwards).

**Setting:** Team rosters made available by the MLS organisation were used to gather data. Teams are located in the United States and Canada.

**Participants:** All participants were listed as active members of one of the 13 professional MLS teams and were purposefully categorised by position.

**Interventions:** Standardised and internationally accepted formula to calculate BMI was used.

**Main Outcome Measures:** The variables measured included height and weight and each calculated formula was descriptively grouped by team and position.

**Results:** League-wide BMI was 23.60. Teams ranged from 23.13 to 24.10, with average BMI of position players calculated as 23.61 (defenders), 23.63 (forwards), 25.16 (goalies) and 23.16 (midfielders).

**Conclusions:** BMI for professional soccer players in the MLS appears to be rather consistent from team to team, as well as by player position. Although the calculated ranges were minimal, the overall BMI by position is in the "normal" category and questions whether or not a category recognising "elite" individuals needs to be considered, supporting previous studies of other elite athletes.

## 123 EFFECTS OF ORAL CONTRACEPTIVES AND ATHLETIC INJURY

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**Background:** Many female athletes have opted to use oral contraceptives as a way to manipulate their menstrual cycle during their competitive season. Anecdotal benefits have been reported to include pregnancy prevention, decreased premenstrual symptoms, injury reduction and performance enhancement.

**Objective:** To determine the effect of oral contraceptives on musculoskeletal injuries in female athletes as determined by self-reported questionnaire.

**Design:** A written survey was completed as part of a pre-participation physical examination before athletic participation. Once medical records were individually assessed, surveys were de-identified for group analysis.

**Setting:** American women competing in the first year of university athletics at a division 1 level. Sports participation included soccer, field hockey, lacrosse, swimming, diving, volleyball, basketball, softball and cross-country.

**Participants:** Purposeful sample of 90 female college athletes aged 18–20 years.

**Interventions:** Multiple choice questions as part of a written survey were implemented and analyzed for descriptive statistics.

**Main Outcome Measures:** Independent sample t-test correlating frequency of injury with variables that included: eating disorders, intake of multivitamin supplements, avoiding red meats, taking oral contraceptives and going over 3 months without having a period.

**Results:** Many of the variables had a low prevalence rate among the athletes and were not found to be significant at the 95% confidence level. However, the mean number of total injuries for

those taking oral contraceptives (1.6) was significantly lower ( $p = 0.01$ ) than for those who were not (2.6).

**Conclusions:** This study suggests that an added benefit of oral contraceptives may include decreased musculoskeletal injury in university female athletes. Although it cannot be said definitively that oral contraceptives can prevent injuries, the results of this research show a trend that needs more exploration.

## 124 PATIENTS WITH ACHILLES TENDON RUPTURE SUBSEQUENT TO ACHILLES TENDINOPATHY ARE YOUNGER THAN THOSE WITHOUT PREVIOUS TENDON PAIN

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**Background:** Achilles tendinopathy and rupture are frequent sports injuries.

**Objective:** Patients with Achilles tendon rupture without previous pain are different to patients with Achilles tendinopathy with or without subsequent tendon rupture.

**Design:** Prospective controlled cohort study.

**Setting:** Recreational sportsmen as well as athletes at a national level.

**Patients:** 228 subjects were analyzed in four groups: (1) healthy Achilles tendons ( $n = 76$ , age  $39 \pm 12$  years, BMI  $25.8 \pm 3.9$ , women 38%); (2) chronic Achilles tendinopathy ( $n = 111$ , age  $45 \pm 11$  years, BMI  $24.4 \pm 3$ , women 27%); (3) acute Achilles tendon rupture without previous Achilles tendinopathy ( $n = 26$ , age  $41 \pm 8$  years, BMI  $25.1 \pm 3.4$ , women 23%); (4) Achilles tendinopathy with subsequent Achilles tendon rupture ( $n = 17$ , age  $39 \pm 9$  years, BMI  $25.7 \pm 3.0$ , women 12%).

**Assessment of Risk Factors:** Age, gender, BMI, physical activity, family history, medication, concomitant diseases.

**Main Outcome Measures:**  $\chi^2$ -Test, Fisher's exact test and one-way ANOVA were used to compare the prevalence of risk factors and characteristics between groups.

**Results:** We found no effect of gender ( $p = 0.114$ ), but for age on Achilles tendinopathy or tendon rupture with previous tendinopathy ( $p = 0.002$ ). Groups 1 and 4 were younger than group 2 ( $39 \pm 12/39 \pm 9$  years versus  $45 \pm 11$  years;  $p = 0.001/p = 0.032$ ). Regular physical activity was significantly different between groups 1 versus 2 as well as groups 2 versus 3 (1 65% versus 2 93%;  $p = 0.001$ ; 2 93% versus 3 77%;  $p = 0.048$ ). Smoking was significantly different with 30% (1) versus 5% (2) versus 23% (3) versus 13% (4,  $p = 0.001$ ). There was no statistical significance regarding family history of Achilles tendon rupture ( $p = 0.263$ ) or Achilles tendinopathy ( $p = 0.075$ ), diabetes ( $p = 0.338$ ), arterial hypertension (0.097), hypercholesterolaemia ( $p = 0.637$ ), coronary artery disease ( $p = 0.094$ ), corticosteroids ( $p = 1.000$ ), salicylate acid ( $p = 0.401$ ) or chinolones ( $p = 1.000$ ). 17% (3) and 40% (4) had a sural nerve lesion from surgical treatment ( $p = 0.545$ ).

**Conclusion:** Patients with Achilles tendon rupture with previous painful tendon are younger than those without previous pain. Gender and BMI do not play a role, but sural nerve lesions are often underestimated.

## 125 ACUTE INCREASE OF CAPILLARY BLOOD FLOW WITH UNCHANGED POSTCAPILLARY FILLING PRESSURE AND TISSUE OXYGEN SATURATION AFTER CLOSED SOFT TISSUE INJURY AT THE LOWER LIMB: AN ANIMAL STUDY

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**Background:** Closed soft tissue injury induces a progressive microvascular dysfunction as well as regional inflammation. To



what extent changes in the microcirculatory blood flow, tissue oxygen saturation or the capillary venous filling pressure are present after closed soft tissue trauma still remains unknown.

**Objective:** Combined laser-Doppler and spectrophotometry non-invasively assess differences in muscle microcirculation during acute trauma in an animal study.

**Design:** Randomised experimental trial.

**Setting:** Experimental setting with healthy laboratory animals.

**Subjects:** Fourteen male Wistar rats (275–325 g) were used for the experiments.

**Interventions and Main Outcome Measures:** Under pentobarbital sodium anaesthesia, rats were intubated, respired and haemodynamics were monitored. Rats were randomly separated into a trauma ( $n = 7$ ) and non-trauma group (control,  $n = 7$ ). Before and directly after induction of a standardised soft tissue trauma of the soleus muscle, microcirculation of the soleus muscle was assessed using combined laser-Doppler and spectrophotometry (Oxygen-to-see) regarding: muscular capillary blood flow, muscular tissue oxygen saturation, muscular venous filling pressure. Further assessments of microcirculatory parameters were performed 1, 2, 3 and 24 h after trauma induction. Microcirculation of the control animals was also assessed a second time.

**Results:** At baseline there were no significant differences in microcirculatory parameters between the trauma and control groups. Directly after soft tissue trauma induction, muscular capillary blood flow increased by  $43 \pm 13\%$  ( $p = 0.017$ ). No change in muscular tissue oxygen saturation was evident immediately after trauma induction ( $10 \pm 11\%$ ,  $p = 0.148$ ) or after 24 h ( $p = 0.923$  versus baseline). Postcapillary venous filling pressures remained unchanged immediately after trauma ( $p = 0.645$ ). After 24 h, venous filling pressure was decreased by  $20 \pm 18\%$  of the baseline measurements ( $p = 0.290$  versus baseline).

**Conclusion:** Capillary blood flow is significantly increased after closed soft tissue injury with unchanged muscle oxygen saturation and unchanged capillary venous filling pressures.

## 126 OSTEOARTHRITIS OF LOWER-LIMB JOINTS IN RETIRED, FIRST SLOVENIAN FOOTBALL LEAGUE PLAYERS

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**Background:** Over the past decades we are facing an explosion of competition and recreational sports and thereafter more joint injuries. Joint injury is one of the risk factors for early osteoarthritis.

**Objective:** To describe the long-term impact of many joint injuries on the prevalence of osteoarthritis and quality of life of retired professional football players.

**Design:** Retrospective cohort study.

**Setting:** Retired, first Slovenian football league players.

**Participants:** 42 retired professional football players, mean age 47.7 years, and 45 age and gender-matched controls, mean aged 49.1 years who had trained for no sport since finishing grammar school.

**Interventions:** An anonymous self-administered questionnaire designed to gather information on personal data, history of lower-limb joint injury and operation, current medical condition and quality of life.

**Main Outcome Measures:** Risk of developing osteoarthritis of lower-limb joints and quality of life as determined by a questionnaire.

**Results:** More than half of the footballers retired because of injury (57.1%); 45% because of acute and 55% because of chronic injuries; the knee was most commonly injured joint. Of all footballers 47.7% had been medically diagnosed with osteoarthritis, 69% have joint pain in daily activities (knee 68.9%) and 29% of them need analgesics at least three times a week. Compared with controls, only 15.5% have signs of osteoarthritis, 13.3% have lower-limb joint

pain in daily activities and 8.9% of them need analgesics at least three times a week. 47.6% of footballers have already been operated or were waiting for an operation on the joints, compared with 4.4% in the control group.

**Conclusions:** Slovenian football players have a significantly higher risk of developing osteoarthritis, with a direct influence on poorer quality of life compared with the general Slovenian population.

## 127 DIFFERENCES IN JUMPING TECHNIQUE BETWEEN ANTERIOR CRUCIATE LIGAMENT-INJURED AND NON-INJURED TEAM HANDBALL PLAYERS

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**Background:** Little is known about risk factors for non-contact anterior cruciate ligament (ACL) injuries. Therefore, a 5-year prospective cohort study to identify risk factors for ACL injuries has been initiated in the elite series of Norwegian female team handball.

**Objectives:** To compare jumping techniques between previously ACL-injured and non-injured elite female team handball players.

**Design:** Case-control study.

**Methods:** Knee kinematics from 240 Hz three-dimensional motion analysis of a 30 cm maximal vertical drop jump were measured. Clinical joint angles are reported at initial contact and maximum vertical ground reaction force (VGRF). Maximum knee flexion, peak VGRF and time to peak VGRF and maximum knee flexion are reported.

**Participants:** Elite female team handball players, 16 with unilateral ACL injury and 16 controls matched with respect to age and height (age  $25.3 \pm 1.2$  (SEM) versus  $25.1 \pm 1.2$  years, height  $175.0 \pm 2.0$  versus  $175.5 \pm 1.6$  cm).

**Results:** There was a trend towards injured players displaying less knee flexion ( $30.1 \pm 1.9^\circ$  (SEM) versus  $34.7 \pm 1.8^\circ$ ,  $p = 0.053$ ) and valgus ( $-4.0 \pm 1.1^\circ$  versus  $-1.0 \pm 0.8^\circ$ ,  $p = 0.060$ ) at initial contact. There was no difference in internal rotation ( $-4.3 \pm 1.4^\circ$  versus  $-2.1 \pm 1.6^\circ$ ,  $p = 0.21$ ) at initial contact or in flexion ( $54.3 \pm 2.6^\circ$  versus  $56.9 \pm 1.5^\circ$ ,  $p = 0.42$ ), valgus ( $-3.1 \pm 1.1^\circ$  versus  $-0.3 \pm 1.9^\circ$ ,  $p = 0.091$ ) or internal rotation ( $3.3 \pm 1.2^\circ$  versus  $3.0 \pm 1.4^\circ$ ,  $p = 0.85$ ) at maximum VGRF. No differences were found between groups in maximum knee flexion ( $80.7 \pm 3.5^\circ$  versus  $80.0 \pm 2.4^\circ$ ,  $p = 0.87$ ), time to maximum knee flexion ( $177 \pm 12$  ms versus  $167 \pm 12$  ms,  $p = 0.50$ ), maximum VGRF ( $4.6 \pm 0.2$  bodyweight (BW) versus  $5.1 \pm 0.3$  BW,  $p = 0.33$ ) or time to maximum VGRF ( $64 \pm 3$  ms versus  $62 \pm 3$  ms,  $p = 0.67$ ). No differences were found between legs in injured players.

**Conclusions:** No significant differences were found in jumping techniques between previously ACL-injured and non-injured players. However, it is not known whether differences were present before injury and prospective follow-up of the non-injured group is necessary to determine whether the jumping technique is a risk factor for ACL injury.

## 128 STRENGTH AND ANATOMICAL MEASURES IN ANTERIOR CRUCIATE LIGAMENT-INJURED AND NON-INJURED ELITE TEAM HANDBALL PLAYERS

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**Background:** Non-contact anterior cruciate ligament (ACL) injuries represent a major problem in team sports, especially for women and little is known about risk factors. Therefore, a 5-year prospective cohort study has been initiated in the elite division of Norwegian female team handball to identify risk factors for ACL injuries.

**Objectives:** To compare previously ACL-injured and non-injured elite female team handball players and describe side-to-side differences in ACL-injured players.

**Design:** Case-control study.

**Participants:** 184 elite team handball players, 14 with unilateral reconstructed ACL injury.

**Methods:** Isokinetic quadriceps and hamstrings strength, isometric hip abduction strength, hamstrings mobility, knee laxity (KT1000), navicular drop and generalised joint laxity (Beighton index) were examined.

**Results:** No differences were found between groups in generalised joint laxity, leg press strength, navicular drop, hip anteversion or knee laxity. Injured players had greater hamstrings mobility than non-injured players ( $154^\circ$  ( $149^\circ$  to  $159^\circ$ ) versus  $144^\circ$  ( $143^\circ$  to  $146^\circ$ ),  $p = 0.002$ ) and greater hip abductor strength when the non-injured side was compared with non-injured players (13.7 (12.4 to 15.0) kg versus 10.9 (10.6 to 11.3) kg,  $p < 0.001$ ). When comparing the injured and non-injured leg, injured players had lower isokinetic quadriceps (163 (146 to 179) versus 181 (167 to 195) Nm,  $p = 0.048$ ) and hamstrings strength (99 (86 to 111) versus 107 (97 to 118) Nm,  $p = 0.042$ ) in their injured leg and there was a trend towards lower hip abductor strength (12.4 (11.2 to 13.6) versus 13.7 (12.4 to 15.0) kg,  $p = 0.069$ ). No difference was found in the ratio between hamstrings and quadriceps strength (0.61 (0.54 to 0.68) versus 0.59 (0.55 to 0.64),  $p = 0.66$ ). Among previously injured players, there were no significant differences between legs in hamstrings mobility, knee laxity, navicular drop or isometric hip abductor strength.

**Conclusions:** Generally, ACL-injured players were at least as strong as the non-injured group, but have returned to elite level pivoting sport with strength differences between the injured and the non-injured leg. Such side differences may leave players prone to new injuries.

## 129 SNOWBOARD INJURIES IN CHILDREN AND TEENAGERS: MEASURES FOR BETTER PREVENTION

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**Background:** In our clinic we treat a high number of people injured after a snowboard accident. We see differences in the kind of injuries and injured regions between children and adults. Children have a significantly higher rate of wrist and head injuries than adults. In snowboarding, there is a clear trend away from the slopes into freeride areas and to fun parks with half-pipes and oversized kickers. Here we see an increasing number of teenagers with joint injuries, especially of the ankle, traumatic dislocation of the hip joint and spine injuries with neurological damage.

**Design:** The study includes all injuries following snowboarding accidents, which have been treated in the trauma department of the Klinikum Garmisch-Partenkirchen between October 2002 and May 2007. All patients completed a standardised questionnaire concerning the accident and equipment used. The medical data were completed by the treating doctor. We compared the children and teenager group with the adult group.

**Results:** Altogether we examined 1929 patients. 13.0 % ( $n = 250$ ) were teenagers under 14 years and 37.2 % ( $n = 718$ ) were under 18 years. There were significant differences in the locations and type of injuries between children/teenagers and adults. The group under the age of 18 years had 45.4% fractures, the group not older than 14 years had 52.8% (adults 29.3%). The percentage of wrist fractures in this group was 82.1% (43.3% of all injuries in children younger than 15 years). In the children's group we noticed 30% more head injuries than in the adult group.

**Conclusions:** To reduce the frequency and severity of injuries of children, several factors have to be considered. The development and marketing of existing effective protectors, especially for the

wrist and also for the spinal column should be supported. The high rate of head injuries shows the necessity for helmets for children. In snowboarding, beginners should learn how to fall and ride the board to protect the wrist. Severe injuries are mostly caused by an overestimation of the teenager's own boarding skill, as well as misjudgement of the size of half-pipes and kickers.

## 130 FACTORS PREDISPOSING TO SNOW SPORTS INJURY IN SCOTLAND

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**Background:** Snow sports are associated with a risk of injury. Identifying risk factors for injury aids the development of programmes to reduce injury risk.

**Objective:** To investigate the factors predisposing to snow sports injury in Scotland.

**Design:** Retrospective case-control study.

**Setting:** The three largest commercial ski areas in Scotland.

**Participants:** All individuals sustaining an on-slope injury during the six winter seasons 1999/2000–2004/5. Control data were randomly collected from uninjured individuals during the same time frame.

**Interventions:** Individual demographic details and snow sports-related parameters were recorded from all participants.

**Main Outcome Measures:** Overall injury rate, odds ratios for independent factors associated with injury.

**Results:** A total of 2974 injuries were recorded and comparative data were collected from 2930 controls. Total skier days for the study period was 926 324, giving an overall injury rate for the study of 3.23 injuries per 1000 skier days (309 mean days between injury). Looking at the injury rate per study year, it has fallen from 3.72 injuries per total skier days in 1999 to 2.24 injuries per total skier days in 2005. Multivariate logistic regression analysis showed that the following factors were all independently associated with increased injury risk: (1) participant age  $< 17$  years (odds ratio (OR) 1.77, 95% CI 1.52 to 2.06); (2) snowboarding (OR 1.76, 95% CI 1.51 to 2.06); (3) not wearing a helmet (OR 1.42, 95% CI 1.16 to 1.75); (4) first-day participant (OR 3.85, 95% CI 2.97 to 4.98); (5)  $< 5$  days experience that season (OR 3.14, 95% CI 2.60 to 3.78); (6) taking more than 10 lessons (OR 2.86, 95% CI 2.26 to 3.61).

**Conclusions:** The risk of injury from snow sports in Scotland is comparable to rates seen in other alpine countries and the overall injury rate has decreased year on year since 1999. Independent risk factors for injury have been identified. These will aid the preparation and delivery of targeted injury prevention programmes.

## 131 RISK FACTORS FOR SNOW SPORTS INJURIES AMONG CHILDREN IN SCOTLAND

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**Background:** Children (defined as aged  $< 17$  years) have been identified as being at higher risk of snow sports injury in Scotland.

**Objective:** To compare the demographics of injured and uninjured children in all three main snow sports and to investigate the factors predisposing to injury in this age group.

**Design:** Retrospective case-control study.

**Setting:** The three largest commercial ski areas in Scotland.

**Participants:** All individuals sustaining an on-slope injury during the six winter seasons 1999/2000–2004/5. Control data were randomly collected from uninjured individuals during the same time frame. Individuals below the age of 17 years were identified.

**Interventions:** Demographic details and snow sports-related parameters were recorded from all participants.

**Main Outcome Measures:** Overall injury rate, odds ratios for independent factors associated with injury.

**Results:** 1642 (1027 injured and 615 uninjured) individuals under 17 years of age were included in this study. The injury rate among children was 5.28 per 1000 skier days, twice that seen in adults. There was no difference in gender between the two groups, although males predominated in both. The majority of injuries occurred as a result of alpine skiing. Fewer children in the injured group were wearing a helmet. No injured children were wearing wrist guards. Multivariate logistic regression analysis showed that the following factors were all independently associated with increased injury risk among children: (1) use of rental equipment (OR 1.69, 95% CI 1.21 to 2.36); (2) not wearing a helmet (OR 1.66, 95% CI 1.24 to 2.22); (3) <5 days experience that season (OR 2.25, 95% CI 1.47 to 3.46). Injury risk was reduced by increasing ability level and not taking professional lessons.

**Conclusions:** The risk of injury to children from snow sports in Scotland is twice that seen in adults. Independent risk factors for injury have been identified among children. This will aid the preparation and delivery of targeted injury prevention programmes.

### 132 CHRONIC GROIN PAIN: HIP STRENGTH AND FLEXIBILITY IN PROFESSIONAL SOCCER PLAYERS

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**Background:** Muscular imbalance of the combined action of the muscles stabilising the hip and pelvis could be a causative factor of chronic groin pain. The literature disagrees about the muscle functioning around the groin. The rationale of this study arises from the need to obtain a better understanding of the forces acting on the groin area and to identify the role of hip muscle strength and flexibility in developing chronic groin pain.

**Objective:** To evaluate the strength and flexibility of hip muscles in soccer players who experience chronic groin pain and compare findings with a control group.

**Methods:** 19 players with longstanding groin pain were assessed using isokinetic testing. A custom-built unit to facilitate functional testing in a standing position attached to the isokinetic device tested hip flexors, extensors, abductors and adductors muscles. Three functional hip flexibility tests were also performed. The control group consisted of 20 match healthy soccer players who were assessed using the same procedure.

**Results:** Deficit hip muscle strength was found in the symptomatic group compared with the control group. This was significant for all hip muscle flexors tests and some of the hip extensors tests. In the abductors and adductors groups of muscles, the difference between the groups was insignificant. There was no difference in flexibility between the groups.

**Conclusions:** The primary finding of the current study is the strength deficit of the hip muscles, specifically the hip flexors muscles in the symptomatic group. The current study does not consider whether the weakness is primary and arose before the pain existed, or whether it manifested itself after the pain and develops from pain inhibition or disuse atrophy. The current study found no difference in flexibility between the symptomatic and control groups, indicating that flexibility does not play a major role in the pathology of chronic groin pain.

### 133 EFFECT OF DIFFERENT RECREATIONAL ACTIVITIES ON BALANCE CONTROL IN OLD PEOPLE

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**Background:** One benefit of exercise intervention is the improvement of balance control function in order to decrease the risk factors and the contingent events for falls in old people. However,

the effects of various types of recreational activities on standing balance problems for gerontology remain to be resolved.

**Objective:** The purpose of this study was to investigate the standing balance control abilities at various heights of old people involved in different recreational activities.

**Participants:** Three groups of volunteers, ranging in ages from 65 to 74 years, participated in tai-chi quan, tennis and swimming.

**Design:** Six people from each group were chosen randomly and asked to stand using one foot with eyes open for 30 s.

**Main Outcome Measures:** The Catsys 2000 system was used to record and analyze the balance control abilities while the participants stood on ground, on a platform a quarter of the participants' height and on a platform half of the participants' height. The difference for the parameters of balance control ability included: mean sway, transversal X, sagittal Y, sway area, sway velocity and sway intensity. These were analyzed by mixed design, 3 (recreational activity) × 3 (treatment), two-way ANOVA with an alpha level of 0.05.

**Results:** The one-foot stance balance functions (mean sway, sagittal Y, sway area, sway velocity and sway intensity) showed that those who participated in the tai-chi quan exercise were significantly better than those who participated in tennis or swimming ( $p < 0.05$ ).

**Conclusions:** These findings indicate that old people in the habit of engaging in these three recreational activities have equal balance control while standing on both feet. It suggests that old people who play tennis and swimming should consider including more one-leg balance control exercise in their programme.

### 134 BRAZILIAN PHYSIOTHERAPY SERVICES IN THE 2007 PAN-AMERICAN GAMES

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**Objective:** Assess the profile of the treatments performed at the physiotherapy department of the Brazilian Olympic Committee during the 2007 Pan-American Games.

**Design:** Observational study.

**Participants:** All athletes who were official members of the Brazilian delegation during the 2007 Pan-American Games and sought treatment at the Brazilian Olympic Committee physiotherapy department.

**Results:** Most athletes of the Brazilian delegation needed physiotherapeutic treatment ( $n = 434$ , 65.7%), the majority of the lesions occurred within a period of time of less than 7 days ( $n = 288$ , 66.4%) and approximately one quarter of the Brazilian athletes went to the games with a previous injury ( $n = 146$ , 22.1%). The main injuries observed during the treatments were spine-related pathologies (lumbar pain, dorsalgia and cervical pain), in a total of 25.3% ( $n = 89$ ) of all lesions, tendinopathy ( $n = 79$ , 22.4%), muscle lesion ( $n = 43$ , 12.2%), among others. The parts of the body most referred to in the athletes' complaints were the spine ( $n = 204$ , 38.2%), followed by the thigh area ( $n = 66$ , 12.4%) and knee ( $n = 57$ , 10.7%). 2523 physical therapeutic treatments and 3897 physical therapeutic procedures were performed. The most utilised procedures were kinesiotherapy, which represented 24.9% ( $n = 969$ ) of all the procedures performed, ultrasound ( $n = 757$ , 19.4%) and cryotherapy ( $n = 670$ , 17.2%).

**Conclusion:** A large number of athletes required physiotherapy services during the games. One third of the athletes were injured before the competition started. The main pathologies were spine-related ones, tendinopathy and muscle lesion. The spine, the thigh and the knee were the most affected parts of the body. The most frequently utilised procedures at the physiotherapy department were kinesiotherapy, ultrasound and cryotherapy.



### 135 STRESS FRACTURES IN FEMALE BORDER POLICE RECRUITS DURING BASIC TRAINING

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**Introduction:** Female recruits are known to have a relatively high incidence of stress fractures. This was also apparent when female fighters entered the Israel border police training programme.

**Materials and Methods:** From February 1996 to February 1998, five courses of female recruits were held with a total of 229 participants. The four later courses were controlled and strictly documented. Due to the high incidence of stress fractures, 35% total and 27% “dangerous” stress fractures, four modifications were gradually introduced. Shoes were replaced, nutrition was modified, a training scale was programmed and preselection of candidates was eventually added.

**Results:** For 229 female fighters taking part in the five courses the following data were recorded: (1) The incidence of fighters with stress fractures affecting the shaft of the long bones (“dangerous” stress fractures), reduced gradually from 27% to 15%. (2) The incidence of fighters with grade II or higher dangerous stress fractures reduced gradually from 19% to 8.3%. (3) The total average number of dangerous stress fractures per fighter (all grades) reduced gradually from 0.54 to 0.35.

**Discussion:** The above data seem to suggest a tendency towards a gradual reduction in the rate and severity of stress fractures in female recruits following various modes of intervention. The differences are not statistically significant as the total numbers and differences are low but the trend seems to be stable and consistent.

**Conclusions:** Various interventions, including shoe modification, nutrition, controlled training programme and a prerecruitment course seems to have a certain effect in reducing the incidence and severity of stress fractures, especially those termed “dangerous stress fractures”.

### 136 STRESS FRACTURES REDUCTION BY EQUIPMENT MODIFICATION IN BORDER POLICE FEMALE FIGHTERS RECRUITS: PART II

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**Introduction:** Stress fractures are common among female fighters. The aim of this study was to assess whether combat equipment modification, by mildly reducing weight and approximating the gear to the body centre of gravity could reduce stress fracture incidence in female recruits.

**Methods:** 216 border police female recruits, aged 18–19 years, undergoing basic combat training of 16 weeks, were followed prospectively for stress fracture incidence using modified fighting gear: a short M16 rifle and a lighter and closely fitted combat vest. The incidence of stress fractures in the intervention group was compared with a control group of 229 female fighter recruits who used the traditional equipment and who were followed by the same research group along previous years from 2003 onwards.

**Results:** Equipment modification was associated with a significant reduction in stress fractures from 18.3% in the control group to 7.9% in the intervention group. The incidence of “dangerous” stress fractures (fighters with stress fractures of long bones or foot navicular) reduced from 15.3% to 5.6%. The incidence of fighters with stress fractures of the tibial shaft, fibular shaft, femoral shaft or femoral neck decreased from 12.2% to 4.2%. The incidence of

fighters with femoral stress fractures decreased from 5.7% to 2.3%. The major part of these data was strongly significant. The total average number of stress fractures per fighter was reduced from 0.38 fractures to 0.23, whereas the average number of “dangerous” stress fractures per fighter was reduced from 0.27 to 0.15. Training days lost per fighter for reason of stress fracture was reduced from 2.8 days per fighter to 1.4 days.

**Conclusions:** Study results suggest that a significant reduction in the incidence of stress fractures in female recruits may be achieved by reducing equipment weight and changing configuration of the combat gear so as to approximate it to the body centre of gravity.

### 137 PRE-SEASON EVALUATION OF CORE STABILITY IN ELITE FOOTBALL PLAYERS: ISOMETRIC DOUBLE STRAIGHT LEG-LOWERING TEST VERSUS ISOKINETIC TRUNK MUSCLE TESTING

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**Background:** The importance of core stability in athletes is being increasingly recognised. Core stability relates to athletic performance as well as injury risk reduction. Consequently, pre-season evaluation of core stability seems advisable. Isokinetic, isoinertial and isometric methods are being used. Whether a less costly and more simple isometric test could replace a more elaborate isokinetic test has never been evaluated.

**Objective:** To determine the correlation in isokinetic trunk muscle testing (flexion/extension) and the double straight leg-lowering (DSL) during a pre-season evaluation of football players.

**Design:** This prospective study evaluated the maximal concentric isokinetic trunk flexion/extension strength and the DSL in 56 elite football players.

**Setting:** Testing was done at the University Hospitals Leuven. 56 elite football players were tested, 42 professionals, 14 elite youth players.

**Patients:** 56 asymptomatic elite football players (mean age 24.3 years, range 13–37) were tested before the football season 2007–8.

**Interventions:** They had to perform the DSSL test as long as possible with a maximum duration of 60 s. Isokinetic trunk muscle testing was also done (Cybex dynamometer, trunk flexion/extension at angular velocity of 60° and 120° per second). Body weight adjusted peak torque was measured and correlated to the duration (in seconds) of the DSL test.

**Results:** Using the Pearson's and the Spearman correlation tests, the correlation between both tests was weak. The best correlation was found between peak torque extension of the trunk at 120°/s and the DSL (Pearson's correlation coefficient 0.21085,  $p = 0.026$ ; Spearman correlation coefficient 0.19476,  $p = 0.040$ ). Even after correction of attenuation no higher correlation could be found.

**Conclusion:** The isometric DSL and isokinetic trunk muscle test, commonly used to assess core stability, do not correlate well in a pre-season evaluation of asymptomatic football players. This suggests they should be regarded as complementary. Further follow-up of these elite football players will be used to demonstrate the injury prediction aspects of these different tests.

### 138 THE EFFECT OF PREMATURE RETURN TO PLAY ON RE-INJURY RISK IN ELITE ADOLESCENT ICE HOCKEY AND ASSOCIATED PSYCHOSOCIAL PREDICTORS

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**Background:** Hockey has one of the highest injury rates for adolescent sports in Canada. Although the physical risk factors for

injury have been studied, it is not known how psychosocial factors affect injury and re-injury rates.

**Objectives:** To determine whether return to play before medical clearance affects re-injury rates and to investigate the role of athletic identity, attitudes towards body checking, anxiety and rumination in the injury/re-injury process.

**Design:** Prospective cohort.

**Setting:** Participants were randomly recruited by team from the Calgary Minor Hockey Association at the beginning of the 2007–8 season.

**Participants:** 315 participants from elite (A, AA, AAA) Bantam (age 13–14 years) and Midget (age 15–17 years) teams.

**Assessment of Risk Factors:** Participants completed five self-report questionnaires early in the season and again after injury: (1) medical questionnaire; (2) body checking questionnaire; (3) athletic identity measurement scale; (4) competitive state anxiety inventory—2R; (5) stress reactive rumination questionnaire. Participants were followed through the season for injury reports. The injury definition included any hockey injury resulting in medical attention, the inability to complete a hockey session, and/or missing a subsequent hockey session.

**Results:** Based on preliminary univariate analysis, the overall injury rate was 43.99 injuries per 100 players (95% CI 38.44 to 49.65). Incidence rate ratios (IRR), adjusted for clustering by team, suggest a significantly increased risk of injury for players in the highest division (AAA versus AA or A) (IRR 1.75; 95% CI 1.14 to 2.68) and those who scored below the 25th percentile in athletic identity (IRR 1.53; 95% CI 1.05 to 2.22). Injury risk did not differ by age group, previous injury, attitudes towards body checking, level of anxiety or rumination. Further analyses will determine the risk of re-injury associated with these factors and with return to play before medical clearance.

**Conclusions:** Injury risk increases with increasing level of play and decreasing levels of athletic identity. Return to play before medical clearance and increasing levels of anxiety and rumination are expected to predict re-injury.

### 139 EXAMINING ATTITUDES TOWARDS BODY CHECKING, LEVELS OF EMOTIONAL EMPATHY AND LEVELS OF AGGRESSION IN BODY CHECKING AND NON-BODY CHECKING YOUTH HOCKEY LEAGUES

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**Background:** Hockey participation may affect empathy and aggression development in adolescence but the impact of body checking on such psychosocial development has not been examined.

**Objectives:** To determine if attitudes associated with body checking, emotional empathy and aggression differ between players in body checking and non-body checking hockey leagues and to determine the influence of these attitudes on injury rates.

**Design:** Prospective cohort.

**Setting:** Participants were randomly recruited by team from the Calgary Minor Hockey Association at the beginning of the 2006–7 season.

**Participants:** There were 283 participants from Pee Wee (age 11–12 years), Bantam (13–14 years) and Midget (15–16 years) teams. Thirteen teams from the body checking league ( $n = 138$ ) and 24 teams from the non-body checking league ( $n = 145$ ) participated.

**Assessment of Risk Factors:** Participants completed four self-report questionnaires early in the season: (1) medical questionnaire; (2) body checking questionnaire; (3) empathy index for children and adolescents; (4) Buss–Perry aggression questionnaire. Participants were followed through the season for injury reports. The injury definition included any hockey injury resulting in medical attention, the inability to complete a hockey session and/or missing a subsequent hockey session.

**Results:** The body checking cohort reported significantly more positive attitudes towards body checking (35.59; 95% CI 34.52 to 36.65) than the non-body checking cohort (22.43; 95% CI 21.38 to 23.49) ( $t = -17.34$ ;  $p < 0.00005$ ). There was no significant difference between the empathy scores of body checking and non-body checking players ( $t = 1.51$ ,  $p = 0.13$ ). The mean aggression score for the body checking players (76.22; 95% CI 73.18 to 79.25) was significantly higher than the mean for the non-body checking players (70.57; 95% CI 67.35 to 73.80) ( $t = -2.52$ ;  $p = 0.013$ ). There was a fivefold increase in injury risk for body checking players, irrespective of psychosocial factors.

**Conclusions:** Body checking appears to influence attitudes towards body checking and aggression, but attitudes towards body checking, empathy and aggression did not influence injury rates. Additional research is recommended.

### 140 SPINAL INJURIES FOLLOWING CYCLING ACCIDENTS: 14-YEAR EXPERIENCE WITHIN A NATIONAL SPINAL UNIT

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**Background:** The number of adults taking part in cycling both recreationally and as a sport has almost doubled in Scotland in the past 10 years. There are very few data available on the epidemiology of cycling injuries, in particular spinal injuries, which can result in serious and permanent disability.

**Objective:** To investigate the epidemiology of spinal injuries sustained in cycling accidents in Scotland over 14 years.

**Design:** Retrospective review of prospective database information, plus examination of case notes.

**Setting:** Queen Elizabeth National Spinal Injuries Unit, Glasgow, which uniquely serves all patients in Scotland with spinal injuries and threatened or actual cord damage.

**Patients:** Data were obtained on all patients admitted to the unit since its opening who had sustained a spinal injury in a cycling accident. Total patients 38.

**Interventions:** Independent variable: injuries on highway versus off road.

**Main Outcome Measures:** Sex, age, site of injury, severity of neurology, associated injuries and proportion of accidents occurring on the highway.

**Results:** Male predominance (89%). Mean age 37 years (range 15–67). Levels of spinal injury: 27 cervical (71%); nine thoracic (24%); two lumbar (5%). Neurology: eight (21%) patients had complete neurology (loss of sensory and motor function); 12 (32%) were incomplete (some sparing of either sensory or motor function); 18 (47%) were intact (no sensory or motor loss). 67% of all accidents occurred on the highway. 14 patients had 23 associated injuries. Most common were minor orthopaedic injuries, then major orthopaedic limb injuries, then head and trunk injuries.

**Conclusions:** These data highlight the importance of educating both cyclists and other road users on highway safety. Also the need for the upkeep of dedicated cycling tracks and the high index of suspicion required to diagnose spinal injuries in cyclists, taking into account the mechanism of injury and pattern of associated injuries.

### 141 MUSCLE PRE-MOTOR PHASE MEASURES DURING A SIMPLE CHOICE REACTION TASK PREDICT HIGH-RISK KNEE LANDING POSTURES

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**Background:** Peak knee abduction angles during dynamic landings prospectively predict anterior cruciate ligament injury risk in young

women. Reducing knee abduction during these manoeuvres should thus be central to the prevention strategy. The complex control patterns often associated with landings, however, make this goal extremely challenging. Identifying simple neuromuscular predictors of knee abduction may provide a critical springboard in this process.

**Objective:** Determine associations between muscle pre-motor phase timings for a simple choice reaction task and resultant peak knee abduction angles during landings.

**Design:** A single experimental block design.

**Setting:** NCAA division 1 athletes.

**Participants:** Twenty-two women ( $19.7 \pm 2.1$  years) with no previous major lower-limb injury or surgery.

**Assessment of Risk Factors:** Subjects began in a stationary position and pushed off rapidly to the left or right as directed by a randomly timed and ordered light stimulus. Muscle electromyography data were recorded for the dominant limb during trials ( $n = 10$ ) in which it was the "push-off" limb. Pre-motor phase data were calculated for eight dominant limb muscles, defined as times between stimulus onset and respective muscle activation onsets. Subjects then performed unanticipated single-leg landings, with jump direction governed by random light stimuli activated before initial ground contact. Peak knee abduction angle was calculated for trials ( $n = 10$ ) in which the dominant limb was the landing limb.

**Main Outcome Measures:** Correlation coefficients were computed between each of the eight mean subject-based muscle pre-motor phases and mean peak knee abduction angles.

**Results:** Medial gastrocnemius ( $R^2 = 0.63$ ), hamstring ( $R^2 = 0.64$ ) and quadriceps ( $R^2 = 0.42$ ) pre-motor phases all correlated strongly with peak knee abduction angle. In particular, increased knee abduction occurred with relative pre-motor phase increases for each of these muscles.

**Conclusions:** Assessing muscle pre-motor phases during simple choice reaction tasks may improve screening for female anterior cruciate ligament injury risk. The potential to reduce medial gastrocnemius, hamstring and quadriceps muscle pre-motor phases should also be explored within current prevention modalities.

#### 142 THE MOST COMMON INJURY AND MUSCULOSKELETAL COMPLAINTS IN SITTING VOLLEYBALL: A LONG-TERM SURVEY

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**Background:** There are still only a few studies available on the injury rate and pattern in sport for persons with a disability. Through literature search, we did not find any long-term injury survey published.

**Objective:** The main objective of the study was to assess the rate, pattern and predisposing factors for musculoskeletal injury in sitting volleyball.

**Design:** A prospective study was started in 1997, collecting: (1) through several rounds of an original questionnaire to be filled in by the team's medical staff; (2) through the player's individual history of injuries, which was collected as a part of the formal medical classification proceedings.

**Setting:** The research was conducted by the Medical Department of the World Organisation Volleyball for Persons with a Disability (WOVD).

**Participants:** A total of 256 international sitting volleyball players entered the study (168 male and 88 female, mean age at the start  $28.2 \pm 6.1$  years). The inclusion criteria were: player had a defined primary diagnosis/disability, had attended a medical classification and was officially entered for the European and/or World

Championships, European and/or World Cups, the relevant team had a medical personnel (doctor or physio) in charge. The 129 players (82 males and 47 females) finished the study in 2007.

**Assessment of Risk Factors:** All the reported injuries (I) and musculoskeletal complaints (C) were calculated and analyzed in relation to the gender, age, onset, amount of training/competition load, type and duration of the primary disability. There was a subgroup of lower extremity amputees (which averaged to 72% of the contingent) divided for a separate analysis.

**Main Outcome Measures:** Participants have reported the secondary (sports related) I and C, their severity, morphological diagnosis (if available). I, C and their severity were defined by the amount of days completely refraining from sport practice (at least for one day) or soundly aggravating sport-specific movements.

**Results** Low back pain of different origins (42%, mostly chronic), sprains of the wrist and fingers (17%, mostly acute), shoulder rotator cuff pathology (17%, mostly chronic) were the most common I and C. The incidence of I/C was on average one per player/year, it has correlated positively to the age and duration of the primary disability.

**Conclusions:** There was a high prevalence of overuse injuries, mostly in players with a long-term disability; the injury pattern was related to sitting volleyball biomechanics and training load.

#### 143 IMPORTANCE OF THE EYES FOR TACKLE INJURY PREVENTION IN RUGBY UNION

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**Background:** Rugby has a high rate of head and neck injuries caused by tackling. In the case of a tackler's injury, his head often makes contact with the ball-carrier before his shoulder during the contact phase, as a result of averting his eyes from the target.

**Objective:** This study investigated the importance of eye direction and head position in preventing severe tackle injuries.

**Setting:** All competitive level players from U-17 to U-23 age groups.

**Participants:** 10 Japanese rugby union players (age  $21.0 \pm 6.7$  years).

**Intervention:** Participants kept the front-tackle posture to the right for 10 s on the force plate. Laterality of the vertical ground force was measured from the feet and centre of foot pressure in two different head positions: maintaining a straight neck while watching the target and keeping the neck rotated to the left with the eyes averted from the target. The subjects were also pushed on the right shoulders while keeping their posture at maximum effort.

**Main Outcome Measurement:** When the tackler turned his eyes from the target, it was observed that he had difficulty in executing his tackle and was easily thrown down by his opponent at the contact phase. The findings suggest that asymmetric tonic neck reflex during the tackle may demonstrate an association between eye direction and injury rate.

**Results:** During these head positions with and without pushing the shoulder, the ground force changed from right foot to left foot when the players turned their eyes from the target ( $p < 0.05$ ). In both postures, when the player's neck rotated left, centre of foot pressure deflection was significantly shifted from right to left and backwards ( $p < 0.05$ ).

**Conclusion:** Our findings suggest that a tackle performed with attention to the head position and with eyes kept firmly on the the opponent may help to reduce severe tackle injuries in rugby players.



# 144 A REPORT ON THE INCIDENCE OF INJURIES FOR JUNIOR HIGH SCHOOL BASKETBALL TEAMS IN YOKOHAMA: INTRODUCTION OF AN INJURY PREVENTION PROGRAMME

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**Background:** Female basketball athletes tend to land with increased knee valgus and demonstrate a higher incidence of anterior cruciate ligament (ACL) injuries than males.

**Objective:** To determine the incidence of injuries among junior high school basketball teams in Yokohama and the effects of an injury prevention programme on biomechanical characteristics.

**Design:** A retrospective cohort study and longitudinal pre-post-intervention study.

**Setting:** Junior high schools and a biomechanical research laboratory in Yokohama.

**Participants:** From 2003 to 2005, 20 358 junior high school athletes (12–15 years old) participated in the epidemiological study. Thirty female athletes were selected for the pre-post-intervention study.

**Interventions:** Injury data were retrospectively registered. Testing sessions were conducted before and 6 months after the introduction of the Yokohama Basketball Prevention Programme (YBPP).

**Main Outcome Measures:** The frequency of all injuries and the rate of ACL injuries and ankle sprains were calculated. Injury rates were denoted as per 1000 player hours. For the intervention study, three-dimensional kinematics during landing were compared pre and post-YBPP.

**Results:** There were 1974 reported injuries. The ankle was most frequently injured (226 (24%) male and 332 (32%) female reports). The incidence of ACL injury was 0.001 per 1000 player hours for males and 0.007 per 1000 player hours for females. The incidence of ankle sprain was 0.065 and 0.112 per 1000 player hours for males and females, respectively. Females have a significantly higher incidence of ACL injury and ankle sprain than males. Following the YBPP, subjects changed knee kinematics.

**Conclusions:** Whereas female players had a higher rate of injury, they also exhibited significant changes in knee kinematics. In the future, additional studies to examine the epidemiological effects of the YBPP are required.

# 145 THE INCIDENCE OF INJURY FOR THE JAPANESE TOP LEVEL FEMALE BASKETBALL LEAGUE

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**Background:** Female basketball athletes have a higher risk of injury than male athletes. However, no study has reported the incidence of injuries for the Japanese top level female basketball league.

**Objective:** To examine the incidence of injuries in the Japanese top level female basketball league.

**Design:** A retrospective cohort study.

**Setting:** Female basketball athletes: top level league in Japan.

**Participants:** From the 2005–6 season, 137 players from 10 teams were examined. During the 2006–7 season, 158 players from 12 teams were included.

**Interventions:** Injury data were retrospectively registered. The athletic trainer collected the injury data and player hours.

**Main Outcome Measures:** The frequency of all injuries and the rate of anterior cruciate ligament (ACL) injuries and ankle sprains were calculated. The game-related injury rates were also calculated. Injury incidences were denoted as per 1000 player hours.

**Results:** During two seasons, 218 injuries were reported. The ankle was most frequently injured with 76 reports (34.9%) followed by the knee with 49 reports (22.5%). The most common ankle injury was a lateral ankle sprain (50 reports, 22.9%), with an incidence rate of 0.42 per 1000 player hours and 4.14 per 1000 game competition player hours. There were 13 (6.0%) ACL injuries reported, with an incidence rate of 0.08 per 1000 player hours and 2.07 per 1000 game competition player hours. 27 of the 50 lateral ankle sprains and 11 of the 13 ACL injuries were non-contact injuries.

**Conclusions:** The ankle and knee were most commonly injured. Lateral ankle sprains and ACL injuries occurred more frequently during games. Most of the injuries were non-contact injuries. In the 2007–8 season, a three-step injury prevention programme focusing on jump/landing techniques, balance, basketball skill and strength was introduced. In the future, additional studies will be performed to examine the effects of this prevention programme.

# 146 RISK FACTORS FOR GRAFT RUPTURE AND CONTRALATERAL RUPTURE AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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**Background:** Graft rupture and contralateral rupture after anterior cruciate ligament (ACL) reconstruction are not uncommon.

**Objective:** The objectives of this study were to investigate cases with a contralateral ACL rupture and cases with a graft rupture after ACL reconstruction.

**Design:** Retrospective study.

**Patients and Interventions:** There were 578 patients who underwent ACL reconstruction between October 1998 and March 2006. Thereafter, 23 patients (bilateral group) had an ACL injury on the contralateral side and 12 patients (re-rupture group) had a graft rupture due to apparent trauma >6 months after ACL reconstruction. The mechanisms of injury at the initial injury and at re-injury were examined in these 35 subjects. The control group consisted of 223 patients who had unilateral injury. The age at the initial surgery and 6-month postoperative muscle strength for knee extension and flexion were compared.

**Results:** In the bilateral group, non-contact injuries accounted for 96% of the initial injuries and 87% of the re-injuries. In the re-rupture group, non-contact injuries accounted for 83% of the initial injuries and re-injuries. Among those with non-contact initial injuries, 45% in the bilateral group and 60% in the re-rupture group were re-injured by almost the same mechanism as that at the initial injury. The ages at the initial injury were lower for the bilateral and re-rupture groups than the control group. Six months postoperatively, there was no significant difference in the muscle strength among the three groups.

**Conclusions:** Most of the cases had non-contact injuries and not injuries caused by insufficient muscle strength or anterior instability of the involved lower extremity. We saw that the kinesiological predisposing factors are greatly involved in graft rupture >6 months after ACL reconstruction and contralateral rupture. Using a neuromuscular training programme may have a direct benefit in decreasing the number of repeat ACL injuries.

# 147 INFLUENCE OF STATIC LOWER EXTREMITY POSTURE ON HIP AND KNEE MOTIONS DURING DROP JUMP LANDINGS

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**Background:** Static lower extremity posture (LEP), suggested as a risk factor for lower extremity injuries, potentially contributes to abnormal mechanics or compensatory motions. However, the relationship between static LEP and dynamic motion is unknown.

**Objective:** To determine if clinical measures of LEP are predictive of hip and knee motions during drop jump landings.

**Design:** Descriptive cohort study.

**Setting:** Controlled laboratory.

**Participants:** 69 (41 women, 28 men) physically active participants ( $22.2 \pm 2.9$  years,  $169.9 \pm 11.5$  cm,  $69.2 \pm 15.7$  kg).

**Assessment of Risk Factors:** The dominant stance limb was measured for pelvic angle, hip anteversion, quadriceps angle, tibiofemoral angle, genu recurvatum, tibial torsion and navicular drop using clinical techniques. Kinematic data were collected during five double leg drop jump landings. Stepwise linear regressions examined whether static LEP were predictive of joint excursions.

**Main Outcome Measures:** Joint excursion (degrees) was calculated (peak – initial joint angles) during initial landing for hip adduction (hipADD) and internal rotation (hipIR) and knee valgus (kneeVAL) and external rotation (kneeER).

**Results:** Descriptive values (mean  $\pm$  SD) were: pelvic angle ( $11.0^\circ \pm 4.5^\circ$ ), hip anteversion ( $10.5^\circ \pm 6.0^\circ$ ), quadriceps angle ( $12.9^\circ \pm 5.5^\circ$ ), tibiofemoral angle ( $11.2^\circ \pm 3.0^\circ$ ), genu recurvatum ( $3.5^\circ \pm 3.9^\circ$ ), tibial torsion ( $21.1^\circ \pm 7.9^\circ$ ), navicular drop ( $6.2$  mm  $\pm 4.7$  mm), hipADD ( $5.3^\circ \pm 4.9^\circ$ ), hipIR ( $5.9^\circ \pm 5.3^\circ$ ), kneeVAL ( $4.6^\circ \pm 4.8^\circ$ ), kneeER ( $-8.1^\circ \pm 9.5^\circ$ ). Greater hip anteversion ( $R = 0.296$ ) and tibiofemoral angle ( $R = 0.238$ ) combined to predict greater hipADD ( $R^2 = 0.148$ ,  $p = 0.034$ ). Greater navicular drop ( $R = 0.448$ ) predicted greater hipIR ( $R^2 = 0.201$ ,  $p < 0.001$ ). Greater quadriceps angle ( $R = 0.399$ ), hip anteversion ( $R = 0.393$ ) and lower tibiofemoral angle ( $R = -0.085$ ) combined to predict greater kneeVAL ( $R^2 = 0.329$ ,  $p = 0.011$ ). Greater hip anteversion ( $R = 0.244$ ) and tibiofemoral angle ( $R = 0.228$ ) combined to predict greater kneeER ( $R^2 = 0.114$ ,  $p = 0.047$ ). Pelvic angle, genu recurvatum and tibial torsion were not predictive of any joint excursions.

**Conclusions:** Static LEP promoting the potential for inward collapse of the knee may contribute to dynamic malalignments thought to be predictive of lower extremity injury. Further research should examine the influence of static and dynamic malalignments on joint loading patterns.

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# 148 ANKLE NEUROMUSCULAR PROTECTIVE REFLEX ACTION: FATIGUE EFFECT IN MUSCLE RESPONSE TO INSTABILITY

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**Background:** Ankle joint forces have been widely stated in several biomechanical research papers as main risk factors for injury. Quite a few of these studies have also confirmed this joint as one of the most prone to injury in high level sports. Consequently, peroneal muscles set themselves as ankle primary external dynamic stability managers.

**Objective:** Our main purpose was to assess peroneal muscle reflex action, in results of unexpected sudden ankle joint inversion. We also intended to determine the effect of competitive game play fatigue in ankle joint stability of youth handball players.

**Design:** Within-subject repeated measures.

**Setting:** University-based physical activity facility.

**Participants:** For this purpose we gathered a sample of 13 professional youth handball players (national team,  $17.7 \pm 0.5$  years), with a broad sports background (3 years or more) and without musculoskeletal injuries or ankle/knee restraints.

**Interventions:** Players were instructed to step on top of an exclusively designed ankle “trap-door” (handcrafted for joint inversion) placed over a force-plate. Their dominant lower limb was exposed to 10 unexpected unilateral ankle joint inversions (with no previous knowledge of initial action timing). Electromyographic (EMG) signals were recorded from peroneal muscles (long and short portions). The subjects were assessed at the beginning, half and end-game time of a formal competitive team handball game.

**Main Outcome Measures:** EMG onset activation timing; EMG average rectified signal.

**Results:** Our results demonstrated that after the game’s first half, there was a clear tendency for an increase in EMG activation of peroneal muscles and faster reflex action, possibly due to muscle temperature increase, which probably led to reduced muscle inhibitory effects. However, end-game values suggested the existence of a progressive fatigue effect, supported by slower reflex action timings and lower muscle EMG activation, thus enhancing neuromuscular control importance in ankle stability after fatiguing events.

# 149 FUNCTIONAL DIFFERENCES IN KNEE FLEXOR MUSCLES DURING ECCENTRIC KNEE FLEXION

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**Background:** Functional differences of knee flexor muscles, biceps femoris long head, semitendinosus, semimembranosus and gracilis, during eccentric knee flexion exercise and damage after eccentric contraction are still unclear.

**Objective:** The purpose of this study was to clarify the detailed differences in knee flexor muscles of electromyography (EMG) activities during and temporal damage after eccentric knee flexion.

**Design:** Time-series study comparing the physiological reactions before and after experimental loading.

**Setting:** Untrained, recreational level volunteers performed a session of eccentric knee flexion exercises (five sets of 10 at 120% of one repetition of maximum) by using a plate-loaded machine.

**Participants:** Seven healthy male volunteers (age  $24 \pm 2$  years) were recruited from the university community. All subjects provided written informed consent before participation.

**Interventions :** All subjects were instructed to avoid sports activities, refrain from using ice packs or anti-inflammatory medications 1 week before and during the experiment.

**Main Outcome Measures:** The integrated EMG value of each knee flexor muscle during the exercise was computed as a percentage change relative to the value of the first repetition. T2-weighted transverse spin-echo magnetic resonance images of the thigh were obtained before and immediately after exercise as well as 1, 2, 3, and 7 days after evaluation. T2 relaxation time of each muscle was computed as a percentage increase relative to the value measured pre-exercise.

**Results:** Immediately after exercise, the T2 relaxation time increased in all muscles; however, two or more days after exercise, significant increases were found only in the semitendinosus but not in the other muscles.

**Conclusion:** Differences in damage were noted in the knee flexor muscles after eccentric knee flexion exercise and the semitendinosus was particularly affected two or more days after exercise. This difference can be attributed to morphological and functional differences among these muscles.

# 150 AN EPIDEMIOLOGICAL STUDY OF INJURIES WITHIN ENGLISH ACADEMY AND SCHOOLS YOUTH RUGBY UNION

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**Background:** Rugby union has one of the highest injury incidence rates of any sport. There are numerous injury epidemiology research studies into senior amateur and professional rugby union, but investigations into youth rugby union (aged 16–18 years) are limited and there is a need to establish whether the injury model is similar within youth rugby union.

**Objective:** To observe the aetiology of injuries within English academy and schools youth rugby union over one season.

**Design:** A prospective injury audit using questionnaire-based data collection and the Orchard Sports Injury Classification System (version 8).

**Setting:** English premier league rugby union academies and linked elite feeder schools.

**Participants:** Players (aged 16–18 years) were recruited from 13 academies ( $n = 123$ ) and six schools ( $n = 111$ ).

**Assessment of Risk Factors:** Incidence of injury, severity, nature and location were observed.

**Main Outcome Measures:** Incidence of match and training injuries.

**Results:** Injury incidence was 22 and 34 injuries per 1000 player match hours and 0.9 and 1.8 injuries 1000 player training hours for academies and schools, respectively. Upper-limb dislocations were the most severe injuries and lower-limb ligament injuries the most prevalent in both academies and schools.

**Conclusions:** The incidence of match injuries was 50% higher and training injuries 100% higher in English schools compared with academy youth rugby union players. These initial results suggest that schools rugby union may require attention. This research is continuing to clarify these findings further.

# 151 NEUROMUSCULAR DYSFUNCTION IN PERSONS WITH FUNCTIONAL ANKLE INSTABILITY

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**Background:** Functional ankle instability (FAI) may be prevalent in as many as 40% of patients after an acute lateral ankle sprain. Diminished afference resulting from damaged mechanoreceptors after an ankle sprain may lead to reflex inhibition of surrounding joint musculature. This weakness, referred to as arthrogenic muscle inhibition (AMI), maybe the underlying cause of FAI. Incomplete activation and delayed motor unit firing could prevent adequate control of the ankle joint leading to repeated episodes of instability.

**Objective:** To determine if AMI is present in the peroneal musculature of patients with FAI and to examine whether AMI is correlated to dynamic instability.

**Design:** A cross-sectional study design.

**Setting:** Neuromuscular research laboratory.

**Participants:** Twenty-one subjects with unilateral FAI ( $21 \pm 2$  years,  $71 \pm 7$  cm,  $65 \pm 9$  kg) and 21 matched controls ( $21 \pm 3$  years,  $169 \pm 9$  cm,  $64 \pm 10$  kg) volunteered to participate.

**Assessment of Risk Factors:** The independent variable was limb (pathological and non-pathological).

**Main Outcome Measures:** AMI was quantified using the peroneal H : M ratio, whereas dynamic ankle stability was evaluated using peroneal average root mean square electromyography (EMG) amplitude and reaction time.

**Results:** FAI subjects had larger peroneal H : M ratios in their pathological ankle ( $0.399 \pm 0.185$ ) compared with their non-pathological ankle ( $0.323 \pm 0.161$ ;  $p = 0.036$ ), whereas no

differences were noted between the ankles of the controls ( $0.442 \pm 0.176$  and  $0.425 \pm 0.180$ ). FAI subjects also exhibited significantly higher latencies and lower EMG in their pathological ankle (latency  $106.6 \pm 48.7$ ; EMG  $1.7 \pm 1.3$ ) compared with their uninjured ankle (latency  $74.3 \pm 23.3$ ; EMG  $3.3 \pm 3.1$ ;  $p < 0.001$ ), whereas no differences between legs were noted for controls ( $p > 0.05$ ). No significant correlations were found between the peroneal H : M ratio and the measures of dynamic instability ( $p > 0.05$ ).

**Conclusions:** AMI is present in the peroneal musculature of persons with FAI but is not related to dynamic ankle instability. Reversing AMI may not assist in protecting the ankle from further episodes of instability.

# 152 ARTIFICIAL PLAYING SURFACE INCREASES THE INJURY RISK IN PIVOTING INDOOR SPORTS

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**Background:** Floorball is a fast growing indoor team sport that has become very popular in Europe during the past decade. Studies on floorball injuries have shown that floorball is a sport that often results in injuries, with the knee and ankle being the most common injured sites. In recent years, the use of artificial surfaces has increased in floorball centres but the influence of floor type on injury risk has not yet been investigated in floorball.

**Objective:** To compare the injury risk in female floorball between two different surfaces: artificial floors and wooden floors.

**Design:** A prospective follow-up study.

**Setting:** 26 top level Finnish female floorball teams were followed for one competitive season (6 months).

**Participants:** 331 licensed players from the elite league and first division.

**Main Outcome Measures:** All traumatic game-related time-loss injuries were recorded. Injury incidences were calculated as the number of injuries per 1000 game hours for both surfaces. Incidence rate ratios (IRR) were obtained from Poisson regression models.

**Results:** Over the competitive season, 62 traumatic injuries occurred during the games. The injury incidence per 1000 playing hours was 59.9 (95% CI 43.2 to 83.0) on artificial floors and 26.8 (95% CI 18.2 to 39.3) on wooden floors, the adjusted IRR being twofold higher (IRR 2.1; 95% CI 1.2 to 3.5,  $p = 0.005$ ) on artificial floors than wooden floors. The risk for non-contact injuries (adjusted IRR 12.5; 95% CI 2.9 to 54.9,  $p = 0.001$ ) and severe injuries (adjusted IRR 3.3; 95% CI 0.9 to 10.9,  $p = 0.052$ ) was especially high when playing on artificial floors.

**Conclusions:** The study attested that the risk of traumatic injury in floorball is higher when playing on artificial floors than wooden floors. The higher shoe-surface friction on the former surface is likely to explain the increased injury risk.

# 153 A PROSPECTIVE STUDY OF MATCH INJURIES AMONG RUGBY TEAMS DURING THE 2005–6 NATIONAL FRENCH AMATEUR RUGBY CHAMPIONSHIP: INJURY PATTERNS

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**Background:** The prevalence of injuries in rugby has increased since professionalism was instituted (1995). No study has been conducted among French amateur rugby players.

**Objective:** To study injury patterns during the 2005–6 National French Amateur Rugby Championship.

**Methods:** Data were collected prospectively during the championship. Injuries related to each team were recorded (questionnaire) by



their respective team physicians. An injury was defined as an event that forced a player either to leave the field or to miss a subsequent game or a training session.

**Results:** 11.6% of the club matches played over the entire season (one match between two teams equals two club matches) were answered. 103 injuries forced a player to miss a game or a training session over 8 days after the trauma (most often between 8 days and 1 month); this corresponds to 42.1 injuries per 1000 player hours. Leg strains, knee and ankle injuries were the most frequently reported injuries. Tackle, acceleration or twisting to pass and grouping caused most injuries. Backfive players, props and centre-wing players were the most commonly injured positions reported. Most of the knee and ankle injuries were reported for backfive players and these injuries accounted for 50% of injuries reported for these positions. Leg strains were most frequently reported for centre-wings and props players and these injuries accounted for 45% and 33% of injuries reported for these positions, respectively. Unavailability for rugby after leg strains was less than 1 month, except for 50% of the centre-wings players injured, who missed more than 1 month. Repeated injury accounted for 50% and 25% of the ankle and leg strain injuries, respectively.

**Conclusion:** Pointing out game actions associated with injury brings game rules to the forefront of suitable injury prevention measures. The prevalence of repeated injuries and the distribution of injuries depending on players positions stress the necessity of prevention measures during preparation including specific training and medical survey.

#### 154 A PROSPECTIVE STUDY OF MATCH INJURIES AMONG RUGBY TEAMS DURING THE 2005-6 NATIONAL FRENCH AMATEUR RUGBY CHAMPIONSHIP: DESCRIPTIVE REPORT

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**Background:** The prevalence of injuries in rugby has increased since professionalism was instituted (1995). Few studies have been conducted among French rugby players; none among French amateur rugby players.

**Objective:** To study match injury incidence and patterns during the 2005-6 National French Amateur Rugby Championship.

**Methods:** Data were collected prospectively during the championship. Injuries related to each team were recorded (questionnaire) by the respective team physicians. An injury was defined as an event that forced a player either to leave the field or to miss a subsequent game or a training session. Poisson law was applied to fit confidence intervals.

**Results:** 11.6% of the club matches (one match equals two club matches) were answered. 240 injuries were recorded. 103 injuries forced the player to miss a game or a training session over 8 days after the trauma (most often between 8 days and 1 month); this corresponds to an incidence of 42.1 injuries per 1000 player hours. Half the players who did not stop the match after the trauma were later forced to miss training (or more) as a medical decision. 15.8% of the injuries occurred during a situation of brutality or irregular game play and more than two-thirds of players missed a rugby session for at least 8 days. Leg strains, knee and ankle injuries were the most frequently reported injuries (for each stratum of consecutive delay of incapacity to play rugby). Tackle (especially being tackled), acceleration or twisting to pass and grouping caused most injuries. Backfive players, props and centre-wings players were the most commonly injured positions reported; these positions were also recorded with the highest position injury incidence.

**Conclusion:** Injury rate and severity among French amateur rugby players are close to the French professional level. Guidelines for the

prevention of injury could include specific training aims and game rules recommendations.

#### 155 RISK FACTORS PREVENTION OF PAINFUL ELBOW IN GOLF

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**Background:** Elbow injuries among golfers occur frequently, in particular among those who are not experts.

**Objective:** To analyze the different types of elbow injury and to uncover the factors that lead to these injuries.

**Participants:** We prospectively examined elbow injuries and the technique of 103 patients, which we compared with 122 injury-free players. The level of golf of all these players was fairly low.

**Tests:** Injuries were diagnosed by two doctors, specialists in sports injuries. Data on the risk factors were collected using standard tests. An electromyogram was used for compressed nerves.

**Results:** Compression of the dorsal branch of the radial nerve was fairly frequent (22%), in particular among women. As a rule, women experience more medial epicondylalgia than men. Lateral epicondylalgia appears more frequently than epitrochlealgia among golfers. Tendinopathy of the triceps brachialis and biceps brachialis muscles was also found, but only in six cases. Furthermore, we found that the same golfer had multiple injuries, appearing one after the other. Physiological element: the age of the golfer ( $p<0.005$ ), the fact that it was a woman, and over-practising contribute to elbow injuries. Technique: a bad grip ( $p<0.01$ ), a vertical plane of the swing ( $p<0.001$ ), over-tenseness ( $p<0.01$ ) and too many missed shots can also lead to elbow injuries. Equipment: golf clubs that are too rigid ( $p<0.05$ ) or with worn-out grips ( $p<0.01$ ) are important factors in golf injuries. Surface of play: a surface that is too hard on the golf practice ground is a contributory factor ( $p<0.001$ ).

**Conclusion:** Golf elbow can be prevented if the right technique is used on a surface that is not too hard with flexible clubs and a grip that is not worn out.

#### 156 INJURY PREVENTION IN NEW ZEALAND RUGBY

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**Background:** Rugby union is considered the national sport of New Zealand, as a result of the large number of participants and the high media profile the sport enjoys. Rugby results in significantly higher costs to ACC, New Zealand's tax-payer funded injury insurance scheme, than any other sport. RugbySmart, a nationwide injury prevention programme, was implemented at the start of the 2001 rugby season.

**Objective:** The aim of RugbySmart was systematically to reduce the incidence and severity of rugby injuries to players in New Zealand, with a major focus on decreasing spinal cord and head injuries that resulted in permanent disablement. Other areas targeted by the programme were dental, shoulder, leg, knee and ankle injuries and non-disabling injuries of the neck/spine.

**Design:** RugbySmart focuses on educating rugby participants about physical conditioning, injury management and safe techniques in the contact phases of rugby. Evaluation of the impact of RugbySmart has primarily been via descriptive ecological studies.

**Setting:** New Zealand.

**Participants:** New Zealand rugby coaches, referees and players.

**Interventions:** It was compulsory for all coaches and referees to complete RugbySmart requirements annually in order to continue coaching or refereeing. Information was delivered to coaches and referees via video presentations combined with active participation

in workshops; these were supported initially by printed materials and subsequently by Internet resources.

**Main Outcome Measures:** Numbers and rates of injuries to targeted body sites (incidence per 100 000 players per year).

**Results:** The introduction of RugbySmart coincided with a substantial decrease in the number of serious scrum-related spinal injuries occurring in New Zealand rugby. RugbySmart was also associated with a decrease in injury claims per 100 000 players for most body sites the programme targeted; the programme had a negligible impact on non-targeted injury sites.

**Conclusions:** RugbySmart exemplifies the benefit of educational initiatives in injury prevention and the need for comprehensive injury surveillance systems for evaluating injury prevention initiatives in sport.

## 157 PLAYING SITUATION AND BEHAVIOUR: INJURY ANALYSIS USING VIDEO

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**Background:** Video analysis of injury circumstances in sport has received increasing attention over the past 5 years. Information about the inciting event of an injury is often more accurately obtainable from video than from participant or eye-witness recall.

**Objective:** To demonstrate the New Zealand Rugby Union's video-based injury surveillance system. Risk factors for tackle injuries will be presented.

**Design:** A coding schema for recording details of events that required on-field injury assessment or injury replacement was developed. Information about events that did not result in injury was also coded, to allow derivation of rates. The resulting video database permits on-demand review of match events, regardless of whether an injury occurred.

**Setting:** New Zealand professional rugby competitions.

**Participants:** Professional rugby players.

**Main Outcome Measures:** Rates of injuries per 1000 player hours and per 1000 tackles; circumstances of inciting events.

**Results:** In a sample of 434 professional matches, 140 249 tackles were coded from video recordings for height and direction of tackle on the ball carrier, speed of tackler and speed of ball carrier. Injuries were most frequently the result of high or middle tackles from the front or side, but rate of injury per tackle was higher for tackles from behind than from the front or side. Ball carriers were at highest risk of tackles to the head-neck region, whereas tacklers were most at risk when making low tackles. The impact of the tackle was the most common cause of injury and the head was the most common site, but an important mechanism of lower-limb injuries was loading with the weight of another player. Rates of replacement increased with increasing player speed.

**Conclusions:** Combining video-based information with medical information about the injuries (site, type, severity, costs) can provide a powerful tool to increase our understanding of the risk factors for and costs of match-related sports injuries in the professional sporting environment.

## 158 AN ADDITION TO THE TRADITIONAL INJURY PREVENTION MODEL

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**Background:** It is well accepted that the current understanding of injury causation limits injury prevention programmes. This paper proposes an alternative view to the traditional injury prevention model. This new model was developed during team coverage in the professional rugby environment. It also considers a new categorisation of intrinsic risk factors. As a consequence it is recommended that injury causation be viewed from a different perspective.

**Objective:** Injury prevention is an ongoing complicated issue yet to be answered by the sports medicine community. Within the professional team environment it can be the difference between success and failure. The traditional injury prevention model developed by Meeuwisse in 1994 has underpinned most injury prevention programmes but injuries still occur. The current model fails to provide an answer to the question "why does an athlete sustain a hamstring strain one week during a training session when he has performed the exact training session in the preceding few weeks under the same environmental conditions?" It is proposed that intrinsic risk factors should be viewed as fixed, modifiable or variable. It is also proposed that variable risk factor thresholds can be altered by central or peripheral fatigue and when these intrinsic risk factor thresholds are adversely affected injury results.

**Conclusions:** If accepted, a likely outcome of this alternative injury prevention model is that a new direction in injury prevention will evolve. In particular, the early identification of athlete fatigue will be essential. Research into identification of fatigue indicators will become critical. Basic fatigue indicators utilised during the 2007 Rugby World Cup will be presented and case studies discussed.

## 159 LIFETIME TRAJECTORY OF SPORT AND OVERALL PHYSICAL ACTIVITY BY TIME, ENERGY, JOINT FORCE AND KNEE OSTEOARTHRITIS STATUS IN A CANADIAN SAMPLE

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**Background:** High levels of physical activity, such as those associated with high intensity/competitive sports increase the risk of knee osteoarthritis. However, the association between physical activity and osteoarthritis is complex and there is conflicting evidence regarding the role of moderate physical activity (practised by the majority), particularly regarding the type/accumulation of lifetime activity and if the association is modified by local joint characteristics.

**Objective:** To describe lifetime physical activity from sport and other domains (using three different metrics) and knee joint characteristics, by knee osteoarthritis status; to identify potential risk factors for sport-related osteoarthritis.

**Design:** Mixed retrospective/prospective cohort.

**Setting:** Canada-wide population study.

**Data Source:** Baseline data from the Physical Activity and Joint Health cohort, a population three-cycle Internet study, using a validated computer-adaptive survey.

**Source Population:** Canadian Association of Retired Persons.

**Risk Factors:** Lifetime physical activity—from each of 64 sports and all occupational/domestic activity, estimated using time, energy expenditure and knee joint load. Local joint characteristics—alignment, previous injury. Other variables—established knee osteoarthritis risk factors/health determinants.

**Main Outcome:** Knee osteoarthritis.

**Results:** Complete baseline data were collected on 4269 subjects. Time in sport/recreation was highest before the age of 20 years and plateaued by 25 years. Energy expenditure and joint load varied significantly by domain and gender. In crude analysis, subjects with knee osteoarthritis were more likely to be older, have malalignment ( $p < 0.001$ ), previous joint injury ( $p < 0.001$ ), higher lifetime occupational and lower sport/recreational activity ( $p < 0.001$ ).

**Conclusion:** Separately analyzing time, energy and joint force and its interaction with joint characteristics may clarify the relationship between the numerous benefits of physical activity and possible sport injury risk. At the population level, crude analysis shows a

protective effect for overall lifetime sport activity, although the risk profile varied by sport. Further longitudinal/multivariable analysis from this study may clarify the impact of individual sports on knee osteoarthritis risk.

## 160 MOTOR RECOVERY OF ATHLETES AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: VISUAL CONTROL OF BALANCE

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**Background:** Many athletes do not return to their pre-injury sport level after an anterior cruciate ligament (ACL) rupture. Although a reconstruction restores mechanical stability of the knee, the sensorimotor system remains disturbed because of a reduction in proprioceptive information. Throughout rehabilitation, motor programmes adapt to the reduction in proprioceptive information through motor learning. During this process, dependency on visual information as an alternative information source increases. Completion of rehabilitation can be concluded from a decrease in dependency on visual control.

**Objective:** To determine progress in motor learning by means of a balance task. Dependency on visual control of balance can be measured by restricting vision while performing a balance task. Deterioration of postural control is a measure of the dependency on visual control.

**Design:** Postural sway parameters were obtained on a force-plate. One-legged stance of 27 patients was measured with eyes open and with restricted vision 1, 3 and 5 months after ACL reconstruction. 33 healthy athletes were used as controls.

**Results:** Cluster analysis revealed two subgroups in the patient population; relying heavily on vision (visually dependent,  $N = 11$ ) or not (not visually dependent,  $N = 16$ ). No differences were found in one-legged stance with eyes open between all patients and controls. 1 and 3 months postoperatively, one-legged stance with restricted vision was significantly worse in visually dependent patients compared with controls. This difference diminished at 5 months postoperatively. Postural control with restricted vision of the not visually dependent group and controls were similar 1 and 3 months postoperatively. Moreover, at 5 months, the not visually dependent group performed better than controls.

**Conclusion:** A substantial number of patients after ACL reconstruction rely heavily on visual information to compensate for the loss of proprioceptive information. This dependency diminished during rehabilitation. This dependency on visual information was absent in a subgroup, indicating a fast motor learning process in these patients.

## 161 USING TENSIOMYOGRAPHY IN THE MANAGEMENT OF HAMSTRING INJURIES PREVENTION

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**Background:** Soccer is the world's most popular and competitive game, but soccer is known for a high risk of injuries, mostly of the lower limb and the hamstring muscles. Among the most frequent causes of hamstring injuries is an imbalance between quadriceps and hamstring muscles strength, poor strength of the hamstrings and/or a lack of flexibility of the hamstring muscles. The muscle is most vulnerable to injury in the brief transition from eccentric to concentric function.

**Objective:** To use tensiomyographic methods for an objective measurement of muscle contractile parameters in the optimal management of an injury prevention programme.

**Material and Methods:** Twenty soccer players (age  $20 \pm 1.7$  years; weight  $75 \pm 5.4$  kg; height  $182 \pm 7.3$  cm) were randomly divided into two groups: a study group and a control group. During 6 months, for both groups we used a common protocol for hamstring injuries prophylaxis (stretching exercises and strength training with eccentric overload). In the study group, the parameters of prevention training (frequency, intensity, muscle, etc) were continuously adapted depending on the results of tensiomyographic evaluation of rectus femoris, vastus lateralis, vastus medialis, biceps femoris and semitendinosus. The tensiomyographic method was developed at Ljubljana University and enables selective measurements of radial muscle belly enlargements in a single muscle head. The muscle is stimulated with a single electrical stimulus. The measured signal is correlated with muscle composition and represents the mechanical response of the skeletal muscle system. In the control group, the parameters of the prophylactic programme were unchanged during the study.

**Results and Conclusions:** After 6 months of the prevention programme in the study group the incidence of hamstring injuries was 10%, compared with the control group, in which it was 30%.

**Conclusion:** We suggest using the tensiomyographic method as a monitoring tool for a better prevention programme for hamstring injuries.

## 162 EVALUATION OF PRE-PARTICIPATION SELF-ASSESSMENT FOR TRIATHLON AND AQUATHLON RACES

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**Background:** Pre-participation screening of athletes has been carried out in many countries to prevent sudden death, but self-assessment of the physical condition performed by participants themselves immediately before participation has not yet been carried out.

**Objectives:** This study was conducted to assess the usefulness of a self-assessment questionnaire of physical conditions before sports.

**Methods:** We performed a self-assessment questionnaire of physical conditions in 1530 participants (1181 men and 349 women) in seven triathlon competitions and two aquathlon competitions (total, nine competitions) on the day of participation in triathlon or aquathlon events. The participants were obligated to return the completed questionnaire. We confirmed whether the participants completed the race and whether they visited first-aid stations and analyzed the association between the results of the questionnaire and the presence/absence of the completion of the race or that of visiting first-aid stations.

**Results:** 1483 participants (97%) submitted a questionnaire. The dropout rate and the rate of visiting first-aid stations in the participants who did not return the questionnaire were 3.7–5.1 times and 4.8–6.4 times, respectively, that in the participants who returned the questionnaire. The dropout rate in participants with abnormality at least in one self-assessment item was 2.3–2.4 times that in those without any abnormality, but the rate of visiting first-aid stations did not differ between them. Among the self-assessment items, “lack of sleep” and “diarrhoea” were significantly related to dropout from competitions.

**Conclusions:** Pre-participation self-assessment questionnaire of physical conditions is useful for the prediction of the presence/absence of the completion of the race or that of injuries in the race.



## 163 SPORT INJURIES IN JUDO: COMPARISON OF THE RISK PROFILE IN JAPAN AND EUROPE

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**Background:** Few studies about injuries in judo exist and available data are often limited to a certain age group or are specific for a single country. International competition continuously influences the originally Japanese sport of judo. Different training methods and philosophies could also cause different risk profiles.

**Objective:** To elucidate the injury and training profile of judo athletes in Japan and compare these results with European athletes in order to provide a basis for injury prevention.

**Design:** Descriptive by retrospective questionnaire.

**Patients:** So far 455 Japanese recreational and competitive judo athletes were investigated (by March 2007, 800 Japanese judo athletes will be investigated). These are compared with 800 German judo athletes.

**Main Outcome Measures:** Injury frequency, location and training methods during the past 3 years.

**Results:** Knee (approximately 25%) and shoulder (15%) injuries were predominant in Japanese athletes and approximately 10% had soft tissue injuries in the hand. Only 1% had chronic muscular pain, whereas in Germany it was 34%. In Japan 27% of all injuries occurred during competition, 67% during sparring (Randori) and only 5% when training technique. Four times as many judo athletes in Japan performed additional stretching and three times as many weight training. The risk of being injured in Japan was 5% per hour of training.

**Conclusion:** Different injury locations in Japan and Germany seem to reflect preferred judo techniques. Overall the injury rate is lower in Japan compared with Germany, which may partly be related to the additional stretching and weightlifting. Non-competitive training (technique) in judo has a very low injury frequency in both countries.

## 164 CORE STABILITY TRAINING PROGRAMMES IMPROVE THROWING VELOCITY

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**Background:** Core stability training has been evaluated in a number of studies related to low back pain and injury prevention. However, few published studies have examined the effect of core stability training on sports performance tasks such as throwing for maximal velocity.

**Objective:** To quantify the impact of a sling exercise therapy (SET) based core stability programme on maximum throwing velocity among handball players.

**Methods:** 28 female high school handball players ( $16.6 \pm 0.3$  years,  $63 \pm 6$  kg,  $169 \pm 7$  cm) were recruited to participate in the study. The subjects were divided into a SET training group ( $n = 16$ ) and a control group (CON,  $n = 12$ ). There were four dropouts because of failed inclusion criteria or illness. 14 SET and 10 CON throwing performances were compared. The maximal throwing velocity (360 g standard female handball) was determined using photocell array from the 7 m penalty throw position. Each subject had 10 attempts, with the average of the three best throws being used for further analyses. In addition to their normal team handball training, the SET group performed a progressive, 7-week, twice a week core stability training programme consisting of six unstable, closed kinetic chain exercises. The CON group only performed their regular handball training.

**Results:** The averaged throwing velocity increased 4.9% from  $17.9 \pm 1.8$  to  $18.8 \pm 1.5$  m/s in the SET group ( $p < 0.01$ ), but was unchanged in the CON group  $17.2 \pm 1.4$  to  $17.0 \pm 1.3$  m/s ( $p > 0.05$ ).

**Conclusions:** A strong and more stable core may generate higher rotational velocity and increase throwing velocity. The results of this study suggest that core stability training using closed kinetic chain in unstable movements can improve maximal throwing velocity significantly. High levels of core strength and stability may be an important precondition for generating high rotational velocity in multisegmental movements.

## 165 EFFECTS OF PROPRIOCEPTIVE TRAINING IN THE LANDING IN PROFESSIONAL FOOTBALL PLAYERS

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**Background:** The evaluation of a jump is an indicator of the efficiency of the neuromuscular system of the athlete. The analysis of jumping represents a favourable method to modify technique and to reduce the risk of injuries (Louw *et al*, 2006). Football is a sport that imposes different loads on the lower limbs, as the players use one leg to kick and the other to jump and subsequently regain contact with the ground.

**Objective:** To evaluate the effects of proprioceptive training on load distribution among the two lower limbs when landing.

**Design:** Prospective study of 16 training sessions (8 weeks, two sessions per week) on 28 (16 proprioception group, PG; 12 control group, CG) professional players ( $25.7 \pm 3.3$  years,  $74.5 \pm 4.3$  kg,  $179 \pm 2$  cm).

**Interventions:** PG integrated the normal sessions of preparation off season with 16 sessions of proprioceptive training; the CG followed the usual pre-championship training. To assess the load supported by any single limb, counter movement jump was analyzed through two platforms of separate power (TwinPlates, Globus Italia, 1000 Hz). The separate platforms gave different values for the right limb and for the left limb.

**Results:** In the PG (pre-test) there was a load difference between limbs of  $15.5 \pm 8.4\%$ . In the post-test the limb difference was 0.7% of the kicking limb load ( $p < 0.001$ ). A statistically significant difference was found ( $p < 0.05$ ) after the comparison post-test between the load values of the PG and CG. No statistically significant difference was found between the pre and post-test CG.

**Conclusions:** The training that aimed at reducing the imbalances of load between the two limbs of the professional football player, the integrated use of motor proprioceptive duties represents a valid methodological path both in the technical and preventive field.

## 166 EFFECT OF SINGLE-LEG STANDING TRAINING ON LOWER EXTREMITY KINEMATICS DURING SINGLE-LEG DROP LANDING

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**Background:** It has been shown that hip abductor strength may prevent knee injuries, but study of the effects of hip abductor strength training on lower extremity kinematics is limited.

**Objective:** To evaluate the effect of single-leg standing training of hip abductors on lower extremity kinematics during single-leg drop landing trials.

**Design:** Randomised controlled trial.

**Setting:** Motion analysis laboratory.

**Participants:** 22 (male 16, female six) healthy subjects (mean age 22.0 years) volunteered to participate in this study. The subjects were randomly assigned into a control group (12 subjects) and training group (10 subjects).

**Intervention:** Two kinds of training, single-leg standing with contralateral hip abduction and hip external rotation, were performed 10 times three sets, 3 days a week for 4 weeks. Selective gluteus medius activation was shown using the same training in a previous study with surface electromyography.

**Main Outcome Measures:** The subjects were asked to perform the single-leg drop landing manoeuvre from a height of 30 cm. A three-dimensional motion analysis device was used to measure the angles of hip and knee joints in all three planes. Maximal angles up to 500 ms after contact were measured. Nineteen retroreflective markers were used according to the Helen Hayes Hospital marker system. Isometric peak torque of the hip abductor was measured using an isokinetic dynamometer.

**Results:** In the control group, no parameters showed significant changes. Hip abduction angle of the training group significantly decreased ( $p < 0.05$ ) after training, whereas other parameters did not show significant changes. The training group showed significant improvement ( $p < 0.05$ ) in isometric peak torque of the hip abductor.

**Conclusions:** Single-leg standing training of hip abductors affects not only hip abduction strength but also lower extremity kinematics.

### 167 A COMPARISON OF SOCCER INJURY SURVEILLANCE SYSTEMS USING CERTIFIED ATHLETIC TRAINERS VERSUS E-MAIL

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**Background:** Soccer is the most popular sport worldwide and is growing in popularity among female youth in the United States.

**Objective:** To compare two soccer injury surveillance systems among a cohort of 12–14-year-old female soccer players.

**Design:** Prospective cohort study.

**Setting:** Youth soccer club in Seattle, Washington, USA.

**Participants:** Female youth soccer players 12–14 years of age ( $N = 80$ ).

**Assessment of Risk Factors:** We compared certified athletic trainers (ATC) attending one soccer practice per week with a weekly soccer parent e-mail system. We also measured athletic exposure hours (AE) for each player.

**Main Outcome Measures:** We evaluated acute soccer injuries resulting in loss of participation time and overuse soccer injuries defined as at least 2 weeks of pain due to soccer participation, regardless of time loss. We compared injury rates using the ATC system only, the e-mail system only and both systems combined. We evaluated the two surveillance systems for agreement on injured body region and laterality of injury using the kappa statistic.

**Results:** We found acute injury rates of 3.0/1000 AE, 3.9/1000 AE and 4.7/1000 AE and overuse injury rates of 1.0/1000 AE, 2.9/1000 AE and 2.9/1000 AE for ATC only, e-mail only and both systems combined, respectively. Players sustained 28 acute injuries reported by either or both systems, with 64% reported by ATC and 82% by e-mail. Players sustained 17 overuse injuries reported by either or both systems, with 35% reported by ATC and 100% by e-mail. Among players for whom we had both ATC and e-mail injury data, injured body region had a  $\kappa = 0.87$  and laterality of injury had a  $\kappa = 0.92$ .

**Conclusions:** The weekly parent e-mail system captured a greater proportion of injuries compared with the ATC and had comparable accuracy of injured body region and laterality of injury. The use of a weekly parent e-mail injury surveillance system provides fairly complete and accurate injury data with less expense than the use of ATC.

### 168 RELIABILITY OF MEASURES TO ASSESS HIP AND KNEE MUSCLE STRENGTH AND JUMP BIOMECHANICS AMONG FEMALE YOUTH SOCCER PLAYERS

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**Background:** Lower extremity muscle strength and jump biomechanics may be predictors of injuries among young athletes.

Determining the reliability of these measurements is essential for their use in research studies.

**Objective:** To evaluate the inter-rater and intra-rater reliability of knee muscle strength, hip muscle strength and jump biomechanics measurements.

**Design:** Prospective cohort study.

**Setting:** Youth soccer club in Seattle, Washington, USA.

**Participants:** Female youth soccer players 12–14 years of age ( $N = 92$ ).

**Assessment of Risk Factors:** Using standardised techniques, six trained physical therapists (PT) used the Biodex Pro 3 to measure concentric hamstring and quadriceps strength at  $180^\circ/\text{s}$  and  $300^\circ/\text{s}$ , the MicroFet2 hand-held dynamometer to measure hip flexor, extensor, abductor and adductor muscle strength, and the Sportsmetrics video analysis system to measure distance between the hips, knees and ankles, and maximal jump height during a drop jump test. Triplicate measurements were taken, twice by one PT and once by a second PT.

**Main Outcome Measures:** Intra-rater and inter-rater coefficient of variations (CV) were calculated using linear mixed modelling.

**Results:** Intra-rater reliability as measured by CV ranged from 3% to 12% for hamstring strength and from 7% to 16% for quadriceps strength. Intra-rater CV ranged from 13% to 20% for hip muscle strength and 2% to 21% for jump biomechanics. Inter-rater reliability as measured by CV ranged from 18% to 22% for hamstring strength and from 7% to 13% for quadriceps strength. Inter-rater CV ranged from 18% to 22% for hip muscle strength and 0% to 9% for jump biomechanics.

**Conclusions:** The majority of the lower extremity muscle strength and jump biomechanics can be reliably measured in female youth soccer players.

### 169 THE EFFECT OF GAIT VELOCITY ON CALCANEAL BALANCE AT HEEL STRIKE: IMPLICATIONS FOR ORTHOTIC PRESCRIPTION IN INJURY PREVENTION

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**Background:** Lower-limb injuries are a common source of morbidity in sport whose causation is multifactorial. Pressure plate analysis has been used as an assessment tool. Studies examining running and walking gait with pressure plates have been performed; however, no study comparing plantar pressure differences between running and walking gait has been reported.

**Objective:** To compare calcaneal loading patterns at walking and running gait with a view to comparison of D3D orthosis prescription.

**Design:** A prospective cohort study. Power calculations were performed to determine the sample size with  $\alpha = 0.05$  with 80% power. Plantar pressure data were collected at both walking and running gait, over a 1 m Footscan pressure plate five times with each foot. Heel contact was measured between 0 and 15% of gait cycle. A line of axis was then generated about which medial heel (HM) and lateral heel (HL) pressure data were compared.

**Setting:** An Australian University sporting population.

**Participants:** 60 university students were recruited with human ethics approval and informed consent obtained.

**Main Outcome Measures:** A direct comparison was made of the HM/HL force balance to determine heel balance.

**Results:** Data were interpreted with SPSS version 15.0. At 5%, 10% and 15% of heel contact (representing heel strike) HM force was greater than HL, indicating calcaneal pronation. In addition, force ratios were higher in walking by 27%, 26% and 266% for the

respective times. Using Fisher's test demonstrated that the difference between the two sets of data was significant with a  $p < 0.01$ .

**Conclusions:** Calcaneal pronation on heel strike, as measured by HM/HL force distribution, is significantly decreased in running. These outcomes may result in an altered D3D orthosis prescription for the patient, suggesting that dynamic gait assessment is essential when designing orthosis.

## 170 HEAT SHOCK PRECONDITIONING ATTENUATES OXIDATIVE STRESS AND MUSCLE INJURY AFTER DOWNHILL RUNNING IN RATS

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**Background:** The mechanisms of the protective effect conferred by heat shock preconditioning (HS) are currently unknown.

**Objective:** To determine the effect of HS on muscle injury after downhill running and address the mechanism behind the effect.

**Study Design:** Controlled laboratory study.

**Methods:** Female Wistar rats were assigned to HS, downhill running (E), and downhill running after heat shock preconditioning (HS+E) groups. HS and HS+E rats were placed in a heat chamber for 60 minutes (ambient temperature  $42 \pm 1.0^\circ\text{C}$ ) 48 h before downhill running. The present study measured superoxide dismutase (SOD) activity as antioxidant capacity determined by electron spin resonance and heat shock protein 72 (HSP72) mRNA expression in rat quadriceps femoris. Leucocyte infiltration and degenerated muscle fibres were determined histopathologically.

**Results:** SOD activity significantly increased at 3 days after HS and HSP72 mRNA significantly increased immediately after HS. No decrease in SOD activity was observed in the HS+E rats at 2 days after exercise, unlike the E rats. Degenerated muscle fibres in HS+E rats were significantly less than in E rats. The numbers of degenerated muscle fibres correlated with leucocyte infiltration in both the E and HS+E groups and leucocyte infiltration was significantly suppressed in the HS+E group immediately after exercise.

**Conclusions:** These data demonstrated that HS can inhibit the decrease in SOD activity as antioxidant capacity after downhill running and have a protective effect to skeletal muscle, thus HS may have the potential as a prophylactic method to attenuate both initial damage and delayed damage.

## 171 PSYCHOLOGICAL RISK FACTORS FOR INJURY

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**Background:** Many clinicians believe that an athlete's psychology affects his/her risk of injury.

**Objective:** To explore the relationship between psychological profiles and injury risk in Cirque du Soleil artists.

**Design:** Historical cohort study.

**Setting:** The 2003 Cirque du Soleil general training period.

**Participants:** 47 elite circus artists from all disciplines who appropriately completed a standardised psychological profile (RESTQ-76) during their first week of the Cirque du Soleil 2003 general training.

**Interventions:** None.

**Main Outcome Measures:** The primary outcomes were the odds ratios (OR; calculated through Poisson regression) for risk of injury during the 2003 general training period between subjects with high and low scores (based on medians) for each of the following RESTQ-76 subscales (decided a priori): conflicts/pressure, fatigue, emotional exhaustion, injury and low self-efficacy. We conducted a secondary analysis for the remaining 14 subscales of the RESTQ-76, and for sex and country of origin (dichotomised: eastern Europe versus other).

**Results:** There was a total of 46 injuries after the forms were completed. All a priori exposures of interest were associated with an increase in injury risk except conflicts/pressure: conflicts/pressure 0.76 (0.40 to 1.45),  $p = 0.410$ ; fatigue 2.16 (1.16 to 3.99),  $p = 0.015$ ; emotional exhaustion 1.78 (0.98 to 3.24),  $p = 0.060$ ; injury 2.76 (1.51 to 5.07),  $p = 0.001$ ; low self-efficacy 2.56 (1.38 to 4.74),  $p = 0.003$ . Of the subscales examined for our secondary analysis, only high social stress appeared to be important with an OR of 1.92 (95% CI 1.07 to 3.45,  $p = 0.03$ ). Ten of the other secondary analyses had  $p$  values of 0.30 and the remaining  $p$  values were 0.11, 0.19 and 0.19. Neither sex nor country of origin was significant. In a multiple regression model that included all primary exposures of interest, only low self-efficacy was significant (OR 2.07, 95% CI 1.07 to 4.01,  $p = 0.03$ ).

**Conclusions:** Of the several specific psychological profiles that are considered risk factors for injury, low self-efficacy appears to have the strongest relationship.

## 172 MAKING APPROPRIATE INFERENCES FROM SPORT INJURY PREVENTION DATA

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**Background:** The outcome of interest for sport injury prevention research is often the number of injuries or injury rate (count data). Analyzing these data requires an understanding of clustering, repeated measures, Poisson distribution and negative binomial distribution in order to draw appropriate conclusions.

**Objective:** To describe the effects of inappropriate analyses of count data.

**Design:** Data were extracted from an existing database of injuries.

**Main Outcome Measures:** We compared the magnitude of effect estimates and confidence intervals (CI) from appropriate and inappropriate analyses.

**Results:** When describing patterns of injury (eg, proportion of upper extremity versus lower extremity injuries versus trunk), a simple comparison of proportions are inappropriate because individuals are compared with themselves (inappropriately wide CI) and multiple testing is being conducted (inappropriately narrow CI). Comparing injury rates, simple t-tests are inappropriate because the data are not normally distributed. For Poisson versus negative binomial regression, point estimates are often not substantially different but Poisson regression CI are too narrow when there is over dispersion (mean > variance), and negative binomial regression CI are too wide when there is no over dispersion. Examining yearly trends yields inappropriately narrow CI when some of the same people are measured from year to year. When describing injury rates based on counts of injuries and exposures, simply counting total injuries and total exposures hides heterogeneity of risk across individuals. Summarising the heterogeneity via the weighted median and weighted interquartile region can be quite useful because the distribution is usually skewed, the mean rate is an overestimate and CI are inappropriately symmetrical and the median rate inappropriately gives equal weight to individuals with few exposures and individuals with many exposures.



**Conclusions:** Of the several specific psychological profiles that are considered risk factors for injury, low self-efficacy appears to have the strongest relationship.

### 173 INJURIES IN PROFESSIONAL DUTCH FOOTBALL: A PROSPECTIVE COHORT STUDY

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**Background:** The number of sports injuries in The Netherlands is approximately 1.5 million every year and the yearly costs are high. To get more insight into the risk factors of sports injuries adequate registration is needed.

**Objective:** To study the incidence, location, severity and risk factors of injuries in professional Dutch football.

**Design:** The Dutch web-based injury system (BIS) was used for this prospective cohort study. An injury was defined as physical complaints caused by playing football and resulting in a time loss from playing football of at least one day.

**Setting:** 33 of the 38 professional football clubs in The Netherlands were included.

**Participants:** 1104 elite male football players.

**Assessment of Risk Factors:** Besides anthropometric data of the players (age, height, weight, dominant leg and playing position), a member of the medical staff registered information about the injury (eg, location, injury nature, duration, treatment and prevention measures). Assessed risk factors were surface (artificial versus natural grass), moment during match, re-injuries, offences and contributing factors (eg, contact with other players, fatigue, field conditions, weather conditions).

**Primary Outcome:** Incidence (number of injuries/1000 h) per injury.

**Results:** 760 injuries were reported, of which 84% were registered as "new". Preliminary results show no differences for the number of injuries in defenders, midfielders and forwards. Most injuries were a result of a direct trauma (70%). Almost half of the injuries were located at the lower extremities (21% knee, 17% ankle). The natures of injuries were mainly muscle ruptures/tears/strains/cramp (27%) and sprain/ligament injuries (18%). Contributing factors such as contact with other players (39%), distortion (15%) and take-off/landing by a jump (13%) are of more importance than playing on artificial grass (4%).

**Conclusions:** The rate of injuries among professional Dutch footballers is high. BIS provides sports teams with helpful information to improve their prevention management.

### 174 CORRELATION BETWEEN THREE SIMPLE, CLINICAL TESTS FOR ASSESSING KNEE CONTROL IN ELITE FEMALE HANDBALL PLAYERS

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**Background:** Anterior cruciate ligament (ACL) injuries represent a major problem in handball. Poor knee control, leading to valgus collapse, is frequently reported in injury situations. Preventive exercises can improve knee control and reduce the number of injuries. To optimise such training, it is necessary to develop simple, clinical tests that can identify players with poor knee control.

**Objective:** The aim of this study is to examine the correlation between three different tests designed to identify players with poor knee control.

**Participants:** 184 female Norwegian elite and national team handball players.

**Method:** The players completed three tests; single-leg squat (SLS), single-leg vertical drop jump (SLVDJ) and two-legged vertical drop jump (VDJ). The tests were assessed subjectively by one

physiotherapist using a graded scale from 0 to 2, in which 0 corresponds to good performance, 1 reduced performance and 2 poor performance (lateral tilt of the pelvis and dynamic knee valgus).

**Results:** The correlation between the test results was weak (Spearman's  $r$  from 0.16 to 0.43). Poor knee control in either leg was identified in 40% and 39% of the players using SLS and VDJ, respectively. Only 5% of the players were identified as having poor knee control using the SLVDJ test, indicating that this test may be less sensitive. A comparison of SLS and VDJ revealed that only 50% of the players with poor knee control were identified in both tests.

**Conclusions:** Weak relationship was found between the three tests. SLS and VDJ identified different players with poor knee control, indicating that these two tests may have to be combined when screening players for poor knee control. However, the results must be interpreted with caution, as the ability of each test to identify players with an increased risk of injury has not yet been assessed.

### 175 EFFICACY OF THE F-MARC 11 TRAINING PROGRAMME ON COLLEGIATE FOOTBALL TEAMS

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**Background:** The International Federation of Football Association (FIFA) recommends F-MARC 11, an injury prevention programme; however, the efficacy of this programme has not yet been clarified.

**Objective:** To elucidate the efficacy of the F-MARC 11 programme on both injury prevention and performance improvement.

**Design:** A prospective study and pre-post-intervention study.

**Setting:** The first division of the collegiate football league in the Kanto area of Japan.

**Participants:** 92 collegiate male football players participated. Players were divided into three groups: the F-MARC 11 group who participated in the programme ( $n = 30$ ), the F-MARC+a group who participated in an adjusted programme ( $n = 32$ ) and a control group ( $n = 30$ ).

**Interventions:** The two training programmes were conducted once or twice per week for 6 months. Injury occurrence was analyzed using a specialised check sheet.

**Main Outcome Measurement:** The incidence of all injuries, lower-extremity injuries and ankle sprains was measured. Incidence rate was denoted per 1000 player hours. Using several field tests (sprint, pro-agility, cutting), each subject's performance level was evaluated before training as well as 6 months after training.

**Results:** The most common injury was an ankle sprain (38.1% of all players). The incidence of lower-extremity injury was 1.07 per 1000 player hours (control group), 0.36 per 1000 player hours (F-MARC 11 group) and 0.54 per 1000 player hours (F-MARC+a group). Sprint time and cutting time were significantly shortened in the F-MARC 11 and F-MARC+a group ( $p < 0.05$ ).

**Conclusions:** The incidence of football injuries could be reduced with suitable training. The F-MARC 11 programme may have the added benefit of improving performance, especially sprint time and cutting time.

### 176 RE-INJURY PREVENTION IN ELITE SPORT IN LUXEMBOURG

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**Background:** In Luxembourg (450 000 inhabitants) only 10% of athletes are professional. The injury of an athlete is a dilemma for all teams. We investigate motivation in athletes with moderate and/or major injuries to try to understand the athlete's motivations

before injury and during the rehabilitation period. Factors such as work, gender, study or family life interfere with sport and injury treatment. Personal motivations have an impact on recovery and re-injury.

**Objective:** To assess whether these motivations differ between injured and non-injured athletes.

**Design:** During the second period of 2007, a retrospective questionnaire was sent to athletes of elite clubs. This included a biographical questionnaire and the sport motivation scale (Pelletier, 1995).

**Settings:** Athletes of elite division clubs, athletes of the Olympic programme, in 12 different sports.

**Population:** 262 athletes; 198 men, 64 women; 108 injury free, 154 injured.

**Main Outcome Measures:** In our population in which 90% of the athletes are students or workers we found that 73% of actual injured athletes were injured last season.

**Results:** The ANOVA between distinct variables: motivations, gender, injury show the influence of motivations in injury and re-injury: (1) intrinsic motivation (towards accomplishment: difference in gender and in injury; to experience stimulation: difference in gender  $\times$  injury); (2) extrinsic motivation (introjection: difference in gender  $\times$  injury; identification: difference in gender  $\times$  injury; external regulation: difference in gender).

**Conclusion:** Athletes who are engaging in an activity in order to experience stimulating sensations, athletes in whom the source of motivation has been internalised and those who value and judge behaviour as important are susceptible to re-injury. We thus have to consider gender differences in motivation to prevent injury.

## 177 REDUCTION OF SPORT INJURIES IN MALE ELITE ICE HOCKEY IN SWEDEN: A PSYCHOLOGICAL INTERVENTION STUDY

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**Background:** According to current statistics ice hockey is ranked as a high-risk injury sport. However, recent research shows the possibility of preventing the occurrence of sport-related injury in high-risk sport through psychological intervention.

**Objective:** The objective was to study the potential of reducing injuries among male elite ice hockey players through brief psychological interventions during a season.

**Design:** An experimental prospective intervention study, using a matched pair, experimental control group design was used followed by a pretest–posttest and a qualitative analysis.

**Setting:** One Swedish elite ice hockey team was contacted for psychometric testing. Moreover, brief intervention was performed outside the training facilities of the team.

**Main Outcome Measurement:** Athletic coping skills inventory—28 and the sports anxiety scale was used to measure coping and anxiety before and after the intervention. A sport injury frequency form was used to record all injuries before and during the study. In addition, a critical incidence diary was used (experimental group) to record situations that were experienced as positive and negative within as well as outside ice hockey.

**Participants:** Altogether 10 players in the experimental group and 14 players in the control group constituted the group of participants in the study.

**Interventions:** Five individual sessions using somatic and cognitive intervention as well as self-confidence and goal-setting training were conducted within the experimental group.

**Results:** The study showed that the experimental group faced fewer injuries compared with the control group ( $p < 0.05$ ). Although no statistical differences emerge using the psychometrics, the qualitative analysis, using citation techniques of the critical incidence diary, showed that the experimental group had more

difficulty finding negative stressful moments at the end of the study compared with the beginning.

**Conclusion:** It seems possible to decrease sport-related injuries through psychological interventions such as stress management in a brief intervention programme for ice hockey players.

## 178 INJURIES AMONG WORLD CUP FREESTYLE SKIERS 2006/7

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**Background:** Previous studies have shown a high incidence of injury among World Cup freestyle skiers. Freestyle is still developing as a sport, with new disciplines such as ski cross and half-pipe added to the World Cup programme and new elements in the technical repertoire.

**Objective:** The aim of this study was to describe the incidence and type of injury among World Cup freestyle skiers.

**Methods:** Injuries were registered through interviews with athletes and/or coaches from nine selected World Cup teams towards the end of the winter season 2006–7 regarding injuries during the season. An injury was defined as any injury that occurred during training or competition requiring attention by medical personnel. To describe the injury, a standard form was used that included information about injury type, body part injured, circumstances, duration of absence and specific diagnosis. Incidence was calculated as the number of injuries per 100 athletes per season.

**Results:** A total of 49 injuries were recorded among 153 athletes interviewed (46 women and 107 men); 23 during competition, 14 during official training in World Cup/World Championship events and 12 during other training. The overall incidence was 32 injuries per 100 athletes; 35 for moguls, 65 for aerials and 21 for skicross. Of the 49 injuries, the most common location was the knee ( $n = 13$ , 49 %) and the main injury type was joint and ligament injuries ( $n = 17$ , 35%). 43% of the injuries were graded as severe injuries with an absence from training/competition of over 28 days.

**Conclusion:** Serious injuries are common, especially knee injuries, during competition and official training. To reduce the risk of serious knee injuries, more research is needed into their mechanisms.

**Funding:** The FIS Injury Surveillance System has been established through a generous grant from DJO.

## 179 ERGOMETER ROWING IN SLIDES: IMPLICATIONS FOR INJURY RISK

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**Background:** The Danish national team rowers perform approximately one-third of the total training volume in rowing ergometers. Consequently, the type of ergometer may have a strong influence on rowing performance and risk of injury. The commonly used Concept2 rowing ergometer can be placed in slides, which may reduce the exposure to mechanical stress forces in the musculoskeletal system.

**Objective:** To investigate force production during rowing with and without slides.

**Primary Hypothesis:** Rowing in slides reduces the peak force of each rowing stroke while affecting stroke frequency.

**Design:** Randomised crossover study.

**Setting:** Danish national rowing team.

**Participants:** Eight female and 14 male healthy and uninjured rowers.

**Interventions:** All subjects performed two 3.5 minute rowing trials at 75% of maximal power output with and without slides in a randomised order. Force production was measured with a strain gauge (1000 Hz) and a potentiometer measured the handle displacement (1000 Hz).

**Main Outcome Measures:** Peak handle force (PF), stroke frequency (SF).

**Results:** During slide-rowing male rowers increased SF from  $25.9 \pm 1.2$  (mean  $\pm$  SD) to  $28.7 \pm 1.7$  strokes/minute ( $p < 0.001$ ) and decreased PF from  $887 \pm 87$  to  $811 \pm 74$  N ( $p < 0.001$ ) compared with stationary rowing. Female rowers increased SF from  $25.0 \pm 1.8$  to  $25.7 \pm 1.9$  strokes/minute ( $p < 0.05$ ) and decreased PF from  $632 \pm 53$  to  $612 \pm 52$  N ( $p < 0.01$ ). Power output remained unchanged between slides and stationary conditions, respectively (men  $330.4 \pm 30.1$  versus  $329.4 \pm 26.2$  W; women  $217.5 \pm 18.3$  versus  $218.0 \pm 19.0$  W).

**Conclusions:** Placement of the rowing ergometer in slides decreased peak force production for each rowing stroke while the same external power output was maintained. Consequently, rowing in slides may reduce the risk of musculoskeletal overuse injury without compromising training efficiency and rowing performance. Prospective controlled studies are required to test this hypothesis.

#### 180 PREVALENCE OF JUMPER'S KNEE AND PATELLAR TENDON ULTRASOUND CHANGES AMONG NORWEGIAN ELITE JUNIOR VOLLEYBALL PLAYERS: BASELINE DATA FROM THE OSTRC PATELLAR TENDINOPATHY COHORT STUDY

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**Background:** As previous research on the causes of patellar tendinopathy is based on cross-sectional and case-control studies, the OSTRC cohort study is designed to assess risk factors prospectively for patellar tendinopathy.

**Objective:** To examine the prevalence of jumper's knee and ultrasound changes in the patellar tendon in young elite volleyball players.

**Design:** Cross-sectional study.

**Setting:** Elite junior (15–18 years) volleyball athletes attending a 3-year boarding school programme (ToppVolley Norge, TVN) in Sand, Norway.

**Participants:** 73 of 74 students.

**Methods:** All students were examined clinically, as well as using grey-scale and colour Doppler ultrasound at the start of the school year. The diagnosis of jumper's knee was based on clinical criteria alone.

**Results:** A total of 13 of 73 (18%) students had jumper's knee, 11 in the patellar and two in the quadriceps tendon. Prevalence was no different between boys (nine of 38) and girls (four of 34;  $p = 0.21$ ), but increased with the number of years of training at TVN (new students: two of 35; one year: four of 21; 2 years: seven of 17;  $p = 0.007$ ). The prevalence of players with greyscale ultrasound changes in the patellar tendon was higher (21 of 73), but did not increase with the number of years at TVN (new: nine of 35; one year: six of 21; 2 years: six of 17;  $p = 0.77$ ). Nine of 11 students with a clinical diagnosis of jumper's knee had hypo-echoic changes in the patellar tendon, eight of them combined with neovascularisation. Among asymptomatic students, 11 of 59 had hypoechoic changes, in four cases combined with neovascularisation.

**Conclusions:** The prevalence of players with symptoms of jumper's knee increased with the numbers of years of exposure to

elite volleyball boarding school training, whereas the proportion with ultrasound changes remained unchanged.

#### 181 RISK FACTORS FOR INJURY IN A KARATE COMPETITION

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**Background:** Only observational studies categorising types and rates of injury exist in the current karate sports medicine literature.

**Objective:** This study looks at risk factors associated with injury at an elite-level karate competition.

**Design:** Questionnaire-based prospective observational study.

**Setting:** The study took place at an elite-level national karate championship—the 2007 USA National Karate Federation championship.

**Participants:** Adult athletes presenting to the medical tent for aid. Of 373 adult competitors, 19 were injured, all of whom participated in this study.

**Assessment of Risk Factors:** Injury data: location, type, time of day, event occurrence and severity level. Training data: acute illness, training hours, dieting and stretching practices. Event-specific data: weight loss within the week to make weight class, time between events, number of events and warm-up immediately before events.

**Main Outcome Measures:** Injury at a national-level karate competition resulting in presentation to the medical tent or judge referral to the medical tent.

**Results:** All injuries occurred during sparring, with an injury rate of 5.09%, which is consistent with existing literature. Data were analyzed using frequency tables and Fisher's exact test. Being unable to perform their usual warm-up routine immediately before their competition event was associated with a higher chance of getting severely injured (57% versus 8%,  $p = 0.0379$ ). Severity was categorised as low versus high, high defined as requiring emergent hospital evaluation. No other risk factors were noted to be highly prevalent among the injured or correlated with severity of injury.

**Conclusions:** Karate athletes are often unable to perform their routine warm-ups immediately before sparring events because of errors in event timing. This study demonstrates a significant relationship between ability to warm-up before the event and severity of injury. This knowledge may be helpful to future event planners in order to minimise injury.

#### 182 THE EFFECT OF STATIC STRETCHING VERSUS DYNAMIC WARM-UPS UPON THE ATHLETIC PERFORMANCE OF RECREATIONAL KARATE ATHLETES

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**Background:** Dynamic warm-ups are advocated in the sports literature as superior to traditional static stretching in enhancing athletic performance.

**Objective:** The purpose of this study is to assess any long-term difference between static stretching and dynamic warm-ups upon the athletic performance of recreational athletes.

**Design:** This single-blinded, prospective cohort study randomly assigned karate volunteers into a static stretch or dynamic warm-up group. Five standardised tests of athletic performance were performed at the beginning, 4-week midpoint and 8-week endpoint. Tests were administered by the investigators who remained blinded regarding each participant's protocol.



**Setting and Participants:** Karate athletes from a single dojo (no confound of differing sports training), recreational level participation one to three times per week. 32 athletes participated, 30 completed the full 8-week course.

**Intervention:** Static stretch and dynamic warm-up protocols were based upon those previously utilised in the literature. Protocols were reviewed to ascertain matching of target muscle groups. Protocols were supervised by the instructor sempai of the karate dojo who attended an educational session conducted by the investigators.

**Outcome Measures:** These five standardised tests of athletic performance have been used in previous literature: vertical jump, long jump, seated medicine ball toss, 15-meter sprint and sit-n-reach flexibility.

**Results:** T-test analysis of the 4-week and 8-week data demonstrate no statistically significant difference in the change of athletic performance with any of the five tests. Whereas  $\chi^2$  analysis initially demonstrated a significant association ( $p < 0.05$ ) between static stretching and 15-meter sprint improvement (100% versus 0%) for the BMI  $> 25$  subset at the midpoint, there was no statistically significant association by the 8-week endpoint.

**Conclusions:** There may be no significant long-term difference between the effect of static stretching and dynamic warm-ups upon standardised tests of athletic performance for recreational karate athletes. This is unique from previous literature that looked at immediate changes in professional athletes.

### 183 COMPARISON OF INJURIES FROM TWO PARALYMPIC WINTER GAMES: SALT LAKE 2002 AND TORINO 2006

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**Background:** The International Paralympic Committee (IPC) injury survey commenced in 2002 to look at injuries occurring during Winter Paralympic Games. The survey was repeated in 2006 and the comparative data are presented.

**Objective:** To capture information on all athlete injuries presenting for medical care during the 2006 Paralympic Games and compare with 2002.

**Design:** Prospective study of athletes presenting for medical care for musculoskeletal injuries.

**Setting:** Winter Paralympic Games Torino 2006.

**Participants:** Any athlete presenting for medical care with a musculoskeletal injury during the 2006 Paralympic Games consenting to use of the information for research purposes.

**Intervention:** Attending physician completed the IPC injury questionnaire.

**Main Outcome Measures:** Athlete demographics, occurrence of injury, mechanism of injury, clinical diagnosis, radiological investigations and fitness to continue in sport.

**Results:** Questionnaires were collected on 40/474 athletes giving an injury rate of 8% of the competing athletes, with 32 out of 375 men (8.5%) injured compared with eight out of 99 women (8%). The average age of male athletes injured was 35 years (range 19–48) compared with 27 years (range 19–36) in female athletes. The injury rates by sport were alpine 12%, sledge hockey 11%, Nordic and biathlon 4% and curling 0%. Injuries were traumatic 73%, overuse 25% and unclassified in 2%.

**Conclusions:** The data suggest a slight reduction in injury rates with a fall from 10% in 2002. The injury rates by sport are very similar, apart from sledge hockey, which shows a 3% reduction. There were no lower-limb injuries in sledge hockey in 2006 compared with five lower-limb fractures in 2002. Recommendations to improve protective clothing and safer sledge design were introduced after 2002.

### 184 LATERALITY IN THE ANKLE SPRAINS

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**Introduction:** Ankle sprains are the most common injuries among athletes, usually leading to lateral ligament damage (anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL)). Little is known about the influence of lateralisation on muscle control and severity of the injuries.

**Materials and Methods:** 52 patients after acute ankle sprains were analyzed (39 prospectively and 13 retrospectively). All the patients were assessed in clinical examination, sonographic examination and by the AOFAS scale. Lateralisation was determined by Coren's questionnaire by checking dominance of the hand, leg, ear and eye. The data were analyzed to check if there are any interrelationships between affected side, severity of trauma and brain laterality.

**Results:** 56% ( $n = 29$ ) of patients had right-sided ankle sprains, 44% ( $n = 23$ ) left-sided sprains. In 62% ( $n = 32$ ) of patients, straight lateralisation (right side dominance) was confirmed, 37% ( $n = 19$ ) had crossed lateralisation. Only one patient presented straight laterality with left side dominance. Most of the patients with straight lateralisation (59%,  $n = 19$ ) experienced minor trauma (only ATFL tear), whereas those with crossed lateralisation more often had more severe damage (ATFL and CFL) (68%,  $n = 13$ ). In addition, in patients with straight lateralisation, the AOFAS score in the group with severe damage (ATFL and CFL) was higher (68 points) than in the group with crossed lateralisation (56 points).

**Conclusions:** The type of lateralisation affects the severity of trauma in ankle sprains.

### 185 THREE-DIMENSIONAL MOTION ANALYSIS FOR SINGLE-LEGGED SQUAT IN ANTERIOR CRUCIATE LIGAMENT-DEFICIENT PATIENTS

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**Background:** 70–80% of all anterior cruciate ligament (ACL) injuries are non-contact injuries. Of these it has been reported the majority come from a valgus position of the lower leg at single-legged landing. Therefore, preventing excessive valgus during single-legged landing is expected to help reduce the risk of ACL injury. We usually correct valgus knee position of an ACL-deficient patient when she or he performs single-legged squat pre and postoperatively. Surprisingly, many patients cannot perform stable squatting. We therefore performed three-dimensional motion analysis of single-legged squat in ACL-deficient patients. In addition, this method can be performed more safely and easily than correcting leg position at single-legged landing.

**Materials and Methods:** Before ACL reconstruction, we evaluated a relative angle between body, thigh and lower leg using an electromagnetic motion tracking device (Polhemus FASTRACK) at single-legged squat of 63 ACL-deficient patients (men 32, women 31). We defined half squat as the position at which they could keep their balance well.

**Results:** The maximum flexion angle of the knee was  $74.3 \pm 13.6^\circ$  (male uninjured side),  $64.7 \pm 19.1^\circ$  (male injured side),  $73.9 \pm 13.3^\circ$  (female uninjured side),  $68.8 \pm 13.2^\circ$  (female injured side) at the half-squat position. There was no significant gender difference. The maximum hip flexion angle of injured hip was larger than the uninjured side in both men and women ( $p < 0.05$ ). The injured side lower leg valgus/varus angle of men showed more varus ( $p < 0.05$ ). The injured side lower leg rotation angle of women showed less external rotation ( $p < 0.05$ ). Lower leg valgus/varus angle of men showed more varus than women ( $p < 0.05$ ).

**Conclusion:** This method can be performed more safely and easily than correcting leg position at single-legged landing. The results suggested that a patient with ACL-deficient knee could perform more stable single-legged squat by keeping more varus position of the lower leg in men and by limiting external rotation in women.

## 186 ANALYSIS OF KNEE VALGUS MOMENT DURING THREE DIFFERENT SPORTS TASKS IN FEMALE BASKETBALL PLAYERS

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**Background:** Three-dimensional motion analysis has shown excessive valgus lower-limb alignment to be a risk factor for non-contact anterior cruciate ligament injuries.

**Objective:** To investigate the valgus moment of the knee during different sports tasks in female college basketball players.

**Design:** Controlled laboratory study.

**Setting:** Female basketball players belonging to a university basketball club.

**Participants:** Eight healthy female college basketball players (16 knees) participated in this study.

**Assessment of Risk Factors:** All subjects performed three different tasks; drop-jump test with both legs landing from a 35 cm platform and immediately performing a maximum vertical jump, stop-jump test with both legs stopping from an approximately 4 m approach run and immediately performing a maximum vertical jump and slide step test with both legs stopping from an approximately 4 m approach run and immediately performing a 90° lateral sidestep cut. The motion of the lower limbs was recorded and analyzed using a three-dimensional motion analysis system (VICON) and a force plate (AMTI).

**Main Outcome Measures:** The maximum valgus moment of the knee joints from initial foot contact to maximum flexion of the knee joint was determined. The correlation of the maximum valgus moment between three different sports tasks (drop-jump, stop-jump, and slide) was investigated.

**Results:** Significant correlation was shown between drop-jump and stop-jump ( $r = 0.84$ ,  $p < 0.01$ ), stop-jump and slide ( $r = 0.69$ ,  $p < 0.01$ ) and drop-jump and slide ( $r = 0.84$ ,  $p < 0.01$ ).

**Conclusions:** There were strong positive correlations between the three different sports tasks, suggesting that some female athletes were subjected to the risk of anterior cruciate ligament injury in multiple sports movements.

## 187 PREOPERATIVELY NO SIGNIFICANT DIFFERENCE IN FUNCTIONAL SCORING (KOOS) IN ANTERIOR CRUCIATE LIGAMENT-INJURED KNEES WITH AND WITHOUT A FULL-THICKNESS CARTILAGE LESION

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**Background:** Chondral lesion has been estimated as one of the major factors for early osteoarthritis of the knee after injury and especially in combination with anterior cruciate ligament (ACL) injury. It is also reported that patients with chondral lesion of the knee have pain as the major symptom preoperatively. As such it can be estimated that these patients with the combination of ACL injury and chondral lesion would experience severe symptoms and low functional scoring preoperatively, which has been advocated for early treatment of the chondral lesion simultaneously with ACL reconstruction.

**Objective:** This study investigates whether the combination of ACL injury and full-thickness cartilage lesion demonstrated significant difference in functional scoring before ACL reconstruction.

**Design:** Cross-sectional data from a national ACL register (3704 primary ACL surgery cases) were used. Thirty patients (group A) met the following inclusion criteria: less than one year since knee injury, no meniscus injury, a full-thickness chondral lesion and age less than 40 years. The control group was matched with two controls for each patient in group A but no cartilage lesion was noted. All patients completed preoperatively a functional scoring form (KOOS) and the surgeon peroperatively marked the depth of the cartilage lesion according to the ICRS scale and size of the lesion.

**Results:** No significant difference was found for any of the five subgroups in KOOS score. A chondral lesion was located on the medial femoral condyle in the majority of the 30 patients in contrast to the bone bruise on magnetic resonance imaging in ACL-injured knees, which is often described on lateral femoral condyle.

**Discussion:** This is a clinical study that used narrow inclusion criteria to evaluate full-thickness cartilage lesion as the only variable in order to define its contribution as a risk factor.

**Conclusions:** The combination of a full-thickness cartilage lesion does not result in an inferior knee function before ACL reconstruction evaluated with KOOS functional outcome scores. However, later follow-up on the same material would be important to estimate the risk of arthrosis or decreased functional scoring after ACL reconstruction due to the chondral lesion.