

# Abstracts

## 001 HORMONAL THERAPY AND ACL INJURY

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**Background:** Current reports in the literature demonstrate that no definitive explanation for the difference in rate of male and female non-contact anterior cruciate ligament (ACL) injury has been found. The hormonal environment, known to be different in men and women, has been hypothesised as the possible source for this difference in injury rate.

**Purpose:** To confirm our earlier work looking at periodicity of non-contact ACL injury. To determine the rate of non-contact ACL injury and ankle sprains in collegiate basketball and soccer. To determine if the use of oral contraceptives affects the rate of non-contact ACL injury and ankle sprains.

**Methods:** This was a longitudinal cohort using collegiate basketball and soccer athletes. Data were collected from a sample of NCAA schools over the 2000-2001 basketball and the 2001-2002 basketball and soccer seasons.

**Results:** Recall and prospective data collection of length of menstrual cycle did not produce equivalent results. Periodicity was present only in the recall group of "off pill" users. The rate of non-contact ACL injury and non-contact ankle sprains was twice as high in basketball as in soccer. There was no difference in rate of injuries between those athletes using hormonal therapy and those athletes not using hormonal therapy.

**Conclusions:** Non-contact ACL injuries and ankle sprains occurred at significantly higher rates in basketball than in soccer, but this rate difference cannot be linked to hormonal usage. The overall rate of non-contact ACL injury and ankle sprain to women's collegiate basketball and soccer players is very low. Over the three seasons studied, there were 45 non-contact ACL injuries and 116 non-contact ankle sprains.

## 002 MUSCLE LENGTH DEPENDENT INCREASES IN STRENGTH AFTER PROGRESSIVE ECCENTRIC BIASED TRAINING

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**Background:** Unaccustomed eccentric exercise, where we use our muscles as brakes, commonly leads to muscle damage and soreness. The subsequent repair process includes adaptation that protects the muscle against damage.<sup>1</sup> Better understanding of this protective mechanism can lead to improved rehabilitation strategies and help reduce the incidence of more severe muscle injuries. There is evidence that adaptation includes remodelling of muscle fibres by longitudinal addition of sarcomeres,<sup>2</sup> which is observable in length-tension measures. Evidence of this has been reported in human hamstring muscles following an acute bout of damaging eccentric contractions.<sup>3</sup>

**Purpose:** To use a progressive eccentric training programme to minimise muscle soreness, while achieving adaptation as measured with angle torque assessment.

**Methods:** Maximum voluntary isometric torque was measured in untrained subjects ( $n=7$ ) at five knee angles between 60° and 0° of knee flexion while seated (90° hip flexion), using a Kin-Com dynamometer. Testing occurred on three occasions before training, then at 2 weeks and 4 weeks post-training. Training consisted of eight sessions of eccentric biased exercise (hamstring lowers) over 4 weeks, gradually increasing the number of repetitions from one to eight sets of 10 repetitions. Muscle soreness was rated using a visual analogue scale.

**Results:** After 4 weeks of training, maximum torque increased at all test angles, but was significantly greater at longer muscle lengths (for example, 13% at 60°; 35% at 0°). Post-exercise muscle soreness for all sessions averaged less than 1 of 10.

**Conclusions:** Progressive eccentric training led to adaptation through significant increases in strength that were greatest at longer muscle length, and were achieved without causing high levels of muscle soreness.

1. **McHugh MP**, Connolly DA, Eston RG, *et al*. Exercise-induced muscle damage and potential mechanisms for the repeated bout effect. *Sports Med* 1999;27:157-70.
2. **Lynn, Morgan**. *J Appl Physiol* 1994;94:831-8.
3. **Brockett CL**, Morgan DL, Proske U. Human hamstring muscles adapt to eccentric exercise by changing optimum length. *Med Sci Sports Ex* 2001;33:783-90.

## 003 EFFECT OF MUSCLE FATIGUE ON PROPRIOCEPTION AT THE HUMAN ELBOW JOINT

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**Background:** It is a common experience that we feel clumsy after a period of intense exercise. This led to the proposal that exercise can disturb proprioception. We considered that this disturbance might be caused by damage to muscle spindles. However, animal experiments revealed no disturbance to muscle receptors after intense eccentric contractions.<sup>1</sup>

**Purpose:** To examine whether the loss of force from fatigue was responsible for the disturbance to proprioception.

**Methods:** Subjects ( $n=13$ ) had their forearms strapped to a pair of lightweight paddles. In position matching tasks, the experimenter placed one (reference) forearm at a particular angle and asked the blindfolded subject to match the position with the other (indicator) arm. For movement matching tasks, the experimenter moved one forearm into extension (10-50°/second) and asked the subject to match the movement with the other arm. Subjects then exercised one arm to fatigue by lifting a weight (30% maximum). Matching tasks were repeated immediately after exercise and 1 hour later. Movement matching was also repeated on fresh muscle while the flexors of one arm were vibrated (80 Hz).

**Results:** The exercise resulted in 30% force drop, and was accompanied by significant position matching errors. Errors occurred in different directions depending on whether the indicator or reference arm was fatigued. Fatigue caused no significant disturbance to movement matching. Vibration, on the other hand, caused significant movement mismatches.

**Conclusions:** These experiments support the hypothesis that a centrally derived sense of effort contributes to the sense of limb position, and that fatigue can produce errors by altering the relationship between effort and force. Movement sense does not seem to depend primarily on the sense of effort, but is disturbed by vibration, supporting the view that muscle spindles play a primary role in movement sense.

1. **Gregory JE**, Morgan DL, Proske U. Responses of muscle spindles following a series of eccentric contractions. *Exp Brain Res* 2004;157:234-40.

## 004 RISK OF ANKLE RE-INJURY IN PROFESSIONAL FOOTBALL VERSUS AMATEUR ELITE VOLLEYBALL

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**Background and purpose:** Ankle injuries are common in many sports. In a previous study on amateur volleyball players without medical supervision, we showed that a history of recent previous injury is a strong predictor for acute ankle sprains.<sup>1</sup> We therefore wanted to compare these data with professional football, where supervised early functional treatment and proprioceptive training are readily available.

**Methods:** Amateur elite volleyball players (212 women, 259 men) answered a questionnaire regarding their history of previous injuries to each ankle prior to the start of the 1993 season. Male professional football players ( $n=291$ ) completed an identical form prior to the 2000 football season. Reports on new acute time loss ankle injuries were collected prospectively by team medical staff (football) and coaches (volleyball) during the subsequent season.

**Results:** Of 1524 ankles, a previous ankle injury was reported for 842 (football 62% v volleyball 51%;  $p<0.0001$ ). There were 102 new ankle sprains during the season (volleyball 80 (8.5%, no sex difference within volleyball) v football 22 (3.8%); odds ratio (OR)=2.4,  $p<0.0001$ ). However, there was no difference between sports in the risk of injury to previously healthy ankles (volleyball 5.9% v football 4.1%);  $p=0.33$ ). The increased risk in volleyball was limited to ankles with previous injury only (volleyball 11.0% v football 3.6%; OR: 3.3,  $p<0.0001$ ), in particular injuries within the previous 6 months (volleyball 37% v football 3.1%). The prevalence of ankle protection (bracing/taping) was similar between sports (ankles with previous injury: volleyball 18% v football 15%; no previous injury: volleyball 1.1% v football 0%).

**Conclusions:** Previous injury was a risk factor for new injury in amateur volleyball, but not in professional football. It may be hypothesised that this is due to closely supervised follow up of professional athletes by team medical staff in football.

1. Bahr *et al* 1996.

### 005 DYNAMIC POSTURAL STABILITY IN BLIND ATHLETES USING THE BIODEX STABILITY SYSTEM

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**Background:** Three systems affect the upright standing posture in humans: visual, vestibular, and somatosensory. It is well known that visually impaired individuals have poor postural balance. On the other hand, it is a well documented fact that some sports can improve postural balance.

**Purpose:** To evaluate the dynamic postural stability in goal ball athletes.

**Methods:** In total, 20 blind goal ball players, and 20 sighted and 20 blind controls were evaluated using the Biodex Stability System (BSS). Three adaptation trials and three test evaluations (a 20 second balance test at a platform stability of 8) were applied to the blind people, and to the sighted controls with eyes open and closed. Dynamic postural stability was measured on the basis of three indices: overall anteroposterior, and mediolateral (ML). Means of each test score were calculated. The tests results were compared for the blind athletes, and for the sighted (with eyes open and closed) and blind controls.

**Results:** There were significant differences between the results of the blind and the sighted subjects for all three indices. Although the stability of goal ball players was better than sedentary blind subjects, only the ML index values were statistically different from the other groups (mean (SD) 4.47 (1.24) in the goal ball players; 6.46 (3.42) in the blind sedentary subjects,  $p=0.04$ ).

**Conclusions:** Dynamic postural stability was demonstrated to be affected by vision; and it was found that blind people playing goal-ball 1–2 days per week have higher ML stability than sedentary sighted people.

### 006 THE INCIDENCE AND RISK FACTORS OF ANKLE INJURIES IN BALL SPORTS

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**Purpose:** To determine the rate of ankle injury and examine risk factors of ankle injuries in mainly professional athletes.

**Methods:** In total, 222 (107 soccer, 49 basketball, 49 volleyball, and 17 handball players; mean (SD) age 22.6 (5.3) years) professional athletes were treated in our clinic, and nine types of ankle injury documented. The ankle injured players participated in a physiotherapeutic programme and a history was taken of the progress of their injury, to obtain information about time missed, treatment sought, and changes in shoes, protective equipment and warm up on returning to play. Injury observes sat clinic to determine the occurrences of ankle injuries in ball sports. Ankle injured players and/or a group of sports branch participated to this study.

**Results:** The rate of ankle injuries was 2.22 per 100 participants, with almost half (47.5%) missing one week or more of competition and the most common mechanism being landing and changing shoes (41%). Over half (62.4%) of the ankle injured players sought professional treatment by a physical therapist. Three risk factors for ankle injury were identified: (a) players with a history of ankle injury were almost five times more likely to sustain an ankle injury (95% confidence level); (b) players wearing shoes without appropriate their sports were more likely to injure an ankle than those wearing shoes relating to their sports; (c) players who did not stretch before the game were more likely to injure an ankle than players who did a warm up and stretching programme. There was also a trend toward ice application and use of ankle brace decreasing the risk of ankle injury in players with a history of ankle injury.

**Conclusions:** Ankle injuries occurred at a rate of 2.22 per 100 participants. The most common mechanism of ankle injuries was landing. These findings should all be considered when preventive strategies for ankle injuries in ball sports are being formulated.

### 007 A KINETIC, KINEMATIC, AND EMG STUDY OF THE EFFECT OF FOOTBALL BOOT MIDSOLE HEIGHT ON HAMSTRING MUSCLE ACTIVITY

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**Background:** Hamstring injury is the most frequent injury in the Australian Football League (AFL) and accounts for approximately 15%

of all recorded injuries. A change in the joint angle and joint moment at the level of the hip and knee alters the load on the hamstrings and potentially be a contributor to hamstring injury. The raise gradient is the change in height, exerted by the midsole of a shoe, from the heel to the toes.

**Purpose:** To measure plantar pressure distribution and force, and EMG signals in the hamstrings, and thereby assesses the strain developed in the hamstrings with and without a raise gradient.

**Methods:** In total, 36 footballers were recruited for this study. The height range was 172–198 cm (mean (SD) 181.8 (4.2)); age 20–29 years (25.7 (2.1)). The subjects were assigned to one of three groups: a control (barefoot) group, a no raise gradient (NRG) group, and a raise gradient group (RG; 10 mm raise gradient) All subjects ran at 4.2 m/s, with kinetic data collected with an in shoe pressure system. Three dimensional kinematic data were collected. Surface EMG measured muscle activity in nine muscles. Two way analysis of variance was used to determine the statistical significances of the effects of the test variables.

**Results:** The kinematic data of the knee and ankle joints displayed prolonged extension movements in the barefoot and NRG states. There was significant increase in hip, ankle and knee flexion in the RG group ( $p<0.05$ ). Integrated EMG decreased in the BF, ST, SM, Ga and So muscles, with no significant change recorded in RF, VM, VL and G and S muscles as the raise gradient was increased ( $p<0.05$ ). There was a significant reduction in both the average peak pressure and the average magnitude of the second VGRF peak for the RG compared with NRG groups ( $p<0.01$ ).

**Conclusions:** The early results indicate that the introduction of a 10 mm raise gradient between the outsole and upper of football boots may reduce electromyographic activity in the hamstrings and triceps surae muscles of running athletes. In addition, the 10 mm raise gradient alters the kinematic response of the athlete, such that there is increase in hip, knee and ankle flexion.

### 008 MEASUREMENT OF IMPACT DURING GYMNASTICS SKILLS

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**Purpose:** To examine the musculoskeletal loading experienced by young female gymnasts and develop a portable method for assessment of training loads and injury risk in the field.

**Methods:** Accelerometers were attached at the pelvis to record data for landings on both the upper and lower body during gymnastics skills in the laboratory and in a gymnastics training centre. Skills analysed in the laboratory were performed on a landing mat placed over two Kistler force platforms from which ground reaction forces (GRFs) were obtained. Single mass models (rigid body and spring dashpot) were applied to acceleration data to estimate GRF. Laboratory data were collected for landings of 12 subjects for 9 different skills in 223 trials. Field data were collected for 2 subjects for 11 skills in 58 trials. Upper and lower limb GRFs were measured in the range of 1.2–11.8 times body weight (BW).

**Results:** In the laboratory, landings on the upper limb showed significantly ( $p<0.01$ ) mean (SD) lower peak accelerations and GRFs (21.5 (6.4)  $m/s^2$  and 2.4 (0.6) BW) than those on the lower limb (73 (24.7)  $m/s^2$  and 5.4 (1.6) BW). Peak acceleration correlated with peak GRF with a Pearson  $r$  of 0.71; however, the magnitude of GRFs calculated using measured accelerations overestimated forces by 1.5 (2.1) BW. In the gymnasium, measured accelerations were similar to those found in the laboratory with averages over all skills in the laboratory (61 (31)  $m/s^2$ ) and in the field (69 (32)  $m/s^2$ ).

**Conclusions:** Results from simple modelling methods do not demonstrate appropriate accuracy to estimate GRFs in the gym for individual skills; however, acceleration is suitable to distinguish between skills showing high and low GRFs. An acceleration based index of loading may be developed to classify high and low risk training regimens, which, coupled with injury data, could constitute an injury risk assessment tool.

### 009 THE RISK OF CONCUSSION ASSOCIATED WITH MOUTHGUARD USE AMONG PROFESSIONAL ICE HOCKEY PLAYERS

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**Purpose:** To determine if the risk of concussion and concussion severity is significantly different for ice hockey players wearing mouthguards (MG) versus no mouthguards (NMG).

**Methods:** A prospective cohort study was conducted over one National Hockey League (NHL) regular season (2003–2004) using 1006 athletes from all 30 teams. Equipment managers and NHL personnel documented individual mouthguard use and playing time (seconds), respectively, for all players during every regular season game. Team physicians completed a standardised injury report form for all game related concussions, and recorded the date when a concussed athlete was medically cleared to return to competition. Video footage of all game related concussions was obtained to allow for an accurate description of concussion mechanism.

**Results:** In total, 72 concussions were reported by team physicians during 2003–2004 regular season games (MG 39, NMG 33). The primary mechanism of concussion for both cohorts was body checking/collision (open ice), followed by boards/glass contact, and fighting. The risk of concussion for players not wearing a mouthguard was 1.42 times greater than players who wore a mouthguard (95% CI 0.90 to 2.25). Although this difference was not statistically significant, the clinical significance might be considered. Concussion severity measured via time loss from competition was not significantly different between the two cohorts (MG, 21.5 days lost per concussion, 95% CI 20.0 to 22.9; NMG, 19.8 days lost per concussion, 95% CI 18.4 to 21.4). However, symptom severity measured subjectively via the McGill Abbreviated Concussion Evaluation symptom score was significantly greater for athletes who did not wear a mouthguard compared with those who did ( $p < 0.01$ ).

**Conclusions:** No statistically significant reduction in concussion risk or concussion severity (time loss) was observed between players who wore a mouthguard versus no mouthguard at the time of injury.

#### 010 HANDLING OF IMPACT FORCES IN INVERSE DYNAMICS IN LANDING AFTER A JUMP

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**Purpose:** To improve the inverse dynamics for the assessment of knee moment by using data from accelerometers mounted on the segments.

**Methods:** Two different inverse dynamic based methods were compared with study the impact dynamics of landing: the standard inverse dynamic method (SM), using accelerations from filtered (20 Hz) position data and GRF, and the accelerometer based method (AM), using accelerations from accelerometers and GRF. Measurements of both methods were applied to a three segment rigid body model.

**Results:** The SM knee moment showed major differences compared with the AM. These differences mainly took place during the first part of impact. SM showed an extension moment peak during impact, whereas the AM showed a flexion moment peak, directly followed by an extension moment peak. It turned out that this flexion peak was the result of an underestimated correction factor in the AM, used to determine the linear acceleration of the centre of mass, which are calculated from filtered position data. Furthermore, our rigid body model assumes that the foot is one rigid segment without damping. Thus, we can state that during impact the real contribution of GRF is in great part neutralised by the segmental acceleration of foot and shank, suggesting that the high impact peak moment shown by the widely used SM moment is an artefact.

**Conclusions:** The SM used in this study is a widely used method to determine biomechanical parameters. When estimating net joint moments during impact in activities such as running and jumping, the inaccuracy of the net joint moment during impact when using rigid body models should be taken into consideration. In our opinion, adjustments to the widely used filter techniques can overcome artefacts in net impact joint moments, by using the same cutoff frequency for both kinematic and force data. Complementary to this, we recommend not considering impact peaks as the source of chronic overuse injuries such as jumper's knee.

#### 011 ICE HOCKEY PLAYERS WITH AND WITHOUT MULTIPLE CONCUSSIONS: A COMPARISON STUDY IN A SWISS PROFESSIONAL TEAM

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**Background:** Ice hockey has the highest incidence of concussion in contact sports, and concussion management is a subject of ongoing discussion. There is a lack of knowledge regarding long term outcomes associated with multiple concussions.

**Purpose:** To evaluate symptoms and function in ice hockey players with and without career concussions during the off season.

**Methods:** In total, 14 male hockey players (mean (SD) age 23.9 (3.4) years) of a Swiss League professional team were examined in the off season. One group included six players who had a history of multiple concussions (~2–5) but were in a concussion free period of over 5 months on average. The control group was comprised of six matched players and two goalkeepers who had never suffered a concussion during their career. The post-concussion symptoms scale (PCSS), balance error scoring system (BESS), core strength, cervical range of motion (CROM), neural tension tests (NTT) for the upper extremities, and specific cervical strength (with VAS) was examined for all players. One-way analysis of variance ( $0.05$ ) was used to detect differences between the concussion and non-concussion group. Pearson correlation coefficients were calculated for all variables.

**Results:** PCSS ( $p=0.016$ ), BESS ( $p=0.000$ ), and VAS cervical strength ( $p=0.011$ ) were significantly impaired, and extension CROM ( $p=0.061$ ) and core strength ( $p=0.092$ ) were diminished in the concussion group. No significant differences were found in the other CROM or NTT examinations. Moderate to high correlations were found between the number of concussions and BESS ( $R=0.92$ ), BESS and PCSS ( $R=0.76$ ), and number of concussions and PCSS ( $R=.70$ ).

**Conclusions:** The compounded effects of multiple concussions, despite a concussion free period of ~5 months, still persist with significant impairments. BESS and PCSS are demonstrated to be relevant markers of these lasting effects and could be valuable additions in monitoring post concussion treatment in long term observations.

#### 012 "THE 11": THE F-MARC INJURY PREVENTION PROGRAMME FOR AMATEUR FOOTBALL PLAYERS

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Football is the most popular sport in the world, played by approximately 200 000 professional and 240 million amateur players. Football has a relatively high risk of injury. Risk factors for football injuries have been described in the literature, and a variety of preventive interventions has been proposed. However, only a few studies have been conducted regarding the effectiveness of prevention programmes in football. Summarising the literature, there is good evidence that intervention programmes can reduce the incidence of football injuries. The preventive programme, "The 11", was developed in cooperation with national and international experts under the leadership of F-MARC. It is designed to reduce typical types of football injury, such as ankle sprains, hamstring and groin strains, and ligament injuries in the knee. "The 11" is a simple and catchy programme that includes 10 evidence based or best practice exercises and the promotion of fair play. It requires no equipment other than a ball, can be completed in 10–15 minutes, and should be performed in every training session. The exercises focus on three main areas of intervention: core stability, neuromuscular control, and plyometrics. Deficits in these areas are associated with increased risk of injury and reduced athletic performance. Core stability and strength is essential to control trunk, pelvis, and lower extremities, while optimum neuromuscular control of the lower extremities is crucial for joint stability. Sport specific plyometrics, agility, and speed are key to responding to the football demands on the field. Knowing that a substantial number of injuries are caused by foul play, the regard to fair play is an essential aspect in the prevention of injury. "The 11" is currently implemented in a countrywide campaign in cooperation of F-MARC, the Swiss National Accident Insurance Fund (SUVA leisure time safety), and the Swiss Football Association.

#### 013 DENMARK OPEN 2004. OVERUSE INJURIES IN ELITE BADMINTON PLAYERS: ULTRASONOGRAPHICAL INVESTIGATION BEFORE AND AFTER MATCH

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**Background:** The significance of ultrasound Doppler activity in tendons remains to be clarified.

**Purpose:** To investigate changes by ultrasound Doppler in elite badminton players at baseline and after participation in a 6 star ranked international badminton tournament.

**Methods:** In total, 72 players from 11 different countries were interviewed and 64 were scanned before and 45 rescanned after the match. The interviews were performed by the same person and all scans were performed by the same experienced doctor, both blinded to the other data. Scanning was performed with a 15 MHz linear transducer with Doppler of the achilles, patellar and extensor communis tendons.

Endpoint was amount and distribution of Doppler activity. Doppler changes were graded 0 to 4.

**Results:** In total, 62 players had had severe complaints from 91 tendons over the previous 3 years; 45 from the patellar complex and 34 and 12 from the achilles and elbow tendons respectively. In 60%, the problems had begun slowly, and median length of symptoms was 4 months (range 0–36). Most (86%) accept pain as a part of the game, 50% play while in pain, and 21% while on painkillers, mainly NSAIDs. Median follow up time to ultrasound after match was 38 minutes (range 7–643). At baseline, Doppler activity was seen in the majority of players, especially in the patellar complex region. After the match, a highly significant increase was observed in the tendons on the non-dominant side: quadriceps (Willcoxon  $p < 0.001$ ), patellar tendon ( $p < 0.05$ ), and achilles mid portion ( $p < 0.05$ ).

**Conclusions:** Doppler activity was found in all tendons of elite badminton players indicating a high degree of strain on these tendons. An increase in colour Doppler fraction was only significant in the non-dominant leg. This may be explained by the fact that badminton players set off and land more frequently on this side. The Doppler changes corresponded to the higher number of injuries on this side, and may prove of prognostic value.

#### 014 SIGNS OF HYPERAEMIA IN TENDONS OF HEALTHY NON-TRAINED PERSONS AFTER 5 KM LONG DISTANCE RUN

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**Background:** In tendons, signs of hyperaemia are interpreted as a sign of pathology, and in patients with clinical signs of tendonitis, ultrasound Doppler reflects hyperaemia.

**Purpose:** To investigate signs of hyperaemia in non-symptomatic, healthy non-trained subjects before and after a run.

**Methods:** In total, 10 healthy non-trained subjects were recruited (mean (SD) age 28 (11), BMI 21 (2)). An inclusion criterion was absence from regular training for at least 2 years. In each subject, both achilles tendons and patellar tendon complexes were scanned with an Acuson Sequoia 15 MHz linear transducer before and after the run. Running time and maximum and average heart rate were recorded. Pain was determined before and after the run on a visual analogue scale (VAS) and by a telephone interview 2 days after.

**Results:** Mean (SD) heart rate was 180 (16), average heart rate 167 (17) and time 34 (6) minutes. All patients had VAS of 0 before running. Mean VAS after run was 4 (0–35) in achilles and 9 (0–62) in patellar. All but two patients (80%) showed signs of hyperaemia after running. Four patients (40%) had pre-existing signs of hyperaemia before running, and all showed increased or sustained activity after running. In particular, the achilles tendons showed signs of new Doppler activity after running. One patient complained of pain in the tendon (right patellar) in the telephone interview. Appearance of Doppler activity over time was significant ( $p = 0.005$ ) for the achilles but not for the knee tendons ( $p = 0.213$ ).

**Conclusions:** Doppler activity can be seen after repeated loading of the tendons in some patients and may be regarded as a physiological phenomenon. In particular, the achilles tendons showed signs of new activity and may indicate that untrained persons strain their achilles tendons more than their knee tendons when running on a flat surface. Patients with pre-existing signs showed sustained or increased Doppler activity. Doppler activity was not correlated with symptoms.

#### 015 IMMEDIATE ACHILLES TENDON RESPONSE AFTER ECCENTRIC STRENGTH TRAINING EVALUATED BY ULTRASOUND WITH DOPPLER

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**Background:** Eccentric training is generally accepted in the rehabilitation of tendinopathy, but the mechanism behind the supposed effect has never been clarified.

**Objectives:** To test the immediate tendon response (Doppler activity) of eccentric strength training in patients with chronic achilles tendinopathy (AT).

**Methods:** In total, 11 patients (8 men; mean age 34 years, range 25 to 56) with clinical and ultrasonographical diagnosis of AT were included in this study. Two patients had bilateral symptoms. All patients had pain, swelling, and tenderness at palpation. Three patients had signs and symptoms of AT from the insertion area. The symptomatic

tendon(s) underwent 3 sets of 15 repetitions of heavy loaded eccentric training, with the knee in a slightly bent position. Immediately after the exercise, the tendons were rescanned. End point was the amount and distribution of Doppler activity.

**Results:** All patients had Doppler activity in the tendon with a large variation in colour fraction. Before the run, the median colour pixel fraction was 0.05 (range 0.01 to 0.33). After the run, seven tendons showed a marked increase in colour Doppler activity, while three decreased, and the most active tendon showed no change; post-run median fraction was 0.07 (range 0.01 to 0.33; Willcoxon test  $p = 0.21$ , NS). Tendons with a colour fraction below the median at baseline increased significantly after the run ( $t$  test  $p = 0.02$ ), whereas in individuals above the median, no significant increase was observed.

**Conclusions:** A closing of the vascular supply to the diseased achilles tendon has been proposed as part of the effect of eccentric training. However, the immediate ultrasonic effect of eccentric training in this material was an increase or sustained intratendinous Doppler signal, indicating hyperaemia after eccentric training. A standardised regimen with regard to training activity must be prescribed before a diagnostic ultrasound Doppler examination.

#### 016 COMMUNITY FOOTBALL PLAYERS' ATTITUDES TOWARDS PROTECTIVE EQUIPMENT

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**Background:** Personal protective equipment (PPE) is used to control injury risk, and its effectiveness has been investigated in many physical activities. In Australian football, many studies have documented a significant risk of head and neck injuries. Barriers to the use of PPE include the attitudes and behaviours of the target population. On the one hand, it is important that people choose to wear PPE and on the other hand it is important that those who wear PPE are not doing so to cover up risk taking behaviours. A possible indicator of whether players will adapt their playing practices while wearing PPE is their attitudes towards it.

**Purpose:** To present the results of a baseline survey of community Australian Football players' attitudes towards protective equipment.

**Methods:** The Australian Football Injury Prevention Project (AFIPP) was a randomised controlled trial to assess the effectiveness of protective equipment in Australian Football. In total, 301 players volunteered for the project, which involved completing a pre-season attitudinal survey. The survey requested information on demographics, playing and injury history, current use of protective headgear and mouthguards, and general attitudes towards PPE.

**Results:** Almost three quarters of players (73.6%) reported wearing mouthguards during the previous playing season, compared with only 2.1% wearing headgear. The most common reasons for not wearing headgear and mouthguards were "I don't like wearing it" (headgear 44.8%; mouthguards 30.6%) and "It is too uncomfortable" (headgear 40.7%; mouthguards 45.8%).

**Conclusions:** The higher mouthguard usage rate reflects the favourable attitudes towards them by Australian football players generally. Similarly, the low headgear usage rates reflect the low acceptance of this form of protection in this sport. Further research should be directed towards establishing the reasons why players seem to have the belief that headgear plays a role in injury prevention, yet few of them wear it.

#### 017 CHALLENGES OF CONDUCTING SPORTS INJURY RESEARCH AT COMMUNITY LEVEL

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**Background:** Sports injuries in any instance are a concern. With the majority of participants of all sports being at the community level, an understanding of the injuries among this group is essential. Owing to the voluntary nature of community sport and the lack of trained medical staff, conducting sports injury research at this level poses a number of questions. What is the best method to recruit players to make sure that maximum participation is gained? What type of data can you collect and who will collect it? How do you maintain and measure participant compliance? Why do some players choose not to be involved in injury prevention research? In Australia, Australian football is the most popular team sport participated in by males.

**Methods:** The first ever randomised, controlled field trial of protective equipment was conducted at the community level of Australian Football in Victoria. The project had four study arms: (a) protective headgear, (b) protective mouthguard, (c) protective headgear and mouthguard, and (d) usual protective practice. Teams were to be randomly assigned to one

of four of these intervention arms. Club and team recruitment then took place using an expression of interest method and nine clubs volunteered a total of 23 teams. Recruitment of the 301 players for the project took place during the pre-season during training sessions. Each team was responsible for providing a data collector who was trained during the pre-season.

**Conclusions:** This paper presents the results of an evaluation into this project including issues common to all community based research, such as reliability of data collectors, recruitment of sports clubs and team members, and reason for non-participation in sports safety research.

### 018 THE INCIDENCE, SEVERITY, AND NATURE OF CERVICAL INJURIES IN PROFESSIONAL RUGBY UNION

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**Purpose:** To investigate the epidemiology of cervical injuries sustained during professional Rugby Union competition.

**Methods:** The study was conducted over two full seasons using a cohort of 546 professional Rugby Union players from 12 English Premiership clubs. Medical personnel at each club prospectively reported every lost time injury. Match exposure data were recorded.

**Results:** There were 117 cervical injuries (incidence of 7 per 1000 player hours; average severity 15 days); these represented 7% of all injuries and 5% of all days lost. The incidence was significantly higher for forwards (10) than for backs (4) and particularly high for hookers (16). Injuries to the cervical nerve root (43%) and cervical facet joint (29%) predominated, although none of the injuries was catastrophic and there were no cervical fractures. However, two injuries caused players to retire from the sport. Tackling or being tackled was the most common injury mechanism (53%), and caused the greatest loss of time (40%), considerably more than scrummaging (12% and 16%). There were no cervical injuries sustained in a collapsed scrum.

**Conclusions:** Previous studies reported that cervical injuries have caused permanent paralysis or death, in particular from collapsed scrummages. The IRB has changed the scrummage laws in order to reduce this risk, and no injuries resulting from this mechanism were recorded in the current study. Forwards were at a significantly higher risk of sustaining a cervical injury, probably owing to the greater demands placed on them during the physical aspects of the game. However, cervical injuries represented only 5% of the overall injury risk. While emphasis should continue to be placed on the prevention of catastrophic cervical spine injuries in Rugby Union, it is also imperative to address other risk factors and reduce the high incidence of other less severe cervical injuries that can also eventually lead to permanent, degenerative changes in the cervical spine.

### 019 THE INCIDENCE, SEVERITY, AND NATURE OF SCRUMMAGING INJURIES IN PROFESSIONAL RUGBY UNION

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**Purpose:** To investigate the epidemiology of scrummaging injuries sustained during professional Rugby Union competition.

**Methods:** The study was conducted over two full seasons using a cohort of 300 professional Rugby Union forwards from 12 English Premiership clubs. Medical personnel at each club prospectively reported every lost time injury. Match exposure data were recorded.

**Results:** There were 92 scrummaging injuries (incidence 10 per 1000 player hours; average severity 21 days); these represented 11% of all injuries and 13% of all absence to forwards. Calf muscle strains (15%) and lumbar disc/nerve root injuries (8%) were most common. Shoulder injuries caused the greatest proportion (33%) of time loss (dislocation/instability 30%; rotator cuff/impingement 30%). Cervical injuries caused only 15% of the absence and none was catastrophic. Front row players received the majority of injuries (91%) (tight head: 45%; loose head: 27%). The incidence of injury increased towards the end of the season and the majority were sustained in the final quarter of a match (38%) (incidence: starting 17; replacements 12). Only 15% of injuries were due to collapsed scrums.

**Conclusions:** The unique action of scrummaging contributed a substantial proportion of the injury risk in professional Rugby Union. Front row players received the majority of the injuries, probably due to the exposure to high forces during scrummaging. Fatigue is implicated as a risk factor owing to the higher incidence of injury towards the end of the season and the end of the match for starting players. There were no

catastrophic neck injuries, and only 15% of the injuries were sustained during a collapsed scrum, suggesting that changes to the scrum engagement laws have reduced this risk. While emphasis should continue to be placed on the prevention of cervical spine injuries, specific strategies to prevent calf muscle strains and shoulder instabilities in scrummaging should also be developed.

### 020 IS CORPORATE SPONSORSHIP GOOD FOR INJURY PREVENTION INITIATIVES IN COMMUNITY SPORT?

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**Background:** Since 2001, Accident Compensation Corporation (ACC) has been the principal sponsor of New Zealand's largest multisport event, the Masters Games, an annual 9 day event with an average of 67 sports and 8000 competitors. Competitive age groups depend on the sport, most starting at 30+ years. Reasons for sponsorship include corporate promotion, dissemination of injury prevention (IP) information to a target group (81% of ACC sport claims are adults; research shows 64% of competitors are able to pass IP information to others) and demonstration of social responsibility. ACC has leveraged its sponsorship to influence the event organisation and implement IP initiatives, including: the collection of injury data to obtain injury rates and focus future IP work; compulsory injury management at venues; provision of IP messages to participants; and support for organisers to implement IP in their sport. Measures of effect include brand recall and appropriateness of sponsorship, impact on IP understanding, and changes in injury rate.

**Methods:** Independent post-event telephone interviews of participants were undertaken (n=300 in 2004) and injury reports returned by injured participants were analysed (387 in 2001; 178 in 2004).

**Results:** ACC's sponsorship was recognised by 80% of participants and 90% consider ACC's involvement appropriate and a suitable vehicle to promote sports IP. In 2004, 26% of interviewees claimed their understanding of IP was better or much better having attended the 2004 event. Over all sports the estimated injury rates (using the proportion of injured people who submitted injury reports) were 10.3% in 2001 (range 8.9 to 12.0%, p<0.05) and 5.0% in 2004 (4.4 to 5.7%, p<0.05). The sponsorship has enabled ACC to reach many people with IP information, collect injury data, and shows early indications of positive impact on injury rates and IP understanding. Benefits and limitations of implementing and measuring effectiveness of corporate sponsorship of a community sports IP package will be discussed.

### 021 HELMET AND WRIST PROTECTORS IN SKIING AND SNOWBOARDING: EFFECT AND SPECIFICATIONS

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**Background and purpose:** The knowledge and experience of a group of 30 experts from Germany, Austria, France and Switzerland was collated to close the gaps in the knowledge of specifications for helmet and wrist protectors in snow sport.

**Methods:** Using a Delphi survey—that is, a structured series of surveys of experts, a consensus was sought on personal protective gear in snow sport. Experts from various specialised snow sports sectors participated in the survey. Information was gathered on which articles of protective equipment were practical, and which should be worn and actively promoted in work on accident prevention. Investigations were also made as to whether a ski helmet should differ from a snowboarding helmet and what functions wrist protectors should perform for snowboarders.

**Results:** Almost all the snow sport experts are convinced of the advisability of wearing a helmet. The experts also believe that measures should be taken to increase the proportion of snowboarders wearing wrist protection. Based on the feedback of the experts, the Swiss Council for Accident Prevention bfu has drawn up 10 requirements for snowboarding wrist protectors, the most important of which are that he wrist protector must have a palmar positioned stabilising element; and that the stabilising element must stretch in a distal direction proximal to the metacarpophalangeal joint but no further, and must reach in a proximal direction to the middle of the forearm.

**Conclusions:** The experts consider the wearing of a helmet while skiing or snowboarding and the use of wrist protectors while snowboarding to be essential measures for the avoidance of injury. A ski helmet conforming to the EN 1077 is suitable for both skiers and snowboarders. This bfu list of specifications for wrist protectors can form the basis for the design of an effective product, serve as a purchasing guide for the consumer, and provide the bfu with the basis for assessment of wrist protectors for the awarding of the bfu safety mark.

### 022 CAN WE PREDICT KNEE FUNCTIONALITY OF ACL DEFICIENT AND ACL RECONSTRUCTED PATIENTS USING TIBIAL ACCELERATION PROFILES?

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**Background:** During abrupt deceleration tasks, tibial acceleration is indicative of tibial stability and shock transmitted through the lower limb.

**Purpose:** To examine relationships between knee functionality and tibial acceleration of anterior cruciate ligament (ACL) deficient and ACL reconstructed patients during landing from a single leg long hop.

**Methods:** Knee functionality was rated using the Cincinnati Knee Rating System for the involved limb of 10 chronic, functional ACL deficient patients and 27 reconstructed patients (14 using patella tendon (PT) and 13 using hamstring tendon (HT) autografts). Tibial acceleration during a single leg long hop was assessed using uniaxial accelerometer attached to the tibial tuberosity of each patient's involved leg.

**Results:** Pearson product moment correlations revealed a significant moderate negative relationship between knee functionality and time to zero tibial acceleration in the ACL deficient patient, indicating patients who minimised the time of positive tibial acceleration had higher levels of knee functionality. For the PT group, a significant moderate negative relationship between knee function and time to peak tibial acceleration was found, indicating that early control of peak tibial acceleration was a determining factor following reconstruction using the PT. No significant relationships were found between knee functionality and tibial acceleration for the HT patients.

**Conclusions:** The relationships between knee functionality and tibial acceleration suggested that those patients who were better able to arrest acceleration of the tibia during an abrupt deceleration task, whether reconstructed or not, tended to display greater knee functionality.

### 023 THE INCIDENCE OF SERIOUS INJURY AND DEATH DURING SPORT AND RECREATION ACTIVITIES IN VICTORIA, AUSTRALIA

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**Background:** Participation in sport and recreation is widely encouraged for general good health and the prevention of some non-communicable diseases. However, injury is a significant barrier to participation and safety concerns are a factor in the decision to participate. An understanding of the sport/recreation activities associated with serious injury is useful for informing physical activity choices, and for setting priorities for the targeting of injury prevention efforts. This population based study describes the epidemiology of serious sport/recreation related injuries sustained by adults in Victoria, Australia.

**Methods:** The Victorian State Trauma Registry and the National Coroner's Information Service were used to identify and describe sport/recreation related serious injuries, including deaths, occurring during the period July 2001 to June 2003. Age adjusted rates of serious injury and death were calculated using participation figures for each sport and general population data.

**Results:** There were 150 cases of serious injury and 48 deaths related to sport or recreation participation. The rate of serious injury was 1.8 per 100 000 participants per year, and the rate of death was 0.6 per 100 000 participants per year. Motor, power boat, and equestrian sports had the highest rates of serious injury, while the majority of deaths were due to drowning.

**Conclusions:** The findings of this study suggest that although risk of serious injury through sport/recreation participation is low, motor, power boat, and equestrian sports should be priorities for further research into injury prevention. The majority of sport and recreation related deaths are due to drowning, highlighting this area for prevention efforts.

### 024 EPIDEMIOLOGICAL STUDY AND PREVENTION EFFICACY ON SHOULDER INJURIES IN ITALIAN ELITE SWIMMERS

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**Purpose:** To perform an epidemiological study on shoulder injuries among the Italian elite swimmers, and evaluating the role and efficacy of prevention exercises.

**Methods:** A pilot study was performed on 53 athletes of the Italian national team, administering a questionnaire (20 questions) developed and approved by the Medical Commission of the Italian Federation of Swimming (FIN). Afterwards, the questionnaire was administered to other 142 elite swimmers (finalists at the Italian championship in 2003). In total, 91 athletes (46.6%) who did not use prevention exercises were randomly split into two groups. In one group a prevention protocol of on land exercises were administered (one session of 25 minutes for each training day). At 1 year follow up, the questionnaire was newly administered to the prevention and control group.

**Results:** In total, 68.7% of swimmers suffered at least once from shoulder problems and 46.1% had symptoms during the previous year of activity. The dominant shoulder was involved in 87.1%, especially among swimmers using crawl, who were more prone to shoulder injuries than those using other strokes. The average (SD) number of missed days of training was 12.8 (18.2), and of differentiated training days was 25.1 (29.2). Swimmers performing prevention exercises comprised 53.4% of the total, and those with a history of shoulder problems 67%. At follow up, the control group showed an incidence of shoulder problems, missed days of training, and differentiated training sessions that was statistically significant higher than prevention group.

**Conclusions:** Shoulders problems are very common among elite swimmers in Italy. The crawl is the highest risk stroke for the shoulder, and the dominant side, which is frequently the preferred side for breathing, is also more involved. The incidence of prevention practices were too low among the Italian elite swimmers but the constant application of prevention exercise for shoulder decreased the incidence of shoulder injuries in 1 year of training.

### 025 STRESS FRACTURES IN CHILDREN: CLINICAL FEATURES AND RISKS FACTORS

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**Background:** The incidence of stress fractures in young athletes has increased with the popularisation of sports among children and adolescents. Stress fractures are less common in children and adolescents than in adults. The recognition of stress fracture in children and differentiation from infections or neoplasm requires knowledge of their most common sites, presentation, and clinical course.

**Methods:** Examination of the medical records from the orthopaedics unit showed that over the period 1985–2004, 11 patients younger than 16 years were diagnosed with stress fracture (eight boys, three girls; mean age 10.3 years, range 9–16). For all these patients, we noted symptoms, location of fracture, sport played, risks factors, and treatment.

**Results:** The most common complaint was pain and limp with activity. The most common site was the tibia (four cases) followed by metatarsals (three) and ischiopubic junction (three cases). The sport played was indoor soccer (five cases), athletics (four cases) and handball (two cases). The preliminary diagnosis included low grade osteomyelitis and osteosarcoma. Treatment in all cases was activity modification or cast immobilisation.

**Conclusions:** Cortical thickening and/or periosteal reaction in long bones of children continue to present a diagnostic difficulty. The diagnosis of stress fracture in a paediatric patient is made after an accurate history and physical examination in combination with appropriated image studies. The "triad" of localised periosteal reaction, endosteal thickening, and/or radiolucent cortical line is typical of stress fracture.

### 026 EPIDEMIOLOGY OF INJURIES IN FEMALE SENIOR HANDBALL PLAYERS: A KNEE JOINT CENTRED STUDY

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**Purpose:** To study injuries in Portuguese senior female handball players, particularly to the knee joint, to characterise the players' gynaecological profiles and analyse their relation with handball level and injuries; to establish an epidemiological injury profile for female handball players (based on severe injuries, before 2003–04 and all injuries in 2003–04); to determine the injury prevalence and incidence in 2003–04; and to observe knee injury incidence, injury mechanism, and associated risk factors.

**Methods:** This was an epidemiological, non-experimental, exploring, transversal and partially retrospective study. A questionnaire was answered by 75 athletes from the first and second national divisions

(return rate of 50%). In the absence of a known validated instrument for our purpose, we had developed a specific questionnaire based on restrict rules, validated by handball, traumatology, and gynaecology specialists.

**Results:** Over 80% of the players have had, in their handball career, at least one severe injury. In 2003–04 we found 42 injuries in 37 athletes (an incidence of 2.6 injuries per 1000 player hours), with a significantly higher incidence in game (16 injuries per 1000 game hours) compared with practice (0.9 per 1000 practice hours). The oral contraceptive pill and menstrual cycle regularity do not seem to be related with injury occurrence. Ankle sprains (33%), knee sprains (24%), and chronic shoulder pain (19%) were the most prevalent incidences and sites of severe injury. Playing in a game, being in the offensive situation (70%), previous injuries in the same body place (30% of recidivist injuries), and a lower handball skill level (ratio 2:3 of first to second division) seem to be risk factors for injuries. Knee injuries mostly occur in cut movement situations (33%). In this joint, anterior Cruciate ligament injury was observed at higher occurrence (50% of knee joint injuries), and we noticed an elevated incidence (50%) of severe knee injuries until the age of 19 years.

### 027 ROUTINE INJURY SURVEILLANCE IN CLUB RUGBY: IS IT FEASIBLE?

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**Background:** A substantial effort has been made to promote injury prevention in New Zealand club (community) rugby. Since 2001, the main thrust of this effort has been implementation by the New Zealand Rugby Union (NZRU) of RugbySmart, a national injury prevention programme. To monitor the effectiveness of this programme, valid and reliable methods were required for recording the incidence, nature and circumstances of injury, and the injury prevention behaviour of players.

**Purpose:** To develop a system for undertaking routine surveillance in club rugby.

**Methods:** A cohort design, with exposure measurement, was used, involving the sampling of players from the NZRU's player database, and weekly follow up throughout the competitive season. Data collection was by telephone interview, with interviewers entering data directly into an electronic database. At the conclusion of the season, incidence rates were calculated by position, grade, and division, and the nature and circumstances of injury and the injury prevention behaviour of players were described. The system was piloted in 2002 and implemented in 2003 and 2004. In 2004, 836 players were recruited prior to commencement of the season and of these, 704 played at least one game during the season.

**Results:** Data were collected on 6266 player games and on 621 injury events, giving an incidence rate of 9.9 injury events per 100 player games (95% CI 9.2 to 10.7) or 93 injury events per 1000 player hours. The most common injury localisation was the shoulder (14%), followed by the head (11%) and knee (11%). The most common injury type was sprain/strain (40%), followed by haematoma (21%) and laceration (8%). Players warmed up before 97% and cooled down after 46% of player games. Mouthguards were worn in 94% of player games. Routine surveillance using this system is feasible but there are challenges to its long term implementation, not the least of which is cost.

### 028 REDUCING THE RISK OF HAMSTRING INJURY WHILE ENHANCING ATHLETIC PERFORMANCE: IS ECCENTRIC TRAINING THE KEY?

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**Background:** Although previous research has shown that the length-tension relationship during eccentric contraction plays a role in hamstring injury, training methods to promote beneficial adaptations are still unclear.

**Purpose:** To determine whether an eccentric hamstring specific training programme would result in favourable adaptations for both performance and injury prevention.

**Methods:** The training intervention consisted of an eccentric hamstring exercise performed twice a week during a four week cycle. Pre- and post-training isokinetic strength testing and vertical jump was assessed as a measure of lower body performance. Nine athletic men with no previous strength training experience participated in the study.

**Results:** There was a significant increase in vertical jump, a significant decrease in hamstring position of peak torque (POS) from full extension and a significant hamstring POS difference between limbs.

**Conclusions:** Nordic hamstring training produces favourable neuromuscular adaptations for the possible prevention of hamstring injury while enhancing lower body power performance in untrained men.

### 029 PRE-SEASON ISOKINETIC INTERVENTION AS A PREVENTIVE STRATEGY FOR HAMSTRING INJURY IN PROFESSIONAL SOCCER PLAYERS

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**Purpose:** To verify whether pre-season isokinetic muscle strength testing could identify soccer players at risk of subsequent hamstring muscle strain.

**Methods:** In total, 617 soccer players (mean (SD) age 26 (5) years, weight 77 (6) kg, height 181 (5) cm) from professional teams in France, Belgium, and Brazil benefited from preseason isokinetic testing. The standardised protocol consisted of concentric exertions (60 and 240° per second) of both knee flexor and quadriceps muscles; flexors were also subjected to eccentric exercises (30 and 120° per second). Muscle disorders were determined using statistically selected cutoffs for bilateral differences and flexors/quadriceps (F/Q) ratios. Thereafter, players were followed for 9 months throughout the subsequent competitive season and hamstring muscle injuries were recorded.

**Results:** Of the 435 players who benefited from a complete follow up, 37 sustained a hamstring injury causing them to miss more than 4 weeks of playing time. The risk factor of hamstring injury for one season significantly differed according to the preseason isokinetic profile and the presence or absence of strength disorder management. This risk factor was set at 4.1% in the context of a normal isokinetic profile, 16.5% in the presence of strength imbalance without any compensative treatment, and 6.3% in the presence of strength imbalance that had been successfully treated.

**Conclusions:** The risk of hamstring injury appeared significantly increased (four times higher) in players with untreated strength disorders. Correction of preseason muscle imbalance allowed for a significant reduction in the risk of subsequent muscle strain. We concluded that isokinetic intervention, as a preseason screening tool in professional soccer players, contributes to a preventive strategy for the hamstring muscle group.

### 030 PREVENTION OF ANKLE SPRAINS IN BASKETBALL: EFFECTIVENESS OF A 22 WEEK SPORTS SPECIFIC BALANCE TRAINING PROGRAMME ON THE INCIDENCE OF ANKLE SPRAINS

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**Purpose:** To investigate whether a prescribed in season balance training programme of 22 weeks, based on basketball skills, is sufficient in the prevention of ankle sprains in basketball players in that particular season.

**Methods:** A clinical trial was set up with both a intervention and a control group of basketball players. In total, 34 men (19 intervention and 15 control) and 15 women (7 intervention and 8 control) participated for 22 weeks of the 2003–2004 basketball season. Both groups matched (independent *t* test;  $p < 0.05$ ) for age, weight, body mass index and level of competition (elite). There were five dropouts, who all ceased playing basketball because of problems with their coach. The intervention group (three teams: two male, one female) performed a prescribed sports specific balance training programme with balance semi-globes for 22 weeks, with three sessions a week for 5–10 minutes during the warm up. The control group (three teams: two male, one female) followed their normal training routine. Exposure sheets were completed individually and gathered at the end of each week. All injuries were entered in the Blits® Online Injury Diary in a prospective manner.

**Results:** Statistical analysis revealed a significant difference (0.30; 95% CI 0.84 to 0.11) in the incidence of ankle sprains between the intervention and control groups, with the intervention group at lower risk. No significant differences were found for ankle re-injuries or new ankle injuries, but both control groups showed higher risks per 1000 playing hours.

**Conclusions:** We have developed a balance training programme that (a) is sports specific by inclusion of basketball skills, (b) takes in account

the aetiology of ankle sprains by using balance semi-globes, and (c) can easily be applied during basketball practice. The use of this sports specific balance training programme is effective in the prevention of ankle sprains. Therefore, the balance programme should be recommended for basketball players.

### 031 INFLUENCE OF SEX ON THE SPORTS INJURIES RATE AMONG SLOVENIAN TOP ATHLETES

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**Background:** This research study, comprising 1500 top level athletes, started in 2003 and will be resumed every year for the next 5 years. This paper reviews data from year 2003.

**Purpose:** To determine the incidence, anatomical distribution, and time onset of injury in relation to pre-season versus season and training v competition, and to evaluate the influence of sex on incidence of injuries.

**Methods:** We posted 1300 questionnaires to top level Slovenian athletes, listed by the Slovenian Olympic Committee. In total, 1037 athletes from 54 different sports returned the questionnaire (79.8%); 699 men (67.4%) and 338 (32.6%) women. Mean (SD) age was 21.5 (6.4) years for men and 19.7 (5.7) years for women, weight was 76.6 (6.4) kg for men and 61.2 (8.8) kg for women, height was 181.9 (7.7) cm for men and 170.3 (6.9) cm for women.

**Results:** We followed injuries acquired in the past 12 months. Overall injury rate (regardless of sex or age) was 135 injuries per 100 athletes during 12 months (year 2003). Distribution according to sex the injury rate was 136 injuries per 100 women and 134 injuries per 100 men. The *t* test for independent variables did not show significant differences between the sexes ( $p > 0.05$ ).

**Conclusions:** This study has given an extensive amount of information that cannot be presented in one place. This part of the analysis showed us that sex is not a defining factor for the rate of sports injuries over a 12 month period. As we are longitudinally following the same group of people, it will be interesting to do the follow up and compare data year by year. These data will help us reorganise the medical care of top level athletes on the national level, as we are planning to introduce intervention measures regarding the predominant injuries (knee injuries 22%, ankle injuries 14%).

### 032 INJURIES IN NORWEGIAN SKI RESORTS 2002–2004

A. Ekeland, A. Rødven. *Martina Hansens Hospital, Oslo, Norway*

**Background:** Since 1996, the Norwegian Ski Lift Association has conducted a central registration of the injuries occurring in the major ski resorts to survey the injury types.

**Methods:** The injuries occurring on the slopes of 12 major ski resorts, representing about 60% of the ski lift transports in Norway, were recorded by ski patrols for the seasons 2002/2003 and 2003/2004.

**Results:** In total, 7252 injured skiers were recorded. The number of skier days in the two seasons was 4884 million, and the injury rate was 1.5 injuries per 1000 skier days. Most of the injuries occurred during alpine skiing (49%) and snowboarding (43%), while telemark skiing and skiboarding each accounted for 4% of the injuries. Many of the injuries were similarly distributed among skiers and boarders, but a number of significant differences were observed ( $p < 0.001$ ) (table). The percentage of knee injuries was almost double for female than for male skiers in all four disciplines ( $p < 0.001$ ). Most of the injuries were caused by the skiers' own falls (85%), but collision was more frequently the injury cause for alpine skiers (17%) than for skiboarders (9%), telemarkers (9%), and snowboarders (8%) ( $p < 0.001$ ).

#### Abstract 32

Injury type (%)	Alpine skiers	Snow-board	Tele-mark	Ski-board
Arm	4	9	4	6
Wrist	5	28	5	6
Hand	7	4	8	5
Back	7	10	11	5
Knee	25	7	12	19
Lower leg	11	2	5	15
Fracture	20	35	24	30
Lower leg fracture	7	1	2	15

**Conclusions:** Injured alpine skiers are prone to knee injuries. Snowboarders are prone to wrist injuries and fractures, and skiboarders to lower leg injuries and fractures.

### 033 INJURY TYPES IN ALPINE SKIING AND SNOWBOARDING RELATED TO AGE GROUPS

A. Ekeland, A. Rødven. *Martina Hansens Hospital, Oslo, Norway*

**Background:** Since 1996, the Norwegian Ski Lift Association has conducted a central registration of the injuries occurring in the major ski resorts to survey the injury types.

**Methods:** The injuries occurring on the slopes of 12 major Norwegian ski resorts were recorded by ski patrols for the seasons 2002/2003 and 2003/2004.

**Results:** In total, 3453 injured alpine skiers and 3016 injured snowboarders were recorded. Their age and sex distribution were as shown in the table. Contusion was the most common injury type in all age groups. Fractures decreased from 25% to 20% with increasing age in alpine skiers ( $p < 0.005$ ). Dislocations increased with increasing age groups for both alpine skiers and snowboarders ( $p < 0.001$ ), as did shoulder injuries for alpine skiers ( $p < 0.001$ ). Wrist injuries were more common for teenagers than for the other age groups for snowboarders ( $p < 0.001$ ). Lower leg fracture was only recorded for 4% of injured teenagers and adult skiers, but accounted for 15% of the injuries among alpine skiers aged 12 years and younger ( $p < 0.001$ ). The share of injured skiers requiring physician or hospital treatment increased with increasing age for alpine skiers and snowboarders, being about 57% for children and 65% for adults ( $p < 0.03$ ). Collision as an injury cause was highest for injured child alpine skiers (22%), decreasing to about 15% for adolescent and adult alpine skiers ( $p < 0.003$ ).

#### Abstract 33

Skier/boarder (%)	Age (years)		
	Female	Male	<12 3–18 >20
Alpine	45	55	26 25 49
Snowboarders	38	62	13 54 33

**Conclusions:** Lower leg fracture was more than three times as common for injured children as for teenagers and adult alpine skiers. Dislocation increased with increasing age for both alpine skiers and snowboarders. The injury severity seemed to increase with increasing age, as more adults than children needed physician or hospital treatment for their injuries.

### 034 ARTIFICIAL TURF VERSUS NATURAL GRASS: IS THERE A DIFFERENCE IN INJURY RISK?

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**Purpose:** To compare the injury risk when playing football on artificial turf to the risk playing on natural grass.

**Methods:** Seven elite teams having home facilities with the third generation of artificial turf were included in the study: Örebro SK and Västra Frölunda IF (Sweden), Austria Salzburg FC (Austria), Heracles Almelo (Netherlands), Dunfermline (Scotland), Helsinki JK (Finland), and Tromsødal Fotball (Norway). Data were collected from February 2003 to September 2004. In total, 357 injuries were reported from 38 692 hours of football. Each team doctor was provided with attendance record forms and was responsible for completing this form with data about the players' attendances at training sessions and matches. The attendance records included all training sessions and matches. A recordable injury was defined as one that occurred during a scheduled match or training session and caused the player to miss the next match or training session. All injuries were recorded on a special card.

**Results:** There was no difference in injury risk (8.9 v 9.7 injuries/1000 hours of exposure when playing on artificial turf versus natural grass). The incidence of traumatic injuries was significantly lower on artificial turf compared with natural grass (5 v 7 injuries/1000 hours). There was a large variation in incidence rates between the teams. The total injury risk varied between 2 and 17 injuries/1000 hours of exposure, and the risk during matchplay varied between 7 and 43 injuries/1000 hours of exposure.



**Conclusions:** A preliminary study did not display evidence of increased injury risk when playing football on artificial turf compared with playing on natural grass. In fact, playing on artificial turf may lead to a decreased risk for traumatic injuries. A large inter-team variation in injury rates was observed, which may be explained by differences in environmental conditions and the limited dataset.

### 035 EURO 2004 INJURY STUDY

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**Purpose:** To evaluate the risk of injury and to analyse injury patterns during EURO 2004.

**Methods:** All 16 teams that qualified for EURO 2004 participated. We followed the 370 players during the preparation period before the tournament (2 weeks), group matches (2 weeks) and final matches (2 weeks). Each team doctor was provided with attendance record forms to complete with data about the players' attendances at training sessions and matches. An injury was defined as one that occurred during a scheduled match or training session and caused the player to miss the next match or training session.

**Results:** The total risk of injury (7.7 per 1000 hours of exposure) was consistent with recent studies at elite or professional level. During the study period, 66 players (18%) incurred 77 injuries. Many muscle injuries ( $n=24$ , 31%) and fractures ( $n=5$ , 6%) were recorded, which reflects the intensity of play and the high forces generated in contact situations. There were few ankle sprains ( $n=10$ , 13%), which indicates that the medical staff know how to prevent such injuries. Fewer contact (59% v 73%) and more non-contact injuries (41% v 27%) occurred compared with the World Cup 2002. Few foul play injuries ( $n=9/45$ , 20%) were recorded during the actual tournament, illustrating the high standard of refereeing and the adherence to fair play by the teams. Many players ( $n=21$ , 6%) left the tournament still injured; 15 of these players incurred major injuries, causing absences of over 4 weeks.

**Conclusions:** The injury risk at EURO 2004 was similar to that found in top level league play. In all, 41% of the injuries occurred in non-contact situations, and muscle injury was the most common injury subtype; only nine foul play injuries occurred during the tournament; and 15 players left the tournament with major injuries.

### 036 A PREVENTION STRATEGY TO REDUCE THE INCIDENCE OF INJURY IN HIGH SCHOOL BASKETBALL: A CLUSTER RANDOMISED CONTROLLED TRIAL

C. A. Emery, W. H. Meeuwisse. *Sport Medicine Centre, University of Calgary, Calgary, Alberta, Canada*

**Objectives:** To assess the effectiveness of a balance training programme in reducing lower extremity injury in high school basketball.

**Methods:** This was a cluster randomised controlled trial design. In total, 900 adolescent basketball players (ages 14–19 years) were the subjects for this study. All 28 participating schools (four teams, junior and senior, boys and girls) were randomly allocated to the training or control group. All teams completed a standard 10 minute warm up routine at every basketball session (November 2004–March 2005). The teams in the training group received an additional 5 minutes of warm up activities and a daily 20 minute home exercise programme involving a sport specific balance training component using a wobble board. A physiotherapist or certified athletic therapist completed pre-season baseline evaluations and assessed any injury occurring in basketball on a weekly basis. The injury definition included any injury occurring during the basketball season that required medical attention and/or time loss from basketball.

**Results:** The difference between baseline and 6 week follow up dynamic unipedal balance in the intervention group will be compared with that in the control group. The incidence rates of lower extremity injury in the two study groups will be compared. Adjustment for covariates and clustering effects will be made in a multivariate analysis. A similar analysis will be repeated to examine all injury, ankle sprain and knee ligament injury. The estimate of the cost effectiveness of such a prevention strategy will be examined and compared between study groups.

**Conclusions:** Expected differences in change in dynamic balance, injury rates, and costs incurred will be reported. Future research recommendations will be based on final results of this study. It is expected that future research will include the development of other sport specific lower extremity injury prevention training strategies.

### 037 A COMPARISON OF RISK FACTORS FOR INJURY IN INDOOR AND OUTDOOR SOCCER

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**Purpose:** To evaluate and compare injury in adolescent indoor soccer to outdoor soccer in the same cohort of players.

**Methods:** This is a prospective cohort study. The study population includes players ( $n=142$ ) continuing to play indoor soccer who had previously been involved in an outdoor soccer cohort study ( $n=317$ ). The subcohort continuing to play in the indoor soccer season (October 2004–March 2005) comprised players from each division, from each of U18, U16, and U14 age groups for both boys and girls. The injury definition included any injury occurring in indoor soccer that resulted in medical attention and/or time loss from soccer.

**Results:** The overall injury rate (IR) found in indoor soccer over the first 13 weeks of the regular season was 4.36 injuries per 1000 player hours (95% CI 2.44 to 7.18). The overall IR found in the regular outdoor season was 5.59 injuries per 1000 player hours (95% CI 4.42 to 6.97). Injuries sustained in the initial indoor season and outdoor season resulted in time loss from sport in 78.6% and 86.9% of cases, respectively. The relative risk of injury suggests that there was no significant difference between male and female injury rates in indoor soccer or outdoor soccer. Preliminary results in indoor soccer suggest that previous injury history increases the risk for injury, as was found in outdoor soccer.

**Conclusions:** Based on the first half of the indoor season alone, there was no significant difference in injury rate by session type (games versus practices), sex, age group, or division of play. Previous injury is a risk factor for injury in indoor and outdoor soccer.

### 038 RISK FACTORS FOR INJURY IN ADOLESCENT SOCCER: IMPLEMENTATION AND VALIDATION OF AN INJURY SURVEILLANCE SYSTEM

C. A. Emery, W. H. Meeuwisse, S. Hartmann. *Sport Medicine Centre, University of Calgary, Calgary, Alberta, Canada*

**Purpose:** To implement and validate an injury surveillance system and examine risk factors for injury in adolescent soccer.

**Methods:** This was a prospective cohort study, conducted during the outdoor soccer season in Calgary, Alberta, Canada (May to August 2004). The study population was a random sample of 21 soccer teams from a Calgary minor soccer club ( $n=317$  players). One team from each skill division and age group (U18, U16, and U14, boys and girls) was randomly selected to participate. A certified athletic therapist completed pre-season baseline evaluations and assessed any injury occurring in soccer on a weekly basis. The injury definition included any injury that required medical attention and/or time loss from soccer.

**Results:** Based on completeness of data, validity of diagnosis, and time loss, this method of surveillance has proven to be effective. The overall injury rate was 5.59 injuries per 1000 player hours (95% CI 3.34 to 5.61). There was an increased risk of injury associated with games versus practices in both boys (relative risk (RR)=2.57; 95% CI 1.19 to 6.16) and girls (RR=3.26; 95% CI 1.51 to 7.81). Direct contact was reported for 46.2% of all injuries. Soccer injury resulted in time loss from soccer for 88.5% of the injured players. Ankle and knee injuries were the most common. Girls may be at greater risk of knee ligament injuries than boys (RR=5.06; 95% CI 0.57 to 239.25). The risk of injury in was greatest in the most elite divisions in U14 and U16. Previous injury in the previous year increased the risk of injury (RR=1.74; 95% CI 1.0 to 3.1). Players who are left leg dominant may be at greater risk of injury than those who are right leg dominant (RR=2.06; 0.84 to 4.37).

**Conclusions:** There were significant differences in injury rates found by division, previous injury history, and session type (practice versus game). Future research includes the use of such a surveillance system to examine prevention strategies for injury in minor soccer.

### 039 RISK FACTORS FOR INJURY IN MINOR HOCKEY: IMPLEMENTATION AND VALIDATION OF AN INJURY SURVEILLANCE SYSTEM

C. A. Emery, W. H. Meeuwisse, L. Maffey. *Sport Medicine Centre, University of Calgary, Calgary, Alberta, Canada*

**Objectives:** To implement and validate an injury surveillance programme and examine risk factors for injury in minor hockey.

**Methods:** This was a prospective cohort study, conducted during the minor hockey season in Calgary (September 2004 to March 2005). The study population was a sample of 80 hockey teams from the Minor

Hockey Association of Calgary (n=936 players), and included two teams from each age group (9/10, 11/12, 13/14, and 15/16 years of age) and division (1–10). Pre-season medical questionnaires were completed by all participants. A team designate recorded participation hours at every practice and game session as well as initiating an injury report form at the time of an injury. Certified athletic therapy (CAT) candidates assessed any injury occurring in hockey on a weekly basis. The injury definition included any injury that required medical attention and/or time loss from hockey. More severe injuries seen by a sport medicine physician were also reported, with a physician diagnosis.

**Results:** The validity of this surveillance system (including diagnosis and time loss) will be examined based on completeness of data in addition to comparison of CAT candidate diagnosis with physician assessment. The overall injury rate (IR) during regular season (number of injuries per 1000 player hours), and the risk of injury associated with games versus practices, division of play, age group, previous injury, and equipment use (specific helmet types and mouth guards) will be reported. Direct contact injuries will be reported by mechanism and associated penalties. Time loss, body part, and injury type will be summarised.

**Conclusions:** Injury rates found by division, age group, previous injury history, and session type (practice versus game) will be reported. Future research recommendations using such a surveillance system to examine prevention strategies for injury in minor hockey will be made.

#### 040 SURVEY OF SPORT PARTICIPATION, SPORT INJURY, AND SPORT SAFETY PRACTICES IN ADOLESCENTS

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**Background:** This is a survey of sport participation, injury, and safety practices in adolescents.

**Purpose:** To examine sport participation, sport injury, risk factors for sport injury, and sport safety practices in adolescents.

**Methods:** A retrospective survey was conducted in 24 Calgary and area high schools, in Alberta, Canada. A random sample of 2873 adolescents completed an anonymous, in class questionnaire in March 2004.

**Results:** In the previous year, 94% of students participated in sport. The top five sports by participation were basketball, hockey, football, snowboarding, and soccer for boys, and basketball, dance, volleyball, snowboarding and soccer for girls. The injury rate including only injuries requiring medical attention was 40.2 injuries per 100 adolescents per year (95% CI 38.4 to 42.1). The injury rate including only injuries presenting to a hospital emergency department was 8.1 injuries per 100 adolescents per year (95% CI 7.1 to 9.2). The injury rate based on injuries that resulted in time loss from sport was 49.9 injuries per 100 adolescents per year (95% CI 48 to 51.8). The rate of loss of consciousness associated with a sport injury was 9.3 injuries per 100 adolescents per year (95% CI 8.3 to 10.5). The greatest proportion of injuries occurred in basketball, hockey, soccer, snowboarding, and football. Injury rates for girls were greater than for boys in soccer and basketball. The top five body parts injured were the ankle, knee, head, back, and wrist. The top five injury types were sprain, contusion, concussion, fracture, and muscle strain. Boys had a higher rate of concussions and fractures, while girls demonstrated higher rates of ligament sprains and muscle strains. A previous injury was associated with 49% of injuries. Direct contact was associated with 45% of injuries.

**Conclusions:** Rates of participation in sport and sport injury are high in adolescents. Future research should focus on prevention in sports with high participation and injury rates to have the greatest population health impact. Prevention strategies should target ankle, knee, and head injuries.

#### 041 CAN SIMPLE BALANCE TESTS, INJURY HISTORY, OR FAOS ANKLE FUNCTION SCORE PREDICT WHICH PLAYERS ARE MORE PRONE TO SUSTAIN A NEW ANKLE INJURY?

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**Background:** Ankle injuries are common in many sports, although effective prevention methods exist (bracing, balance training). However, to better target intervention programmes, there is a need to be able to identify players at increased risk of injury.

**Purpose:** To examine the reproducibility and validity of a simple balance test to assess ankle function and injury risk.

**Methods:** In total, 32 teams (n = 530 players) from clubs in divisions 1 to 3 in the eastern region of Norway were included. The players were tested in the early pre-season (January to March 2004) and screened by self assessment (injury history and FAOS ankle function (five subscores: quality of life, pain, symptoms, sports function, activities of daily living)). The testing included a balance test for each leg (floor and balance mat), where the player was instructed to stand on one foot with the leg straight, the other with the knee bent to 90°, and arms crossed. The tests were scored 1 to 5, with 1 indicating the best and 5 the poorest result. All time loss ankle sprain injuries were recorded by the team physical therapist during the subsequent season.

**Results:** The intertester agreement between repeated tests was moderate (n = 104,  $\kappa=0.41$ ). There were 65 new ankle sprains during the season affecting 50 players, and the injury risk was higher among athletes with a history of previous injury (5.7% v 3.1% in ankles without previous injury; odds ratio 1.9; p=0.045). We observed no relationship between the balance test results (floor, balance mat) and previous injury history or the risk of a new ankle sprain. Players with a history of previous injury reported lower function on all five FAOS subscores, while players with a new injury reported slightly lower scores for sports function, activities of daily living, and pain. However, there was no relationship between FAOS subscores and balance test results.

**Conclusions:** The balance tests did not predict previous injury or future injury risk, but self reported FAOS function scores were related to injury history.

#### 042 PREVENTION OF INJURIES AMONG MALE FOOTBALL PLAYERS: A PROSPECTIVE, RANDOMISED INTERVENTION STUDY TARGETING PLAYERS WITH PREVIOUS INJURIES OR REDUCED FUNCTION

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**Purpose:** To examine the effect of targeted exercise programme to prevent injuries in male football players with a history of previous injury or reduced function in the ankle, knee, hamstrings and groin.

**Methods:** In total, 32 teams (n = 521 players) from clubs in divisions 1 to 3 in the eastern region of Norway were included. The players were tested in the early pre-season (January to March 2004) and screened by self assessment (injury history and KOOS -based function scores for the ankle, knee, hamstring and groin). Players fulfilling our inclusion criteria (low function score or history of injury during the previous 12 months) were allocated to a group assumed to have an increased risk of injury. Players in this group (n=396) were randomised individually, and the high risk intervention group (n=191) received one or more specific exercise programmes targeting the relevant body part(s). They were instructed to use the training programme 3 times weekly for a 10 week period during the pre-season, and once a week during the rest of the season. The high risk control group (n=205) trained as usual. The remaining players (n=125), with normal function scores and no history of previous injury, served as a low risk control group. All time loss injuries were registered by the team physical therapist during the 2004 season (April to September), as were exposure data and compliance with the exercise programme.

**Results:** In total, 225 acute injuries to the ankle (n=65), knee (n=62), groin (n=27) and hamstring (n=71) affecting 190 players (36%) were reported during the season. There was no difference in injury risk between the high risk intervention group (82 injuries, 73 injured players, 38%) and the high risk control group (112 injuries; 89 players, 43%, odds ratio (OR)=1.24; 95% CI 0.83 to 1.85). However, there was a significantly lower injury risk in the low risk control group than the two other groups (31 injuries, 28 injured players, 22%, OR=0.47; 0.28 to 0.78 v intervention group, and OR=0.38; 0.23 to 0.63 v control group).

**Conclusions:** The introduction of a specific exercise programme targeting players with a history of previous injury or reduced function in the ankle, knee, hamstrings, or groin did not affect the risk of injury in high level amateur football players.

#### 043 INFLUENCE OF METEOROLOGICAL CONDITIONS IN SKIING: A PROSPECTIVE STUDY IN BAQUEIRA/BERET, SPAIN

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**Background:** One of the most important problems found when trying to identify risk factors while practising a sport is how to measure the

exposure to accident. This always depends on the practice patterns, which vary widely when the sport is generally considered as a recreational activity.

**Purpose:** To consider the different injury rate used in skiing as a recreational activity and its use to assess risk factors and prevention measures.

**Methods:** We analysed the data registered daily by a ski patrol on injured skiers and nivo-meteorological conditions for skiing, and cross matched these with data on exposure collected at the bases of the lifts. We calculated the injury rates based on three different measures of exposure: injuries per 1000 skier days, injuries per 1000 lift transported skiers, and injuries per 100 000 km skied downhill. We also analysed the injury rate trends from 1997 to 2003 and cross matched these with meteorological conditions in order to see the influence of environment. The injury rate was statistically analysed using variance analysis and Scheffé test.

**Results:** We found a global injury rate of 1.76 injuries per 1000 skier days (95% CI 1.70 to 1.83), 0.145 injuries 1000 lift transported skiers (95% CI 0.14 to 0.15) and 0.397 injuries per 100 000 km skied downhill (95% CI 0.382 to 0.411). All were statistically different depending on the environmental conditions (one way analysis of variance  $p < 0.05$ ), and Scheffé test showed that better conditions were related to higher incident rate when exposure was measured by 1000 skier days and lower when measured by 100 000 km skied downhill.

**Conclusions:** Measuring the exposure to risk in recreational activities must take into account the practice differences between skiers. The injury rate by 100 000 km skied downhill gives the real exposure to risk and shows logical changes related to environmental conditions.

#### 044 IS POSTURAL CONTROL SPORT SPECIFIC? A DESCRIPTION OF SCORES FOR COLLEGIATE ATHLETES

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**Background:** Humans usually take for granted their ability to stand upright and maintain balance.

**Purpose:** To measure the postural control scores in two separate conditions (eyes open and closed) for 454 collegiate athletes to ascertain whether postural control scores differed for athletes in different sports.

**Methods:** Prior to the start of their competitive season, we assessed the postural control of 454 NCAA Division I collegiate athletes (233 men, 221 women) from 23 sports. Each participant was free of existing ankle sprain, and of acute or persistent orthopaedic pathology. Postural control was measured with an AMTI Accusway force plate (ATMI Inc., Watertown, MA, USA) interfaced with a laptop computer using Swaywin software (ATMI Inc.). Three dimensional ground reaction forces were collected at 50 Hz. The AMTI force plate measures translational forces (Fx, Fy, Fz) and moments of force (Mx, My, Mz), and the software programme calculates centre of pressure (COP) trajectories. The origin of the COP path was the initial point of COP during each trial. The dependent measure was the COP excursion velocity. Postural control was measured as the COP excursion velocity while each athlete maintained a unilateral stance for 15 seconds, for both the left and right leg, for three trials with eyes open. Subjects were asked to maintain a single leg stance while standing barefoot on the force plate. All data were entered into SPSS software and analysed using descriptive statistics.

**Results:** Overall, women generally had a lower (better) score (in eyes open and eyes closed testing conditions) in sports where both male and female teams participate, except in basketball, where men had a better average with eyes closed (left and right) than women. Further research should focus on postural sway scores and their relation to injury. An intervention introducing proprioception training and its effect on postural control among this group of athletes would be beneficial.

#### 045 INJURIES IN ELITE FEMALE SOCCER PLAYERS

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**Background and purpose:** Because epidemiological data on injuries in female soccer are scarce, this study aimed to analyse injuries in elite female soccer players during one outdoor season.

**Methods:** In total, 89 players of five teams of the German national league were followed during the season 2003–04. The team physiotherapists reported all injuries (including non-time loss injuries) with regard to their location, type, and circumstances of occurrence,

while the trainers documented the exposure to soccer on a weekly basis for each player.

**Results:** During the 10 month season, 217 injuries (2.4 injuries per player) were reported, of which 34 injuries were classified as overuse injuries and 181 as traumatic. The overall incidence rate was 12.3 (95% CI 10.7 to 13.9) injuries per 1000 hours exposure. Most injuries occurred during game (114 v 69 in training;  $p < 0.001$ ). The match injury incidence was 40.8 (95% CI 31.2 to 50.4) per 1000 match hours, and the incidence during training 4.7 (95% CI 3.6 to 5.8) per 1000 hours training. Of the reported injuries, 30% led to no absence in training and/or match, 32% to 1–6 days absence, 30% to 7–30 days absence, and 8% to a longer absence. There was a tendency for more injuries to occur in contact situations (103 v 78;  $p = 0.06$ ), but only for non-time loss injuries was this significant (38 v 14;  $p < 0.001$ ). Most injuries ( $n = 175$ , 81%) affected the lower extremities, concerning mainly the thigh, knee, and ankle. The most frequently diagnosed injury types were sprains ( $n = 67$  including 15 non-time loss injuries) and contusions ( $n = 65$  including 15 non-time loss injuries); 76% of severe injuries were ligament ruptures at the knee ( $n = 8$  including seven anterior cruciate ligament (ACL) ruptures) and ankle ( $n = 3$ ), respectively.

**Conclusions:** The results of the present study revealed a high match injury incidence in female soccer. Considering that nearly one third were non-time loss injuries, the incidence rates observed in this investigation are within the range of elite male soccer players. The frequent occurrence of ACL ruptures represents a serious concern.

#### 046 LIGAMENT INJURIES IN ELITE FEMALE SOCCER PLAYERS

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**Background:** Sprains are among the most frequently diagnosed injuries in soccer and represent a major concern.

**Purpose:** To analyse ligament injuries in elite female soccer players during a complete outdoor season.

**Methods:** In total, 142 players from eight teams of the German national league were followed during the season 2003–04. Trainers documented the exposure to soccer on a weekly basis for each player, while the team physiotherapists reported all injuries with regard to their location, type, and circumstances of occurrence. Baseline information regarding personal and soccer specific characteristics and information on previous ligament injuries of the players was also documented.

**Results:** During the 10 month season, 75 ligament injuries were sustained by 59 players (42%), 92% of which occurred at the lower extremities. The most frequently diagnosed injury was ankle sprain ( $n = 42$  including 14 ligament ruptures) followed by knee sprains ( $n = 25$  including 14 ligament ruptures). Sprains were equally distributed on the dominant and non-dominant leg, but ligament ruptures significantly more frequently occurred on the dominant leg (20 v 8;  $p = 0.02$ ). The average time of absence from training/game due to sprain was 42 days. Players who sustained a ligament rupture were absent for an average time of about 3 months. Most sprains occurred either after a tackling situation ( $n = 24$ ) or after a change in direction ( $n = 15$ ). Players with previous ligament injuries had a 1.5 fold higher risk of sustaining a new one (odds ratio for knee sprains 1.47 and for ankle sprains 1.55).

**Conclusions:** Considering the average time of absence in combination with the high prevalence of sprains, the present data show that ligament injuries represent a major concern in elite female soccer. Scientifically validated neuromuscular training programmes should be included in training routine to prevent ligament injuries in female soccer players, particularly in athletes with a history of previous sprains.

#### 047 EFFECTS OF WARMING UP ON RISK OF INJURY IN SPORTING PERFORMANCE: A SYSTEMATIC REVIEW

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**Purpose:** To use a review of evidence to determine the effects of warming up prior to engaging in a sporting activity on injury risk.

**Methods:** This was a systematic review. Relevant studies were identified by searching Medline (1966 to August 2004), SPORTDiscus (1966–August 2004), and PubMed (1966–August 2004). This review included randomised controlled trials and cohort studies that investigated the effects of warming up on injury risk. Studies were included only if the subjects were human, and only if they used at least two components of a warm up, not simply stretching. Studies reported in languages other than

English were not included. Methodological quality was assessed with the PEDro scale, which is based on the Delphi list. A total score out of 11 is derived for each study from the number of criteria that are satisfied. The quality of included studies was assessed independently by two assessors.

**Results:** Four studies, all of high quality (mean 9 out of 11 points (range 8–9)) reported sufficient data (quality score >7) about the effects of warming up for reducing injury risk in humans. Two of the studies found that performing a warm up prior to performance significantly reduced the injury risk, one study found non-significant improvements, and the final study found that the warm up was not effective in reducing the number of injuries.

**Conclusions:** There is not sufficient evidence to endorse or discontinue routine warm up prior to physical activity to prevent injury among sports participants. Further well conducted randomised controlled trials are needed to determine the role of warming up prior to exercise in relation to injury prevention.

#### 048 OPPORTUNITIES FOR PREVENTION OF GOLFING INJURIES

A. Fradkin, P. Cameron, B. Gabbe. *Monash University, Melbourne, Australia*

**Purpose:** To identify and describe injuries associated with golf participation resulting in presentation to an emergency department and opportunities for injury prevention.

**Methods:** Retrospective analysis of data from the Victorian Emergency Minimum Dataset was performed. Data were collected for all emergency department presentations related to injury in 28 hospitals accounting for 80% of injury cases in Victoria. Golf related injury cases were identified for the period April 1997 to December 2002. Cases where the text description of the injury event included the word "golf" were extracted for analysis. Text narratives of all cases were reviewed to check for inconsistencies in coding and miscoded cases.

**Results:** There were 547 presentations to an emergency department for treatment of a golf injury. The majority of presenting patients were male (75.9%) and the proportions of participants in each age range were similar. A head injury was the most common reason for presentation, accounting for over one third of all cases. The most frequent cause of injury was being struck by a ball or club, or through a collision with another player (69.8%). Falls were also quite common (21.0%). Open wounds were the most common type of injury (26.3%), followed by sprains and strains (20.0%). Eye injuries also commonly occurred (12.7%). Both the cause of injury and the body regions injured showed significant associations with age ( $p < 0.001$ ).

**Conclusions:** Overall, this study described the golf related injuries requiring emergency department attendance and has highlighted potential injury prevention strategies. In particular, changes such as golf course layout and design, the use of protective equipment such as eyewear and helmets, and golfers paying more attention to spatial awareness could all be areas for possible prevention of injuries. Finally, older adults could be advised to participate in other forms exercises such as yoga or Tai chi to help with balance, thus helping to prevent falls.

#### 049 DOES WARMING UP PRIOR TO GOLF PLAY AND PRACTICE REDUCE THE RISK OF INJURY?

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**Background:** It was hypothesised that by performing a golf specific warm up, the incidence of injuries to golfers would be reduced.

**Purpose:** To determine whether performing a golf specific warm up reduces the incidence of injuries to golfers.

**Method:** This study was a cluster randomised controlled trial. Groups of golfers were randomly allocated to one of two study arms: control group or warm up group. All injuries, participation in practice and games, and, in the warm up group, compliance with the warm up programme, were monitored over a 6 month period in 2004/2005. Injuries sustained by all golfers were followed up through self report and medical/health professional record review.

**Results:** In total, 344 golfers were recruited for this study (166 control and 178 warm up). Preliminary analysis shows no significant difference between the main variables in each group (age,  $p = 0.916$ ; handicap,  $p = 0.548$ ; sex,  $p = 0.764$ ). To date, 38 golfers (11%) have reported being injured, with the lower back, shoulder, elbow, and wrist being the most frequently injured areas.

**Conclusions:** Physical activity in the form of warming up prior to sporting performance has, for many years, been widely practised and accepted by sports competitors, however, there have been no randomised controlled trials published investigating this topic. This study should help resolve this issue. An overview of the results of this randomised controlled trial will be presented.

#### 050 PROPHYLACTIC TRAINING REDUCES THE FREQUENCY OF JUMPER'S KNEE BUT NOT ACHILLES TENDINOPATHY

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**Background:** Tendinopathy of the achilles and patellar tendons is one of the most frequent and severe injuries in sports. A previous study has shown it is possible to identify an asymptomatic group of soccer players who have a high risk of developing some of the most serious tendon injuries.

**Purpose:** To evaluate the effect of prophylactic eccentric training on achilles and patellar tendon in soccer players.

**Methods:** In this longitudinal study, all Danish professional players (331) in the top Danish soccer league were examined with ultrasonography before and after a single season (January and December). Of the 12 teams, five were chosen at random to use 5 minutes' eccentric training of the achilles and patellar tendons at least twice weekly.

**Results:** Ultrasonographic screening of the elite soccer players revealed that 18% of the asymptomatic players had a spindle shaped thickening of the achilles tendon and this group had a 38% risk of developing symptomatic pain in the achilles tendon in the subsequent 12 months (relative risk (RR) 3,  $p < 0.01$ ), and that 29% of the asymptomatic players had granulomas and cone shaped thickening of the patellar ligament and this group had a 10% risk of developing symptomatic "jumper's knee" during the season (RR 2,  $p = 0.10$ ). Prophylactic treatment (including eccentric training) for this asymptomatic high risk group of soccer players reduced the tendon diameter of the patellar tendons significantly ( $p = 0.009$ ), but not that of the achilles tendons ( $p = 0.96$ ).

**Conclusions:** By ultrasonography it is possible to identify an asymptomatic group of athletes who have a significant increased risk of developing tendinopathy of the achilles and patellar tendons. Prophylactic eccentric training of this asymptomatic high risk group reduces the ultrasonographic intratendinous changes. It is possible to spot an asymptomatic group with high risk of developing symptoms during the following 12 months. Prophylactic eccentric training reduces this risk.

#### 051 DYNAMIC ANALYSIS OF AN EXPERIMENTAL ANKLE SPRAIN

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**Purpose:** To analyse dynamic ankle kinematics during an experimental ankle sprain using a giving way board and fluoroscopy, and to investigate the effectiveness of the tape fixation and brace fixation from the point of injury prevention.

**Method:** In total, 11 female college athletes who had a history of ankle sprains and complained of ankle instability participated in this study. The dynamic talar tilting angle, surface electromyography (EMG) of the peroneus longus, and the footplate angle were measured during an experimental ankle sprain using a giving way board. To calculate the dynamic talar tilting angle, the ankle kinematics were continuously x rayed by fluoroscopy at 60 frames/second and 2/1000 second shutter speed. The static talar tilting angle was determined from an anterior-posterior x ray taken of the ankle under 10 kg varus load. All tests were performed wearing sports shoes under the conditions of bare ankle, tape fixation, and semi-rigid brace fixation.

**Result:** The dynamic talar tilting angle gradually increased at first, and decreased after the onset of the EMG activation of peroneus longus, and increased again at the end of supination. Under the conditions of tape fixation and brace fixation, dynamic talar tilting angle decreased, and total supination time increased. We also found that dynamic talar tilting angle did not correlate with static talar tilting angle.

**Conclusions:** The use of tape or brace will be effective in preventing sprain injury in cases of an unstable ankle. The analysis of this dynamic instability is important for the prevention of ankle injuries.

### 052 DOES CONDITIONING PREVENT HAMSTRING INJURIES IN AUSTRALIAN FOOTBALL?

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**Purpose:** To determine whether a simple eccentric hamstring conditioning programme reduces the rate of hamstring injuries at the community-level of Australian football.

**Methods:** Seven amateur Australian football clubs were recruited to participate in a randomised controlled trial of an eccentric hamstring conditioning programme during the 2004 season. All players completed a baseline questionnaire and were randomised into either the intervention (conditioning) or control groups. Randomisation within clubs, stratified according to past history of a hamstring injury, was undertaken. The programme included five sessions over a 12 week period, with three sessions occurring during the pre-season and two during the first 6 weeks of the season. Participation in the sessions was recorded, and players were monitored for the full season with respect to hamstring injury surveillance and participation.

**Results:** In total, 220 players were recruited to participate, and were randomised into the control ( $n=106$ ) and intervention ( $n=114$ ) groups. There was no difference between the groups with respect to age, hamstring injury history, playing experience, height, or weight. Compliance with the study sessions was poor, with 46.8% of players completing at least two of the five sessions. Compliance was poorest for the intervention group. Excluding players who completed <2 sessions, the rate of hamstring injuries in the intervention group was 4% compared with 13% in the control group. While not statistically significant ( $p=0.098$ ), there was a trend towards a protective effect in the conditioning group.

**Conclusions:** While the conditioning programme appeared to protect against hamstring injuries, compliance was poor. In particular, the level of delayed onset muscle soreness generated by the conditioning programme, combined with the normal soreness experienced by players as a result of football participation, was the major barrier towards participation in the study sessions. A revised programme will be trialled during 2005.

### 053 RISK FACTORS FOR HAMSTRING INJURIES IN AUSTRALIAN FOOTBALL

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**Purpose:** To identify intrinsic risk factors for hamstring injury in Australian football.

**Methods:** Prospective cohorts of 222 elite and 126 amateur players were recruited from 10 Melbourne based clubs during the 2002 and 2000 seasons, respectively. Baseline measurements were performed for each player during the pre-season period through a musculoskeletal screen and questionnaire. Players were monitored with respect to injury and exposure for the full season. Univariate analyses were performed to identify potential risk factors. Factors showing a trend towards association with hamstring injury ( $p<0.20$ ) were entered into a multivariate analysis, adjusting for exposure and level of play, to identify independent predictors of a hamstring injury.

**Results:** Univariate analyses identified a past history of hamstring injury ( $p<0.001$ ), body mass index ( $p=0.02$ ) and age ( $p=0.02$ ) as significant risk factors for injury while active internal hip rotation range of movement ( $p=0.100$ ) and weight ( $p=0.17$ ) showed a trend towards association. Independent predictors of a hamstring injury were a past history and age. Players with a past history were 3.1 (95% CI 1.6 to 6.2) times more likely to sustain a hamstring injury than those without a past history. Players aged >27 years were 4.6 (95% CI 1.5 to 13.9) times more likely to sustain a hamstring injury than those aged <20 years.

**Conclusions:** This study identified older players and those with a past history of hamstring injury as being at elevated risk of hamstring injury, and highlights these groups for further research. Age and past history are not reversible risk factors; however, a greater understanding of the causal relationships between past history, age, and hamstring injury through future research could result in the identification of risk factors that could be modified (for example residual muscle weakness, reduced motor control), providing valuable information for the development of effective prevention strategies.

### 054 PSYCHOLOGICAL PREDICTORS OF INJURY AMONG ELITE ATHLETES

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**Purpose:** To establish injury rates among a population of elite athletes, to provide normative data for psychological variables hypothesised to be predictive of sport injuries, and to establish relationships between measures of mood, perceived life stress, and injury characteristics as a precursor to introducing a psychological intervention to ameliorate the injury problem.

**Methods:** As part of annual screening procedures, athletes at the Queensland Academy of Sport report medical and psychological status. Data from 845 screenings (433 female and 412 screenings) were reviewed. Population specific tables of normative data were established for the Brunel Mood Scale and the Perceived Stress Scale.

**Results:** Approximately 67% of athletes were injured each year and about 18% were injured at the time of screening. In total, 50% of the variance in stress scores could be predicted from mood scores, especially for vigour, depression, and tension. Mood and stress scores collectively had significant utility in predicting injury characteristics. Injury status (current, healed, no injury) was correctly classified with 39% accuracy and back pain with 48% accuracy. Among a subset of 233 uninjured athletes (116 female and 117 male athletes) five mood dimensions (anger, confusion, fatigue, tension, depression) were significantly related to orthopaedic incidents over the previous 12 months, with each mood dimension explaining 6–7% of the variance. No sex differences in these relationships were found.

**Conclusions:** These findings support previous suggestions that psychological measures have utility in predicting athletic injury, although the relatively modest explained variance highlights the need to also include underlying physiological indicators of allostatic load, such as stress hormones, in predictive models.

### 055 SPORT INJURY PREVENTION: WHAT PLACE FOR PSYCHOLOGICAL INTERVENTION?

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**Purpose:** To determine the impact of some psychological factors on the occurrence of sport injuries in elite Tunisian athletes.

**Methods:** Two groups were formed with reference to their medical records. The experimental group comprised 30 athletes (16 female and 14 male athletes; mean (SD) age 19.83 (2.33) years) who had suffered at least two injuries during the course of the past season. The control group comprised 30 athletes (13 female and 17 male athletes; mean (SD) age 21.33 (1.65) years) who had been injury free also during the past season. Both groups had a clinical interview and were given a personality test (Cattel's 16PF5, 1993) and a specific sport test (Salmela's OMSAT3, 1992). The results of the two groups to see if there were significant differences.

**Results:** The statistical analysis of the results led us to the conclusion that the occurrence of sport injuries depends on several psychological factors which are: self confidence ( $p=0.000$ ), fear control ( $p=0.000$ ), stress reactions ( $p=0.001$ ), relaxation ( $p=0.000$ ), focusing ( $p=0.000$ ), and competition planning ( $p=0.063$ ), obtained from the OMSAT 3 test and the C ( $p<0.004$ ) and the F ( $p<0.03$ ) factors from the 16PF5 test. The number of these injuries depends solely on the stress reaction factor ( $r=-0.835$ ;  $p=0.001$ ) and the C factor ( $r=0.413$ ;  $p=0.04$ ). Their seriousness is related only to the F factor of the 16PF5 ( $f=0.897$ ;  $p=0.001$ ). The clinical interview enabled us to come to the conclusion that sport injury is frequently the result of a deeper psychological conflict.

**Conclusions:** The results thus obtained will enable us to put in place a prevention system consisting of appropriate mental training and psychological follow up, which should have the effect of reducing the risk of the occurrence of injuries in high level athletes.

### 056 THE INFLUENCE OF ANKLE TAPING ON PROPRIOCEPTION, STRENGTH, PERFORMANCE, AND ROM

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**Background:** Taping, especially ankle taping, is ubiquitous in athletics, whether during practice, competition, or rehabilitation. Commonly, it is used for injury prevention and to facilitate the progress of rehabilitation after injury. Numerous explanations have been published in the literature for the mechanism behind the efficacy of taping. While

improved proprioception and neuronal reflex responses are postulated as the main factors, there seems to be a general consent that biomechanical stability through tape on large joints, such as the ankle or knee, only plays a minor role, if at all. Many attempts have been undertaken to investigate the effects of taping on performance, but the statements diverge widely because of the lack of standards applied.

**Purpose:** To investigate the effects of ankle taping (standard protocol) on stability (ROM), proprioception, and performance of high jumpers ( $n=36$ ) recruited from the Bavarian State Championships.

**Methods:** Uniquely in this research field, sensor shoe inlays were used to determine the amount of force applied during jumping, and to visualise the run of the centre of mass projected onto the sole. Data were transmitted at a rate of 300 Hz. The basic test series aimed for balance, and performance. The advanced test series focused on the take off stride—that is, amount of force applied per area, total contact time, the single phases within the take off stride, and loss of stability after each jump. The figures were compared with the standard series without taping.

**Results:** The results suggest that taping does improve performance of more complex motor action, in spite of the significant loss of stability after three jumps. This study underlines the proprioceptive reinforcement through taping being responsible for the preventive and performance enhancing effects postulated in literature over the past two decades.

### 057 USING THE BREAK EVEN POINT AND THE BEHAVIOUR CHANGE RATE TO ASSIST THE DECISION TO IMPLEMENT A NATIONAL SPORT INJURY PREVENTION PROGRAMME

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**Background:** To assist with the decision to implement a national sports injury prevention programme, the Accident Compensation Corporation (ACC) has developed two formulae: (a) number of new entitlement claims (EC) the programme must stop to break even (BE), given as  $BE = P/ALC$  (where  $P$  = programme costs and  $ALC$  = estimated average lifetime cost of a new EC to ACC); and (b) behaviour change rate (BCR)—that is, the number of new EC the programme must stop from the possible number of EC estimated for the group being targeted, given by  $BCR = BE / (T \cdot (H/M))$  (%) (where  $M$  = maximum yearly number of players in a sport,  $H$  = number of historical EC yearly in that sport, and  $T$  = number of people that programme will target).

**Methods:** An EC is a moderate to serious injury requiring entitlement beyond medical treatment as defined under the Injury Prevention, Rehabilitation and Compensation Act 2001. A unique database of 30 years of injury EC information, with over 15 000 new sports EC made to ACC annually provides data for analysis. As an example, if ACC plans to spend \$100 000 on a soccer injury prevention programme for players aged over 15 years, then  $BE = 15$  new soccer EC and 13% BCR ( $ALC = \$6482$ ,  $T = 10\ 000$ ,  $H = 1174$ , and  $M = 100\ 000$ ). The BCR is compared against pilot studies, existing studies in the literature or similar injury prevention programmes for example FIFA's "The 11" prevention programme for soccer. If no research or similar programmes exist, the BCR is compared with sports with similar injuries or a comparison is made with other ACC sport programmes. If the BCR is considered high and not supported by other evidence, then cost ( $P$ ) and size of target ( $T$ ) group is analysed to determine if either can be modified. Each programme is peer reviewed. The limits of this approach are that it is based on achieving a reduction in EC. Analysis needs to incorporate other factors that may influence EC such as changing playing numbers.

**Results:** This approach results in improving the decision making process, and is used to determine ACC programme expenditure/support and assist programme development before national implementation.

### 058 TARGETING INJURY PREVENTION INFORMATION DIRECTLY TO ADULT PLAYERS: TWO NEW ZEALAND PILOT STUDIES

S. Gianotti, A. Spackman, L. McCormack, D. Brooks. *Accident Compensation Corporation, Wellington, New Zealand*

**Background:** SportSmart is the Accident Compensation Corporation's (ACC) sports injury prevention programme. SportSmart's early emphasis has been training coaches in injury prevention given their ability to influence the behaviour of players. This approach has resulted in injury reductions in targeted areas, for example, spinal injuries in Rugby Union and dental injuries in contact sports. However, in New Zealand, only 23% of adults are coached, but over 80% of sport claims to ACC are from adults. A 2002 quantitative survey ( $n = 1107$ ) found that 91% of

players considered they had a role in preventing sports injuries compared with coaches (75%) and referees (79%).

**Methods:** In 2004, ACC undertook pilots in snow sports and touch rugby, distributing SportSmart resources to players, which were then evaluated to determine effectiveness. The snow sport strategy was evaluated using an email survey ( $n=81$ ), while a before ( $n=266$ ) and after ( $n=204$ ) random quantitative survey was completed for the touch strategy using in person interviews. Before and after knowledge and behaviour change for questionnaire items was analysed using unpaired two tailed  $t$  tests.

**Results:** Only 40% of snow sports participants reported taking action as a result of receiving the resources, but 70% reported they had read the contents. Of the touch players who had seen the resources, 69% reported taking action. Comparison of before and after knowledge and behaviour for the touch players showed trends towards increased knowledge and use of correct injury treatment. There were also significant ( $p < 0.05$ ) increases in the proportion of players that strongly agreed that the strategies of cooling down, playing fair, and playing within the rules reduce injuries.

**Conclusions:** Initial findings of the strategy to target players are encouraging in terms of increases in knowledge of injury prevention strategies. The post-evaluation showed that resource distribution was a barrier, as not all players in the touch pilot had received the resources. Work will continue towards improving distribution methods.

### 059 THE PREVENTION OF SERIOUS INJURIES IN NEW ZEALAND RUGBY UNION

S. Gianotti, K. Quarrie, W. Hopkins. *Accident Compensation Corporation, New Zealand Rugby Union, Auckland University of Technology, Auckland, New Zealand*

**Background:** Rugby Union, which is considered the national sport of New Zealand (NZ), generates the greatest proportion of injury claims and claim costs (18% and 17% respectively) for sports injuries borne by Accident Compensation Corporation (ACC), New Zealand's tax funded, no fault, accident compensation and rehabilitation scheme. An increase in serious spinal injuries in rugby occurred in most rugby playing nations during the 1970s and continued through the 1990s. Increasing awareness of this issue prompted the New Zealand Rugby Union and ACC to develop injury prevention programmes. From 2001 onwards, a programme entitled RugbySmart has focused on providing education to coaches, referees and players regarding appropriate physical conditioning, technique in the contact phases, and injury management. RugbySmart has the specific goal of eliminating serious injuries from rugby.

**Purpose:** To compare the number of serious injuries in rugby before and after the implementation of RugbySmart.

**Methods:** Within New Zealand, RugbySmart is compulsory for coaches and referees in tackle grade rugby. Over 8000 coaches and 2000 referees were accredited in 2004. ACC claims data were used to evaluate the impact of the RugbySmart programme.

**Results:** The annual numbers of claims for spine and neck injuries (including back of head and vertebrae) for 1998–2000 were 165, 141, and 134, whereas for 2001–2004 they were 120, 112, 116, and 115. The decrease in claims per annum following the introduction of RugbySmart was thus 21% (90% CI 12 to 29%). Claims for serious injuries (requiring typically 24 hour care) in the same years were 10, 10, and 11 v 3, 1, 2 and 2, representing an 81% decrease (63–90%).

**Conclusions:** These large effects can be ascribed to RugbySmart, because there were no substantial changes in player numbers during 1998–2004 (range 120 000 to 130 000), no other substantial injury prevention initiatives, and no parallel declines in ACC injury claims in other sports during this period.

### 060 VIDEO GAMING PROMOTES CONCUSSION KNOWLEDGE

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**Purpose:** To develop and test the suitability of a video game to impart knowledge about the symptoms of concussion to youth hockey players.

**Methods:** An interactive video game, Symptom Shock®, was designed to convey information regarding concussion symptoms. The game was tested by having youth hockey players play the game and then respond to a knowledge questionnaire. In the first study, 131 youth hockey players participated, while in the second study 39 players participated.

**Results:** Study 1: overall, the participants appeared to understand the strategy necessary to play the game, with games won almost equal to

games lost by their second interactive session. Scores on the symptoms portion of the questionnaire were analysed with a 3 (age) by 2 (game type) one way analysis of variance. Significant main effects were found for age division and game type. No interaction effects were revealed. A similar analysis on time to completion of the knowledge questions complemented the findings found with respect to the scoring. Study 2: This study was essentially a replication of study 1, although the instructions were changed to an interactive tutorial. All participants were bantam age ( $M=13.5$  years). Once again, the experimental group scored higher, and completed the knowledge test more rapidly than did the control group.

**Conclusions:** This study demonstrated that a video interactive game can convey information about an injury that is prevalent in ice hockey, without obviating the inherent purposes of the game. The learning is implicit, rather than explicit. Goals cannot be scored (and the game consequently won) without correct identification of concussion symptoms. Moreover, without the primary purpose of scoring goals, there would be no incentive to identify the symptoms. Whether or not increased knowledge ultimately changes behaviour, thus leading to a reduction of incidence rates, is the subject of our future investigations.

#### 061 EVALUATION OF THE QUÉBEC FAIR-PLAY PROGRAM IN ICE HOCKEY

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**Background:** To reduce the number of transgressions to the rule, the occurrence of violent acts, and to prevent injuries, Hockey Québec adopted the Fair-Play Program (FPP).

**Purpose:** To evaluate the effectiveness of the FPP.

**Methods:** In total, 52 bantam (14–15 years) teams participated in this cohort study. In total, 49 games (13 with the FPP, 36 without FPP) were systematically assessed for transgressions to the rule. Body checking was allowed in all games. Transgressions to the rule data were obtained using a real time observation system in a natural setting, while injury data were collected through a self administered questionnaire. Data were analysed using generalised linear models with generalised estimating equations accounting for potential team effect.

**Results:** In total, 8076 transgressions were recorded for games played without the FPP and 3195 for games played with the FPP. An average of 230 transgressions to the rule was observed per game. The number of penalties was significantly lower in games played with the FPP (adjusted mean number (AMN)=17.5; 95% CI 14.6 to 20.4) than games played without it (AMN=22.2; 19.9 to 24.4). Overall, no difference was noted in the number of transgressions observed during games played with or without the FPP. Players in leagues where FPP was used held their opponents more frequently (AMN=138.4; 130.7 to 146.0) than players in leagues without FPP (AMN=97.1; 89.6 to 104.6). On the other hand, players in leagues without FPP shoved and hit more (AMN=120.4; 110.8 to 130.0) than players in leagues with the FPP (AMN=102.4; 88.1 to 116.7). No difference was noted in the injury rate for games played with or without the FPP.

**Conclusions:** This study shows that the FPP is one of the tools available to help those in the hockey world promote fair play values. Moreover, this project clearly showed the importance of programme evaluation and the value of direct observation in a natural setting.

#### 062 SEVERITY OF SKI PATROL REPORTED INJURIES SUSTAINED BY SKIERS AND SNOWBOARDERS IN SNOW PARKS COMPARED WITH OTHER SLOPES IN QUÉBEC FROM 1999 TO 2004

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**Background:** Over the past few years, the rate of injuries sustained in alpine ski centres of the province has significantly increased.

**Purpose:** To examine the severity of injuries sustained by skiers and snowboarders in snow-parks compared with other slopes.

**Methods:** Subjects were injured skiers and snowboarders who reported to the ski patrol with an injury sustained in a snow-park or other slopes. Cases were severely injured subjects. Four sets of cases were defined; (a) those who sustained two or three injuries during the same event, (a) those who suffered from a potentially severe injury, (a) those evacuated by ambulance, and (a) those who suffered from a potentially severe injury or were evacuated by ambulance. Controls were those injured skiers and snowboarders who sustained an injury in a

snow park or a regular slope and did not have severe injuries. Data on 56 758 injuries were analysed. A logistic regression analysis was performed to relate the severity of injury to the type of slope used when the injury occurred (snow park versus other). All analyses were performed controlling for age, sex, skill level, season, and type of activity (snowboarding versus alpine skiing).

**Results:** There was evidence to suggest that participation in a snow park, compared with other slopes, increased the risk of sustaining two or three injuries (adjusted odds ratio (AOR): 1.16; 95% CI 1.08 to 1.25), suffering from a potentially severe injury (AOR=1.30; 95% CI 1.23 to 1.38), being evacuated by ambulance (AOR=1.26; 95% CI 1.17 to 1.37), and suffering from a potentially severe injury or being evacuated by ambulance (AOR=1.36; 95% CI 1.29 to 1.44). The risk of sustaining a severe head or neck injury was 47% greater in snow parks (AOR=1.47; 95% CI 1.30 to 1.67).

**Conclusions:** Results suggest that the type of activities or manoeuvres performed in snow parks may increase the risk of sustaining a severe injury compared with participation on other slopes.

#### 063 NATIONAL KNEE LIGAMENT REGISTRY

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**Background:** A cruciate ligament injury is a severe damage to the knee joint. Left untreated, it will frequently force young people to cut back on their level of physical activity, and will usually prevent them being engaged in an occupation that puts great demands on the stability of the knee joint. Independent of whether the patient receives surgery or not, it seems that 50–70% of the patients suffer from osteoarthritis, diagnosed with x ray, within a 10 year period after the injury. To date, there is no clear picture of the epidemiology of cruciate ligament surgery, and there is a lack of national guidelines for both the treatment and the rehabilitation of cruciate ligament ruptures.

**Methods:** The National Knee Ligament Registry was established on 7 June 2004, under the direction of the Norwegian Arthroplasty Register. The registry is owned by the Norwegian Orthopaedic Association, and the Oslo Sports Trauma Research Center is accountable for the scientific aspects. The registration process is paper based and consists of two steps: the registration form completed postoperatively by the surgeon and the KOOS form completed preoperatively by the patient. These forms form the basis for later follow ups performed either as the registry's own routines at 2, 5, and 10 years postoperatively, or as other research projects. The patient's signature on a standardised informed consent form precedes all registration and later participation in research projects. The purpose of the register was identified as follows: (a) eliminate methods that result in an unacceptable outcome at an early stage; (b) evaluate the outcome after surgical treatment with different methods; (c) map the importance of prognostic factors; and (d) define the epidemiology of cruciate ligament surgeries in different pre-defined patient populations.

**Results:** As of 28 February 2005, the registry contains 867 surgeries conducted at 37 different hospitals or clinics in Norway.

#### 064 INFLUENCE OF SOCCER BOOT STUD DESIGN ON THE LOADING OF THE ANTERIOR CRUCIATE LIGAMENT

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**Purpose:** To determine anterior cruciate ligament (ACL) tensile force under standardised loading conditions with different type of football (soccer) boots. The special focus of this investigation is to understand more about the influence of stud design on the loading condition of the knee.

**Methods:** We will use a combination of experiment and computer simulation. In the first step, literature studies combined with the results of our ACL research in alpine skiing will be used to define a set of load conditions that seem to be crucial for knee injuries. On this basis, a load simulation and traction measuring device ("TrakTester") has been developed. The distinguishing feature of this device is that it measures not only pure traction forces between shoe and surface, but also loads and torque interacting with the tibia during varus/valgus positions and leg flexion. With this new "TrakTester", different shoes on the market with variable sole design can then be compared under various environmental conditions on both, artificial and natural surfaces. In order to calculate ACL tensile force, this measured data can finally be used as input data for a multibody computer model of the human knee (see presentation from S. Lehner during this Congress).

**Conclusions:** The study should provide information on the influence of boot sole design on ACL tensile force. The results should also help manufacturers to systematically improve their products towards a good compromise between traction and safety. The reason why this study is presented at this early state of investigation is to find co-operating research facilities that are interested in participating in the crucial definition of the loading conditions to simulate.

### 065 IMPROVED SENSORIMOTOR CONTROL IS NOT CONNECTED WITH IMPROVED PROPRIOCEPTION

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**Purpose:** To analyse whether improved sensorimotor control is based on improved proprioceptive capabilities.

**Methods:** In total, 15 physical education students participated in the study. All subjects performed five series, taking 60 seconds each, of random whole body vibration. This treatment is known to improve postural control rapidly. Pre-treatment and post-treatment proprioceptive capabilities were tested using a specially constructed device. Via a goniometer fixed at the knee, joint subjects had to reproduce a slowly oscillating course, which was presented at a computer screen by knee extension and flexion. No feedback concerning success of the task was given. Before testing started, all subjects performed a couple of training sessions, thus they were able to reproduce the course precisely.

**Results:** Performance of subjects was interindividually variable but intraindividually constant—that is, some subjects generated overshooting errors others produced undershooting errors. On average, the amplitude was 1 degree lower compared with the presented course. This error resulted from undershooting errors at both endpoints. Pre-treatment and post-treatment comparison showed only small and statistically insignificant ( $p > 0.05$ ) differences in all analysed parameters: amplitude, maximum endpoint, minimum endpoint, and rhythm.

**Conclusions:** As the treatment leads to a strongly improved postural control of 20–30% ( $p < 0.01$ ) while proprioceptive capabilities do not change, it must be concluded that positive modifications of sensorimotor control can not be explained by an increased perceptive performance. Consequently, other mechanism that might explain these neuromuscular improvements have to be identified. We speculate about changes in interneurone function as well as about modifications in the supraspinal areas, such as in the supplementary motor area.

### 066 DECREASED RE-INJURY RATE IN FOOTBALL PLAYERS WITH CONTROLLED REHABILITATION

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**Purpose:** To study the effect of an intervention programme aimed at preventing re-injury in football.

**Methods:** In total, 20 male amateur football teams were randomly allocated to an intervention (10 teams, 241 players) and control group (10 teams, 241 players). Individual exposure and injuries were registered during all team activities in the 2003 season. Injury was defined as occurring during team training or match play and causing absence from the next training or match. A player was considered injured until given clearance from the coach to participate fully in team activities. Re-injury was defined as an identical injury within 2 months after a previous injury. A three step educational intervention programme was introduced to coaches in the intervention group: (a) information about risk factors for re-injury and rehabilitation principles, (b) a 10 step progressive rehabilitation programme for acute injuries in the lower extremities, and (c) criteria for return to match play after injury.

**Results:** Of 266 injuries, 61 (23%) were followed by an identical injury during the season; 55 of these (90%) had their subsequent injury within 2 months and were considered re-injuries. Re-injuries were more common in the control group (43 re-injuries from 25 players) than in the intervention group (12 re-injuries, 11 players). There was a 69% reduced risk for re-injury for players in the intervention group (hazard ratio 0.31; 95% CI 0.17 to 0.54,  $p < 0.0001$ , Cox proportional hazard regression). The mean (SD) re-injury rate for teams was also lower in the intervention group (2.6 (3.3) v 11.1 (8.3) re-injuries/1000 hours,  $p < 0.01$ , *t* test).

**Conclusions:** The educational, coach controlled intervention programme was effective in reducing the re-injury rate in amateur football. The majority of recurrent injuries occurred within 2 months of the initial injury.

### 067 INJURY PREDICTION IN PROFESSIONAL FOOTBALL

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**Purpose:** To investigate whether injuries to professional footballers could be predicted from their injuries during the previous season.

**Methods:** In total, 197 male football players in 12 teams from the Swedish top division were followed prospectively over two consecutive seasons (January 2001 to November 2002). The team medical staff reported individual exposure and injuries on standard protocols. Injury was defined as leading to absence from at least one training session or match following the event. Age adjusted logistic regression analyses were made for total injuries and for thigh injuries (strain and overuse), groin injuries (strain and overuse), and sprains to the knee and ankle joints separately.

**Results:** Of 197 players, 151 suffered at least one injury during the 2001 season. In the 2002 season, 458 injuries were prospectively recorded from 153 players. Players that had suffered an injury in the previous season were at higher risk of injury than players with no injury (odds ratio [OR]=7.4, 95% CI 3.5 to 15.7,  $p < 0.0001$ ). A previous injury was a significant risk factor for a new thigh injury (OR=2.4, 95% CI 1.3 to 4.5,  $p < 0.001$ ) and knee sprain (OR=3.7, 95% CI 1.5 to 9.5,  $p = 0.01$ ) but not for groin injuries (OR=2.0, 95% CI 1.0 to 4.1,  $p = 0.07$ ) or ankle sprains (OR=2.8, 95% CI 0.8 to 10.5,  $p = 0.16$ ). However, players with a serious groin injury (absence  $> 1$  week) in the 2001 season had an increased risk for a new groin injury in the 2002 season (OR=2.5, 95% CI 1.1 to 5.7,  $p < 0.05$ ).

**Conclusions:** The study supports earlier findings that a previous injury is a significant risk factor for incurring a new injury for elite football players. Players with a previous thigh injury and knee sprain had an increased risk of suffering a new injury in the following season. A previous ankle sprain, however, was not found to be a significant risk factor for a new sprain, which suggests that current treatment and secondary prevention of these injuries are effective.

### 068 THE RELATIONSHIP BETWEEN AGE, HOURS OF WEEKLY DANCE TRAINING, AND TURNOUT IN CLASSICAL BALLET DANCERS

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**Purpose:** To examine, using a cross sectional study, the influence of femoral torsion (FT) and passive hip external rotation (PER) on turnout (TO).

**Methods:** Starting age, years of classical ballet training, and hours of weekly dance training were assessed to determine their influence on FT, PER and TO in pre-professional female ballet dancers. In total, 34 dancers (mean (SD) age 18.16 (1.80) years ) were recruited from four different dance training programmes. Information on dance history was gained using a dance history questionnaire. Femoral torsion was measured using a clinical method. Passive external and internal hip rotation (PER and PIR) were measured in the prone position and TO was measured in standing.

**Results:** Mean TO measured was 136. Mean unilateral PER was 49.4 and mean FT was 18.4. A positive correlation was observed between combine PER and TO ( $r = 0.443$ ,  $p \leq 0.001$ ). A negative association was found between combined FT and combined PER ( $r = -0.402$ ,  $p = 0.001$ ). No association was found between starting age or years of classical training and combined FT, combined PER, or TO. A significant difference was observed in FT between those that danced at least 6 hours weekly between the ages of 11 and 14 years, and those that danced less ( $t_{(50)} = -2.889$ ,  $p = 0.006$ ). When dancers were grouped according to current hours of classical ballet training per week, a significant difference in TO was observed between all groups ( $F_{(2,62)} = 56.035$ ,  $p < 0.001$ ).

**Conclusions:** Dancers who trained for 6 hours or more between the ages of 11 and 14 years had significantly less FT (more retortorsion). Even though combined FT had a significant influence on combined PER, it had no influence on the execution of TO.

### 069 ANTERIOR TIBIAL STIFFNESS IS NOT SIGNIFICANTLY DIFFERENT ACROSS THE MENSTRUAL CYCLE, BUT IS RELATED TO OESTROGEN AND PROGESTERONE LEVELS

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**Purpose:** To determine if anterior tibial laxity and stiffness differed across the menstrual cycle, and assess their relationship to estrogen and progesterone concentrations.



**Methods:** In total, 15 women (mean (SD) age 21.7 (3.7) years) who reported regular menstrual cycles of 28–30 days in length participated in the study, while 15 men (21.1 (2.2) years) served as a control group. Oestrogen and progesterone levels were measured using a 2 ml saliva sample collected via passive drool, then centrifuged and frozen at –70 C. A KT-2000 arthrometer with Compu-KT software was used to obtain anterior tibial laxity values (mm) at 67, 89, and 133 N loads, while anterior tibial stiffness (ATS) values (N/mm) were calculated between 67 and 133 N, and 89 and 133 N. Saliva samples and ACL laxity/stiffness measures were obtained on seven occasions—that is, every fourth day over 28 days, with women entering the study on the second day of their cycle.

**Results:** Sex (2) × time (7) repeated measures one way analysis of variance results indicated that knee laxity was not different between women and men at any of the time intervals ( $p > 0.05$ ). For women, mean (SD) ACL laxity was 5.34 (1.41) mm in the follicular phase, 5.26 (1.45) mm in the ovulatory phase, and 5.64 (1.48) mm in the luteal phase ( $p > 0.05$ ). Female oestrogen levels ranged from 1.86 (1.56) to 4.10 (3.24) pg/ml across the phases of the cycle. Overall ATS between 89 and 133 N was greater in men (71.5 (45.0) N/mm) than women (47.4 (21.9) N/mm) ( $p = 0.016$ ). Significant correlations were observed for ovulatory phase oestrogen and stiffness between 89 to 133 N ( $r = -0.38$ ;  $p = 0.04$ ) and follicular phase progesterone and stiffness between 89 to 133 N ( $r = 0.67$ ;  $p = 0.006$ ).

**Conclusions:** We observed no significant changes in anterior tibial displacement or stiffness across the menstrual cycle, suggesting that no single phase of the cycle predisposes the ACL to injury more than another. However, the significant correlations found between ATS and oestrogen and progesterone levels warrant further investigation.

#### 070 THE INCIDENCE AND TRENDS OF ACL INJURIES IN WORLD CUP FREESTYLE SKIING DURING A 10 YEAR PERIOD

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**Purpose:** To investigate the incidence and the trends of anterior cruciate ligament (ACL) injuries in International Skiing Federation (FIS) World Cup freestyle mogul and aerial skiing over a 10 year period.

**Methods:** Data on ACL injuries among World Cup freestyle skiers for the 10 seasons 1992/93 to 2001/02 was collected by surveys, prospective registering, and review of the accident reports from the World Cup events, the results of all FIS scheduled events for the same period of time, and the skiers' biographies, all filed in the FIS database. The diagnosis of an ACL rupture was suggested when either confirmed by an orthopaedic surgeon, the ACL had been reconstructed, or the skier was absent from FIS scheduled events for at least 6 months according to the FIS database. The number of skiers and days of skiing were also captured from the FIS database.

**Results:** During the 10 year period we registered 65 ACL injuries occurring within 60,048 skier days, giving an overall incidence of 1.08 ACL injuries per 1000 skier days. The ACL incidence in men versus women did not differ significantly ( $p > 0.05$ ). Mogul skiers had a significantly higher risk of ACL injuries than did aerial skiers ( $p < 0.05$ ). Data from the first compared with the second 5 year period showed no change in the incidence of ACL injuries in any of the categories ( $p > 0.05$ ).

**Conclusions:** The overall ACL injury rate among World Cup freestyle skiers was 1.08 injuries per 1000 skier days. There was no difference among male and female skiers. Mogul skiing implied a higher risk of ACL injuries than aerial skiing. The incidence of ACL ruptures in World Cup freestyle skiing remained unchanged from the first to the second half of the 10 year period investigated.

#### 071 SPORTS INJURIES: EPIDEMIOLOGY AND PREVENTION STRATEGIES IN DIFFERENT STAGES OF LIFE

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**Background:** Research in sports injuries frequently has the aim to develop prevention measures for a respective type of sports by means of specific analysis of accidents. Concerning the development of preventive measures for children and adolescents (age <20 years) or the elderly (age >50 years) the question arises if it would be more useful to take into account injury mechanisms, which are independent of the specific types of sport.

**Methods:** Athletes who reported a sports injury received a questionnaire containing questions about the circumstances of the accident,

the injury itself, and the treatment. To date, 130 000 accidents have been registered (response rate 65%). A free text analysis of the mechanisms and situations was carried out on a sample of 40 000 accidents.

**Results:** Injury mechanisms and situations were analysed in three stages of life (<20, 20–50, and >50 years). We found that 80% of adult's (20–50 years) sports injuries resulted from football, handball, volleyball, and basketball. The lower extremities were most frequently (65%) affected, particularly in one on one situations. Sports injuries of children and adolescents were distributed among a greater number of sports, but the injury mechanisms and injured structures were similar. In children, the head and upper extremities were mainly affected as a consequence of a fall, whereas with increasing age the injuries are located in the lower parts of the body. The opposite effect was observed for the elderly with increasing age; a movement of the injured body parts from the lower to the upper extremities and to the head. The most frequent injury mechanism is fall, independent of type of sport.

**Conclusions:** Injury mechanisms of children, adolescents, and the elderly span most types of sport and are mainly dependent on generative and degenerative processes, respectively the change in body proportions. This difference from middle aged adults has to be taken into account in the development of preventive measures for these age groups.

#### 072 EFFECT OF FATIGUE ON SAGITTAL PLANE KINETICS AND KINEMATICS IN A STOP JUMP TASK

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**Purpose:** To determine the effects of lower extremity muscle fatigue on the knee, hip, and trunk kinetics and kinematics during the landing phase of a stop jump task.

**Methods:** Three dimensional videographic and force plate data were collected for 20 healthy recreational athletes (10 male, 10 female athletes) performing a stop jump task before and after completing a fatigue exercise. The fatigue exercise consisted of unlimited repetitions of five consecutive vertical squat jumps followed by two 10 metre shuttle runs at maximum effort. The fatigue exercise was continued until the subject reached a state of volitional exhaustion. Knee and hip flexion angles, trunk inclination angle, and knee anterior shear force in the stop jump task before and after the fatigue exercise were determined using a MS3D computer program package (MotionSoft, Chapel Hill, NC, USA). A two factor analysis of variance with a mixed model design was conducted for each dependent variable. A 0.05 type I error rate was chosen to indicate statistical significance.

**Results:** Both male and female subjects had significantly increased peak proximal tibia anterior shear forces ( $p < 0.001$ ), decreased knee flexion angles ( $p = 0.003$ ), and decreased hip flexion angles ( $p = 0.001$ ) during the landings of the stop jump task when fatigued. Fatigue did not significantly affect the trunk inclination angle for male or female athletes.

**Conclusions:** Fatigued recreational athletes demonstrate altered motor control strategies, which may increase anterior tibial shear force, strain on the anterior cruciate ligament, and risk of injury for both female and male subjects. Additionally, added clinical and research emphasis may need to be placed on the role of adjacent joints in altering knee motion patterns.

#### 073 POSTURAL CONTROL PERFORMANCE IS NOT ASSOCIATED WITH INCREASED RISK OF ANKLE SPRAIN

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**Purpose:** To prospectively assess the influence of postural control performance during single leg stance on the risk of ankle sprain.

**Methods:** Baseline postural control measures and ankle injury history were taken from 442 collegiate athletes (229 men, 213 women) at the start of their competitive seasons. Subjects performed three 10 second trials of quiet single leg standing on a force plate on the left and right legs with eyes open and then closed. The mean centre of pressure velocity (COPV) from each trial was computed. The mean of the COPV measures were then calculated for the left leg, eyes open (LEO), left leg, eyes closed (LEC), right leg, eyes open (REO), and right leg, eyes closed (REC) trials. The mean of the eyes open trials from both legs (BEO) and that of the eyes closed trials from both legs (BEC) were also determined. Athletes were followed for one season for occurrence of ankle sprain. Numerous parametric and non-parametric statistics were used to determine the influence of ankle injury history and postural control performance on ankle sprain risk.

**Results:** Ankle sprains were incurred by 27 athletes during the study. Those with a history of previous ankle sprain were more likely to be injured than those without prior history ( $p=0.05$ ). There were no significant relationships identified between any of the COPV measures and ankle sprain occurrence during the study. Means and standard deviations between those who did (I) and did not (U) suffer ankle sprains were: BEO (I= 3.76 (0.9) cm/s, U= 3.76 (1.0) cm/s), BEC (I= 8.40 (2.1) cm/s, U= 8.58 (2.6) cm/s), REO (I= 3.79 (1.2) cm/s, U= 3.72 (1.0) cm/s), REC (I= 8.29 (2.5) cm/s, U= 8.67 (3.5) cm/s), LEO (I= 3.87 (0.6) cm/s, U= 3.79 (1.1) cm/s), LEC (I= 8.41 (1.6) cm/s, U= 8.49 (2.4) cm/s).

**Conclusions:** We identified an association between previous history of ankle sprain and risk of suffering another ankle sprain; however, this influence was independent of postural control performance.

#### 074 SEX DIFFERENCES IN HIP ADDUCTION MOTION AND TORQUE IN COLLEGIATE ATHLETES

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**Purpose:** To determine whether female athletes display increased hip adduction angles and external adduction moments during single leg landings compared with male athletes.

**Methods:** In total, 36 collegiate soccer players (19 women, 17 men) volunteered to participate in this study. All subjects were from the same university (division I) and were currently on the men's or women's team roster. Eight high speed Eagle video cameras (Motion Analysis Corporation) and two force platforms (AMTI) were used to collect video and force data. An agility speed ladder (Myrand Sports Training, LLC) was positioned in the motion capture volume, and aligned so that the landings would occur on one of the force platforms. Each subject was instrumented with 32 retroreflective markers placed on the sacrum and bilaterally on the shoulder, ASIS, greater trochanter, mid thigh, medial and lateral knee, mid shank, medial and lateral ankle, heel, and toe (between second and third metatarsals).

**Results:** Women had greater hip adduction during landing compared with men ( $p<0.05$ ), and exhibited greater external hip adduction moments during landing 1 ( $p<0.05$ ); however, no differences were found between the sexes during landings 2 and 3. There were no sex differences in hip flexion angles (IC or maximum) during any of the landings during the SLAM. Side to side differences were observed in hip flexion angle at IC during landings 1 and 3 ( $p<0.05$ ), and in peak external hip adduction moment during landings 1 and 3 ( $p<0.05$ ), no interaction was present between side and sex.

**Conclusions:** Female athletes showed greater hip adduction angles and torques than male athletes during multi-directional single leg landing. However, these differences were limited to the frontal plane. Differences were not observed in the sagittal plane. Women also demonstrated significant side to side differences in landing biomechanics.

#### 075 VALIDATION OF A TOOL FOR MEASURING FUNCTIONAL ANKLE INSTABILITY

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**Purpose:** To design and validate a tool to quantify functional ankle instability (FAI).

**Methods:** The Cumberland Ankle Instability Tool (CAIT), a 9 item scale (maximum score 30), was developed from extensive literature search and clinical experience. Concurrent validity was tested by comparing CAIT to the Lower Extremity Functional Scale (LEFS) and a 10 cm visual analogue scale (VAS) of perceived ankle instability in 92 subjects (mean (SD) age 23 (6.1) years; control (C)  $n=35$ , unilateral sprain (U)  $n=27$ , bilateral sprain (B)  $n=30$ ) using Pearson correlation coefficient. Construct validity was examined with goodness of fit statistics generated for items and subjects ( $n=146$ ) with Rasch analysis (U=80, B=66). Internal reliability of CAIT was examined by separation of subjects and items, and cronbachs alpha equivalent (CAE), by Rasch analysis on the same data set. Test retest reliability was examined by intraclass correlation coefficient (ICC<sub>(2,1)</sub>) in 18 subjects (41.3 (9.4) yr: C=8, U=5, B=5) on two occasions 2 weeks apart. To identify a threshold score for FAI, CAIT was administered to 151 subjects (23.2 (6.8) years; C=56, U=45, B=50). Threshold was determined on half the sample by maximum Youden's index (YI) and tested on the other for sensitivity and specificity.

**Results:** Correlation was moderate for CAIT with LEFS ( $r=0.52$ ,  $p<0.01$ ) and high with VAS ( $r=0.84$ ,  $p<0.01$ ). Fit statistics for three

questions were outside the accepted parameters, suggesting CAIT may not be a unidimensional construct. CAIT separated subjects into 2.23 groups, subject reliability index (CAE) 0.83, item separation 16.20, and item reliability index 1.00. Data from 26 subjects (12%) did not conform to the expectations of the RASCH model; 17 (8% of total) were aged 15 years or below. Test retest reliability was excellent (ICC<sub>(2,1)</sub>=0.96, 95% CI 0.93 to 0.98). The threshold CAIT score was 27.5 (YI=68.1), sensitivity 82.9%, specificity 74.7%.

**Conclusions:** CAIT is a valid and reliable tool that can be used to define and measure severity of FAI.

#### 076 THE INFLUENCE OF HORMONE FLUCTUATIONS DURING THE HORMONAL CYCLE ON KNEE LAXITY AND LOWER EXTREMITY STIFFNESS

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**Background:** The incidence of anterior cruciate ligament (ACL) injuries in female athletes is 2–8 times higher compared with their male counterparts. This may be related to hormonal fluctuations.

**Methods:** In total, 12 female netball players who were not using contraceptives and demonstrated regular menstrual cycles participated in the study. Test sessions took place at onset of menses, midfollicular phase, ovulation, and midluteal phase. ACL laxity was determined using a KT2000. MTS was assessed prior to and following a warm up session.

**Results:** MTS was significantly lower at the ovulatory phase and after the warm up intervention. Knee laxity did not change significantly across the menstrual cycle.

**Conclusions:** A reduction in MTS will increase electromechanical delay, therefore muscles will take longer to contract forces within the knee joint. Lower MTS is proposed to be a contributing factor for the higher incidence of ACL injuries at ovulation.

#### 077 VOLUME CHANGES OF ARTICULAR CARTILAGE AND MENISCI OF THE KNEE JOINT INTRODUCED BY DISTANCE RUNNING

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**Background:** Distance running poses considerable forces on the lower extremities. A substantial reduction of articular cartilage volume introduced by distance running and slow volume recovery post exercise may be indicators for the development of osteoarthritis.

**Purpose:** To investigate changes in volume of the articular cartilage of the knee and the menisci after a distance run of 5, 10, and 20 km.

**Methods:** Magnetic resonance images of the knee with a flash three dimensional sequence in water excitation technique were used. In total, 64 sagittal sequences with a 1.5 mm thickness were taken before the run, immediately after the run, and after 60 minutes of rest. The participant started and finished the run directly at the examination table.

**Results:** The reduction in cartilage volume was most notable after 20 km of running. No significant differences were found between the distances. The reduction of volume of the patella averaged 8.1% and 6.1% of the tibial plateau. The meniscus volume decreased by an average of 10.7% at the medial meniscus and 7.7% at the lateral meniscus. The recovery MR image demonstrated a significant increase in volume to nearly normal but failed to reach the original level.

#### 078 DOES LONG DISTANCE RUNNING CAUSE OSTEOARTHRITIS? AN MRI INVESTIGATION

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**Background:** Despite its obvious benefits, the possible deleterious effects of long distance running remain controversial. Repetitive loading could potentially predispose to the subsequent development of osteoarthritis.

**Purpose:** To investigate whether external impact loading creates internal stresses on bone and cartilage that are demonstrable on MR images.

**Methods:** In total, six recreational, two semiprofessional and seven beginners underwent MRI before and after a marathon run.

**Results:** The pre-run and post-run scans failed to demonstrate marrow oedema, periosteal stress reactions, or joint effusions in seven runners. Six of the beginners demonstrated minimal effusions in the hip and knee joints. One patient who underwent reconstruction of his anterior cruciate ligament demonstrated a small effusion before and after the race.

**Conclusions:** Our results suggest that the high impact forces are well tolerated and subsequently not demonstrated on MR images. Beginners do compensate for the impact stresses to a certain extent and it is postulated that long distance runners undergo a natural selection process.

#### 079 THE NEW ZEALAND SPORTSMART INJURY PREVENTION PROGRAMME

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**Background:** SportSmart, an injury prevention education programme for coaches, referees/umpires, and players on how to prevent sports injury, was launched in 1999 by the Accident Compensation Corporation (ACC). SportSmart was developed by an expert panel, based on a review of injury prevention programmes and published literature, with the intention of reducing sport injuries and increasing correct injury prevention behaviour. SportSmart's 10 action points are: Screening; warm up/cool down and stretch; physical conditioning; technique; fair play; protective equipment; hydration and nutrition; injury reporting; environment; and injury management. The SportSmart framework allows for sport specific adaptations such as RugbySmart to provide a more comprehensive and tailored injury prevention programme. ACC uses its database of injury claims and costs to determine which national sporting organisations (NSOs) it supports to implement SportSmart. These NSOs oversee formal, organised sports, with a national organisation and infrastructure, and a large number of coaches, and are ideally suited to implement the 10 action points.

**Methods:** The initial phase involved incorporating SportSmart into NSO coach education programmes, as coaches influence the behaviour of players. For other sport, ACC contracted regional sports trusts to deliver SportSmart along with generic coach education throughout New Zealand, and specifically to schools.

**Results:** In the first year of implementation over 3000 coaches were trained in SportSmart. This has increased to over 19 000 per annum. Some sports such as Rugby Union made RugbySmart an annual mandatory requirement for coaches involved in tackle rugby. ACC measures the impact of SportSmart by: claims numbers and costs; reach to coaches, clubs, schools; NSO injury surveys; and knowledge, attitudes, behaviour in NSOs, young people, and the general population.

**Conclusions:** NSOs that have adapted SportSmart have reduced injury rates and claims in key areas, and players' knowledge, attitudes, and behaviours have improved.

#### 080 BIOMECHANICAL AND USER TRIAL EVALUATION OF HOCKEY AND FOOTBALL (SOCCER) SHIN GUARDS

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**Background:** Shin guards are used to reduce incidence and severity of soft tissue and bony injuries to legs. According to FIFA, shin guards must provide "adequate" protection; however, there is limited evidence of effectiveness of shin guards from epidemiological or biomechanical analyses.

**Purpose:** To compare the biomechanical impact performance data from 34 shin guards available in New Zealand. If shin guards provide adequate protection to the shin area, other factors such as the nature of ankle protection, quality and design of straps and size, and weight and shape of the guard become important when choosing a guard. These factors will influence the perceived comfort of the guard and whether the guard will be worn. Therefore, the second aim was to evaluate the comfort of 26 shin guards specifically designed for soccer in a series of user trials.

**Methods:** Impact testing using a 7.5 kg drop heel and accelerometer was conducted six times on each guard to the centre shin position. Impact testing indicated that force characteristics can be changed by guard,s although the level of protection varied significantly among different guards. In total 29 recreational and higher level players volunteered for the user trials. A range of 3-8 players "play tested" each guard. Comfort was measured using a 150 mm continuous visual analogue scale, and perceptions of protection, appearance, support, fit, playability, and breathability were assessed via questionnaire. The wide variation in scores assigned to the same guard, by different players highlighted the difficulty in recommending one particular guard over another.

**Conclusions:** Individual requirements and preferences appear to vary owing to anatomical differences and performance factors. When

considering the impact test results and subjective responses together, an interesting dichotomy occurred. The most popular shin guards ranked in terms of comfort, fit, playability, and breathability performed less well in impact testing.

#### 081 INJURIES FROM SNOWMOBILE ACCIDENTS: A 10 YEAR SURVEY OF PATIENTS TREATED IN LAPLAND CENTRAL HOSPITAL

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**Background:** Snowmobile driving is very popular in northern Finland; however, little evidence is available on the type of accidents and injuries that occur in snowmobiling.

**Methods:** All patients that were treated in Lapland Central Hospital because of a snowmobile accident between autumn 1991 and spring 2001 were included in the study. For each patient a standardised questionnaire was filled in to obtain information about the injured person, weather conditions, type of accident and injury. In total, 559 cases were studied (23% women, 77% men, average (SD) age 35.3 (14.5) years); 16% were foreign tourists (increase from 5% in 1991/1992 to 33% in 2000/2001), of which 41% were women.

**Results:** Most accidents happened in clear weather (69%) and temperatures between 0 and -10°C (63%) with the purpose of the ride being leisure (59%) or organised safaris (19%), which showed a growing portion from 6% to 38%. The most common accident mechanisms were falling with the snowmobile (34%) or running into a fixed object (30%); falling off the snowmobile (12%) or collision with a moving object (other snowmobile 6%, car 5%) appeared less frequently. The use of helmets increased from 60% to 82% during the study period. Most injuries occurred in the lower extremities (42%), followed by the upper extremities (26%). The head was affected in 10% of the cases, the spine (9%) and thorax (8%) slightly less frequently. Injuries of the neck or abdomen were unusual (3% and 2% respectively). In the lower extremities, knee injuries dominated (34%), followed by lower leg (20%), ankle (17%), and thigh (14%). In the upper extremities, the shoulder was most frequently affected (24%), but clavicle (16%) and wrist and hand injuries (each 18%) were also very common. In the lower extremities, the left side was almost twice as frequently affected as the right. Most of the injuries of the extremities were fractures (51%); however, in the shoulder, luxations were more common (39% v 27%) and in the knee, ligament and meniscal injuries occurred almost as frequently as fractures (25% v 28%).

#### 082 THE SUCCESS OF THE BICYCLE HELMET CAMPAIGN "HELM YOURSELF"

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**Background:** Cycling increased greatly in popularity in the 1980s with the introduction of mountain bikes and an increase in public awareness of physical fitness. However, this was subsequently matched by an almost 100% increase in accident figures. With its "Helm Yourself" campaign, Suva has therefore been promoting the voluntary wearing of bicycle helmets, aimed at preventing head/skull injuries. In connection with "Helm Yourself" and given a positive return on investment, a measurement of the results confirmed that the helmet wearing quota in Switzerland has increased and the proportion of head/skull injuries has been reduced.

**Methods:** In 1987, Suva began selling its first bicycle helmets, which were niche products at that time. At the same time, it began to promote the voluntary wearing of helmets through marketing and communication measures, such as sales campaigns, posters, TV commercials, and events). Statistics on bicycle accidents and on head/skull injuries were also compiled parallel to these measures. From 1994 on, these statistics were extended to include helmet wearing quotas.

**Results:** In the past 10 years, the quota of cyclists wearing helmets has risen from 3% to 33%. Although there have been about 65% more accidents involving bicycles since 1987, the proportion of head/skull injuries has been cut by half. The savings in insurance costs (approximately €13 million/year) have been correspondingly substantial. A bicycle accident involving skull injuries costs the insurance company an average of €26 000, whereas those without any skull injuries only amount to €3300.

**Conclusions:** "Helm Yourself" is a textbook prevention campaign. There is still a long way to go if the quota of helmet wearing cyclists is to be boosted even more. One of the strong points of this campaign is that the indicators for success can be measured reliably.

### 083 WINTER SPORTS IN AN INDOOR FACILITY: ACCIDENT AND INJURY TRENDS

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**Background:** Because of the increasing popularity of indoor winter sport activities, the need for specific investigations with respect to injury prevention is growing.

**Methods:** In a 1 year study, all sports injuries reported at the ski hall in Neuss, Germany were documented and evaluated by way of an accident protocol. Injuries requiring medical attention/treatment were documented in the casualty department and injured persons were interviewed by a telephone survey.

**Results:** In total, 372 indoor skiing accidents were reported, 64.5% concerning male, 35.5% female skiers. The average (SD) age of accident victims was 22.6 (9.7) years (range 4–57); 55.6% were snowboarding and 33.3% were skiing accidents (other accidents 11.1%). The following results are based on 162 telephone interviews. Many accident victims can be considered as beginners with no or minimal experience (42.0%). Snowboarders primarily suffered injuries to the upper body (61.1%), followed by injuries of the lower extremities (25.3%), head (8.4%), and trunk (5.3%). In the case of skiing accidents, injuries of the lower extremities predominated (51.7%), followed by injuries affecting the upper body (27.6%) and injuries of the head and trunk (10.3% each). Fractures were the most common type of injury for snowboarders (41.1%), followed by contusions (27.4%), sprains (21.1%), and luxations (7.4%). Among snowboarders who sustained fractures, injuries to the distal radius were most common. For skiers, very similar percentages of fractures (25.9%), contusions (29.3%), and sprains (25.9%) were observed, with luxations being less common (3.4%). While the majority of ski hall visitors were skiers (57.9%) compared with snowboarders (40.1%) (tyre tubing or others 2.0%), more accidents happened to snowboarders (58.6%) than to skiers (35.8%) (tyre tubing 3.7%, others 1.9%).

**Conclusions:** Snowboarders seem to be a particular risk because they prefer to use the very challenging fun park section of the ski hall, which provokes more dangerous situations, consequently leading to accidents.

### 084 CHANGES OF JOINT MOMENTS IN THE GAIT FOLLOWING LATERAL ANKLE SPRAIN WEARING A LATERAL WEDGE

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**Background:** The clinical efficacy of a lateral wedge for instable subtalar joints, often a cause of repetitive lateral ankle sprain (LAS), has only been anecdotally reported.

**Purpose:** To assess frontal plane kinematics and kinetics of a lateral wedge on the subtalar and knee joint moments during gait with and without a history of LAS.

**Methods:** A crossover design was applied whereby subjects walked with two different wedges: a 0° control wedge and a 6° lateral wedge. In total 50 collegiate male athletes (25 with at least two LASs to the same ankle in the previous year and 25 healthy controls) participated. The LAS group was apprehensive about the clinically performed manual inversion stress test on their affected ankle. Frontal plane angles and moments at the subtalar and knee joints, ground reaction forces, and centre of pressure (COP) were investigated. Moments were derived using a three dimensional inverse dynamics model of the lower extremities.

**Results:** The 6° lateral wedge significantly increased subtalar joint valgus moment and reduced knee joint varus moment compared with no wedge ( $p < 0.001$ ). The difference between wedge conditions was associated with a lateral shift in the location of the COP when using the 6° lateral wedge. There was an inverse correlation between the subtalar joint valgus moment and the knee joint varus moment in all healthy subjects ( $n = 25$ ) and in 76% of the LAS subjects ( $n = 19$ ). However, in six LAS subjects, high variability and counterintuitive effects were observed with the 6° lateral wedge. These same six subjects also showed a medially shifted COP trajectory when wearing the 6° lateral wedge, in contrast to the remaining LAS subjects.

**Conclusions:** These findings indicate that the 6° lateral wedge did not consistently increase the subtalar joint valgus moment in the LAS group. Biomechanical indications and limitations of lateral wedges should be analysed in more detail, possibly leading to new guidelines for the use of such foot orthoses.

### 085 DIRECTION OF LOAD DEFINES THE "HANDBALL GOALIE'S ELBOW"

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**Background:** Elbow problems in goalkeepers in team handball ("handball goalie's elbow") are common. The accepted mechanism in the common injuries is hyperextension of the elbow.

**Purpose:** To describe the elbow position at the time of impact of the ball to the hand, using video analysis.

**Methods:** In total, 15 handball goalies (nine women, six men) who had been playing handball for a mean time of 6.5 years, participated in the study. The participants were not aware of the details of the study. A national team member attacker performed repetitive shots towards the right side of each goalkeeper. The goalkeepers blocked the ball with their own usual style. Each block was videotaped with three digital cameras (one side view, one superior view, one frontal view). The captured shots were later evaluated by three analysts as to the elbow position at the time of the impact.

**Results:** Of 101 shots, 78 (77%) were valgus or mostly valgus load producing shots. The remaining 23 (23%) were hyperextension or mostly hyperextension load producing shots.

**Conclusions:** This study shows that the elbows in handball goalkeepers are frequently subjected to valgus loads. A detailed understanding of the mechanism will help in defining ways to prevent and to treat handball goalie's elbow.

### 086 FACTORS INFLUENCING THE OCCURRENCE OF INJURIES IN SEMI-PROFESSIONAL PLAYERS OF SOCCER AND MINI SOCCER

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**Purpose:** To register the factors may influencing the occurrence of injuries in semi-professional players of soccer and mini soccer and to describe the types of injuries incurred.

**Methods:** We reviewed the past 200 injuries incurred in 191 semi-professional male players of soccer and mini soccer. In total, 104 mini soccer players aged 16–42 years (average 28.4) sustained 109 injuries, and 87 soccer players aged 15–37 years (average 26.8) sustained 91 injuries. The players were of different levels of skill. Previous injuries, severity of injuries, and correlation of injuries (frequency and severity) with age and frequency of playing (or practising) weekly (times/week) were also registered.

**Results:** In total, 57% (59% in mini soccer, 54% in soccer) of injured players were playing mini soccer/soccer 1–2 times per week, usually without any previous practice/training during the week, and 35% (36% in mini soccer, 33% in soccer) of injured players had suffered previous injury in the same area of their body. Injuries were more frequent in players aged >30 years old (almost half of them) and in players of low/medium skill level, but injuries were more severe in younger players (<30 years old) and in players of higher (medium/high) skill level. The lower extremities were involved in 70% of injuries, the upper extremities in 22%, 5% involved both upper and lower extremities, and 3% the spine. Joint sprains predominated (37,5%), followed by fractures (23%; 22% in mini soccer, 25% in soccer), menisci tears (12%), tendon injuries (10%) and ligament ruptures (9%). Injuries of the ankle were most prevalent (43%), followed by injuries of the knee (26%) and the wrist (17%).

**Conclusions:** Soccer and mini soccer players sustained a variety of injuries, mainly in the extremities. "Personal" factors (age, previous injuries, skill), poor physical condition, and inadequate training, seemed to be related to the severity and frequency of the incurred injuries.

### 087 SPORTS INJURIES AND PREVENTION IN THE NETHERLANDS 2000–2003

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**Purpose:** To estimate the number and risk of sports injuries and to verify preventive measures in sports.

**Methods:** This was a national survey on injuries caused by road, occupational, sports, and home and leisure accidents (OBiN,  $n = 40\,000$ ) carried out in 2000–2003. Additional information on general physical activity and sports, including injury prevention, was obtained.

**Results:** In the Dutch population (16.2 million), 50% of them are active in sports. Each year 1.5 million sports injuries are registered (51% medically treated, 42% in organised sports, 70% male athletes), with 39% of the injured athletes aged 18–34 years (n=580 000). The largest contributor in sports injuries is outdoor soccer (n=420 000), followed by running and jogging (n=112 000), outdoor tennis (n=90 000), volleyball (n=80 000), and indoor soccer (n=74 000). The highest injury risk is found in skiing, indoor soccer, indoor handball, basketball, and outdoor hockey. The risk index varies from 2.3 to 6.8 injuries per 1000 sporting hours. Of the Dutch athletes, 78% apply injury preventive measures. Athletes between 18–34 years apply preventive measures most frequently (84%). Warming up and cooling down are performed most frequently (64% and 35%). In outdoor soccer, warming up is performed by 87% (cooling down 40%). Shinguards are used by 72% of the soccer players. In volleyball, warming up is performed by 90% (cooling down 37%), and knee protectors are used by 33%.

**Conclusions:** Popular sports such as soccer dominate the absolute contribution to sports injuries. Some sports with small numbers of participants show high injury risks, and relatively few types of sport show high injury risks. The highest incidence is found among athletes aged 18–34 years, although they also apply preventive measures most frequently. Sports injuries have different contact and non-contact causes. As a result, injury prevention varies enormously in each type of sport. A sport specific policy on injury prevention that focuses on athletes and coaches is necessary.

#### 088 IS ACL RECONSTRUCTION NECESSARY TO PREVENT OSTEOARTHRITIS? 12 YEAR FOLLOW UP RESULTS AFTER NON-OPERATIVE TREATMENT OF ACL RUPTURE

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**Background:** The main indication for anterior cruciate ligament (ACL) reconstruction is to prevent joint instability and thus the development of osteoarthritis. Nevertheless, malfunction and osteoarthritis is seen frequently after ACL reconstruction.

**Purpose:** To analyse the development of osteoarthritis and the functional outcome after non-operative treatment in a long term study.

**Methods:** In total, 38 patients (10 female, 28 male, 13–54 years,  $\bar{x}$  36 years) having arthroscopy after trauma were identified as having an isolated ACL rupture. With a mean follow up of 12 years, all patients were examined clinically and evaluated with internationally accepted scores (Lysholm, Tegner, IKDC); I rays were taken and classified according to Kellgren/Lawrence and Jäger/Wirth.

**Results:** Radiology showed 21 patients (55%) with grade 0 (no significant changes indicating OA), 8 patients (21%) with grade I (osteophytes at the eminentia or patella), 8 patients (21%) with grade II (osteophytes tibial plateau with narrowing of joint space), and 1 patient (3%) with grade III (significant narrowing of joint space). IKDC was A (normal) for 9 patients (24%), B (nearly normal) for 14 (37%), C (abnormal) for 11 (29%), and D (severely abnormal) for 4 (11%). Difference of KT1000 injured versus uninjured knee was a maximum of 15 mm and minimum of 0 mm; mean 5.2 mm. Mean Tegner score was 5.5 (range 2.0 to 10.0) pre-injury and 5.0 (range 2.0 to 10.0) post-injury. Four patients were classified with activity level of 8 or more (soccer 2 patients, wrestling 1, badminton 1); only two of these patients showed radiological signs of OA (wrestling 1, soccer 1). Mean Lysholm score was 89 (range 45 to 100) at follow up examination.

**Conclusions:** More than half of the patients showed no signs of osteoarthritis 12 years after non-operative treatment of ACL rupture. The worst results were seen in patients participating in sports with a high activity level (soccer, wrestling). At this level of activity ACL reconstruction appears to be indicated. In patients with low level activity, good results can even be achieved with non-operative treatment.

#### 089 CONFIGURATION OF THE TIBIAL LATERAL CONDYLE AS AN INTRINSIC RISK FACTOR FOR A NON-CONTACT ANTERIOR CRUCIATE LIGAMENT INJURY

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**Background:** The anterior cruciate ligament (ACL) is extremely important to the competitive athlete, and prevention of injuries to the ACL is a subject of keen interest. In this study, we focused on the configuration of the tibial lateral condyle. We hypothesised that high convexity of the

tibial lateral condyle is an anatomical intrinsic risk factor for a non-contact ACL injury.

**Methods:** For this study, we examined 65 patients who had a checkup because of a knee disorder in our sports clinic. Three groups were compared: bilateral ACL injuries group (12 knees in female athletes), unilateral ACL injuries group (10 knees in male athletes, 17 knees in female), no ACL injury group (18 knees in male athletes, 14 knees in female). For evaluation of the convexity of the tibial lateral condyle, magnetic resonance imaging of the mid-sagittal section of the tibial lateral articular surface was used. Point A was the posterior edge of the articular surface and B is anterior edge, H was the height from the line AB to the top of the articular surface, and the convex index was H divided by AB.

**Results:** In the no ACL injury group, female athletes had a slightly higher convex index than male athletes, but there was no statistically significant difference. In female athletes, the mean convex index was 0.187 for the bilateral ACL injuries group, 0.175 for the unilateral ACL injuries group, and 0.143 for the no ACL injury group. There were statistically significant differences. In male athletes, the mean convex index was 0.161 for the unilateral ACL injuries group, and 0.126 for the no ACL injury group. There was a statistically significant difference.

**Conclusions:** In this study, we hypothesised that when the knee receives flexion and valgus motion on landing, the femoral lateral condyle then slides down to the posterior of the tibial lateral condyle, resulting in ACL injury, particularly if the convex index is high. A high convex index of the tibial lateral condyle appears to be an intrinsic risk factor for a non-contact ACL injury.

#### 090 MUSCLE INJURY PREVENTION BY PROPRIOCEPTIVE TRAINING IN ELITE FEMALE SOCCER

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**Background:** Injuries of the anterior cruciate ligament (ACL) can be significantly reduced by proprioceptive training. Does a prospective proprioceptive coordinative additional training intervention in elite female soccer changes frequency and pattern of muscle injuries?

**Methods:** In total, 24 female soccer players of the German first division team of FC Bayern München were thoroughly supervised during the 2003/2004 season regarding injuries resulting in an absence from at least one scheduled training session or game. During the winter break 2003/2004 an additional proprioceptive coordinative training programme was initiated, which was performed on a regular basis during the second half of the season. Furthermore, we evaluated jump and reach, throwing power, coordinative skills, and flexibility.

**Results:** All evaluated fitness results increased significantly during the season after the training intervention, such as jump and reach (mean (SD) 44 (4) cm v 38 (10) cm,  $p < 0.05$ , coordinative power, respectively 71 (44) s v 45 (37) s left leg; 80 (41) s v 50 (32) s right leg; both  $p < 0.05$ ), flexibility (89 (8) ° v 78 (13) ° left hip; 88 (9) ° v 79 (10) ° right hip;  $p < 0.05$ ). Severe muscle injuries resulting in game or training absence were significantly or completely eliminated after 1 year (12/3/0,  $p < 0.05$ ), while minor muscle injuries throughout half a season were significantly reduced from 36 to 14 ( $p < 0.05$ ). In the first half of the season, two ACL ruptures occurred versus none in the year following the training intervention.

**Conclusions:** Severe muscle injuries resulting in a game absence can be prospectively prevented by a proprioceptive training in elite female soccer. Furthermore, as indicated before, ACL injuries can be prevented and performance in coordinative abilities, jump power, throwing power, and flexibility can be increased within half a season in elite female soccer.

#### 091 EFFECTS OF ANKLE POSITION, MUSCLE CONTRACTION, AND MUSCLE ELONGATION ON ANTERIOR TRANSLATION OF THE TIBIOFEMORAL JOINT

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**Background:** The ability to accurately diagnose anterior cruciate ligament (ACL) injuries plays an important role in determining the treatment intervention and prognosis.

**Purpose:** To assess the effects of ankle position and muscle contraction on anterior translation of the tibiofemoral joint.

**Methods:** In total, 30 male and 30 female intercollegiate athletes, aged 18–23 years, from different sports and with no prior knee pathology were selected to serve as subjects. Each subject was examined for anterior tibial translation in one of four positions and muscle

contraction states. Navicular drop measurements were obtained to assess foot position.

**Results:** All ankle positions and gastrocnemius muscle states decreased the anterior tibial translation of the tibiofemoral joint at the  $\alpha=0.05$  level compared with the normal controlled position. Navicular drop test measurements demonstrated a statistically significant correlation to the amount of anterior tibial translation in women at the  $\alpha=0.01$  level. Regression analysis, coefficient of determination, and standard error of the estimate all revealed poor results.

**Conclusions:** These findings suggest that ACL stability should be tested with a slight plantar flexion of the ankle in a relaxed muscle state. Furthermore, there is a stronger relationship between navicular drop measurements and the amount of anterior tibial translation in women than in men. Future studies should consider subject populations other than non-injured intercollegiate athletes.

### 092 VALIDATION OF A MODEL BASED IMAGE MATCHING TECHNIQUE FOR 3D RECONSTRUCTION OF HUMAN MOTION FROM UNCALIBRATED VIDEO SEQUENCES

T. Krosshaug, R. Bahr. *Oslo Sports Trauma Research Center, Oslo, Norway*

**Purpose:** To assess the accuracy of a new model based image matching technique for three dimensional (3D) reconstruction of human motion from one or more video sequences.

**Methods:** A laboratory trial was performed to compare the accuracy of the method with a seven camera, 240 Hz marker based optical motion analysis system as the gold standard. Three ordinary video cameras recorded one test subject performing a side-step cutting manoeuvre, serving as input for a total of seven matchings (three single camera matchings, three double camera matchings and one triple camera matching). Based on measurements of the subject's anthropometry, a customised computer model was made, using the 3D animation software Poser. A model of the lab was built based on measured landmarks. The cameras were then calibrated by matching the virtual environment in Poser to the background reference, and the skeleton model was accordingly adjusted to the fit the subject at each time step.

**Results:** Good agreement was found for the support leg flexion/extension angles in the hip and knee for all the matchings compared with the ProReflex measurements, with root mean square (RMS) differences ranging from 3 to 12°. Hip adduction/abduction RMS differences ranged from 12–14°, while varus/valgus angles of the knee were in the range of 3–5°. Rotation angles were clearly most variable in both the hip and knee, and RMS differences ranged from 6 to 16°. RMS velocity differences of the centre of mass in all three directions ranged from 0.1 to 0.6 m/s. Accelerations were only acceptable for the matchings that contained perpendicular views, with the triple camera matching as the best (RMS differences of 2.8–4.9 m/s<sup>2</sup>); however, due to low frame rate (50 Hz for PAL videos), the high frequency acceleration peaks were not captured.

**Conclusions:** We found that 3D motion could be successfully reconstructed with adequate precision in all the studied situations. The accuracy, however, improved with the number of camera views available.

### 093 THREE DIMENSIONAL BIOMECHANICAL ANALYSIS OF NON-CONTACT ACL INJURIES

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**Purpose:** To apply a newly developed model based image matching technique for three dimensional (3D) motion reconstruction to three different anterior cruciate ligament (ACL) sports injury situations.

**Methods:** An alpine downhill skiing (filmed with one camera, 50 Hz), team handball plant and cut (three cameras, 50 Hz) and basketball landing (four cameras, 120 Hz) injury were analysed. Computer models of the surroundings were built to estimate the camera pose and focal length parameters at each frame, through model matching. Finally, a frame by frame matching of the skeleton model to the athlete was completed.

**Results:** Visually, the skeleton model matched well in all camera views for all the three matchings. However, it was difficult to assess precisely the exact rotation of, for example the thigh, owing to low resolution and blurriness. In the basketball and handball situations, the information from, for example, the basket and floor markings, made accurate camera calibration possible as indicated by the virtual cameras matching the actual cameras visible on the video images. Relatively small variation in horizontal velocity and vertical acceleration of the

centre of mass in the airborne phase indicated that the position estimates were reasonably accurate. For the basketball injury, a maximal vertical force peak of 4.0 g was obtained 33 ms after initial contact (IC). This agrees well with published literature. The handball matching showed peak forces at 100 ms, but this estimate is probably delayed due to the lower frame rate. In the downhill skiing analysis, it was not possible to produce reliable position estimates owing to the few landmarks present. The acceleration and joint angle data in combination indicated that injury most likely occurs around 30–50 ms after IC, with a knee flexion exceeding 30° and that valgus loading is an important factor. In the downhill skiing injury the knee was severely twisted owing to the ski catching the edge, and up to 24° of valgus and 39° internal rotation was found.

### 094 EFFECTS OF A NEW SKI BOOT ON KNEE LOADING IN FREESTYLE MOGUL SKIING

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**Purpose:** To evaluate a new type of ski boot that allows significantly more dorsal flexion in the ankle joint for its effects on the knee loads in freestyle mogul skiing.

**Methods:** The comparison between the new and the conventional type boot was performed by the use of computer simulation. Necessary experimental data were collected with  $n=21$  competition mogul and ski instructors who underwent a standardised two mogul run with both ski boot models. Each run was documented with video. Furthermore, the ground reaction force was collected with a purpose built measuring binding. A pre-assessment was made by a questionnaire on the personal impressions of the complete group of skiers. After this field trial, the video material was investigated with a motion analysis system. In the spot sample, two trend groups with significant behaviour could be identified. Two skiers with similar anthropometric data were picked from each group. For the modelling of the chosen runs, the mechanical data of all the involved hardware was determined by experiment. Together with segmented models based on the anthropometric data of the chosen skiers, the field test set up was rebuilt in the environment of a software for the simulation of multi body systems. According to the boundary and initial conditions of the hardware, the skiers and the motion analysis data, a forward simulation of the chosen field trials was performed and analysed. The calculated kinematic behaviour of the knee joint was transferred into a computer knee model with all ligament structure.

**Conclusions:** The results of these simulations gave an insight to the ligament strain during typical movements in mogul skiing. With this information, it was possible to complete the assessment of the new ski boot model.

### 095 A COMMUNITY BASED INTERVENTION PROJECT IN NON-ELITE SPORTS: BADMINTON, TEAM HANDBALL, AND SOCCER

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**Purpose:** To (a) implement structured training and rehabilitation procedures in non-elite sports and (b) assess the effects of the implemented training principles on injury figures. The current study was carried out in the three disciplines of badminton, team handball, and soccer.

**Methods:** A randomised intervention study was implemented in 1990–1992. The county was divided geographically into two areas, randomly assigned as intervention and control areas; the intervention area containing 102 teams (2250 players) and the control area 105 teams (2301) players. The intervention was adjusted to the three disciplines, but focused on a structured scheme for warming up, cooling down, and the use of qualified external observers who supervised the teams directly.

**Results:** In total, 4451 players participated. After the trial, the training methods were found to be changed in the desired direction, and 26% of the players in the intervention group encountered severe injuries (needing treatment) compared with 31% in the control group. This difference was significant, with the prevented portion amounting to 0.20 (95% CI -0.01 to 0.36) for all teams. Stratified into disciplines, the figures only showed significant effect within the badminton and team handball teams, not within the soccer teams.

**Conclusions:** Recent reviews have revealed few intervention studies in this field. It was found to be very difficult to perform intervention research in non-elite sports because of the fluctuating participation of players over

time and season, and difficulties in gathering the necessary information on injuries, treatment, and rehabilitation, despite a well functioning project organisation. In spite of the methodological weaknesses in tracing players and data, it is evident that the obtained effects in badminton and team handball are caused by the applied intervention model. The poster will describe the intervention model, methodology problems, and results.

**096 TOWARDS AN ASYMMETRIC SKI BINDING RELEASE: ACL VERSUS BINDING FORCES WITH THE ROTATED KNEE IN DEEP FLEXION**

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**Background:** The high rate of anterior cruciate ligament (ACL) injuries in alpine skiing leads to the question if current bindings systems protect the knee adequately against injuries. One well known injury mechanism appears as deep knee flexion combined with an internal tibial rotation, the so called "phantom foot".

**Methods:** Comprehensive analyses of ACL forces and forces acting upon a ski binding during this particular injury mechanism were carried out using experimental data ascertained with a knee load simulator and data calculated by a computer model. Experimental data were obtained using fresh frozen human cadaver knees embedded in a knee load simulator. Forces in the ACL and resulting binding forces, caused by the application of external forces and torque during specific motion pattern were measured by a load cell. Additionally a multi-body system computer model simulating the experimental tests was created. The model includes the construction of the knee load simulator and the exact geometries of bone structures and soft tissues of the investigated cadaver knees. Force elements describing the mechanical behaviour of the soft tissue structures were validated by experimental data obtained in preliminary tests.

**Results:** The first test series showed a nearly slack ACL structure in knee flexion angles between 90° to 110° and internal tibial rotation angles to 15°. Following this, tests on knee joint flexion positions up to 140° and greater amplitudes of internal/external rotation are currently under investigation, and the results will be available by the time of the conference.

**Conclusions:** Exact ACL rupture mechanisms in alpine skiing are very complex. The comparison of experimentally obtained data with data calculated by a computer model enables a more accurate interpretation of the injury mechanisms. Optimisation of binding design, especially towards an asymmetric ski binding release, could be promising for prevention of knee joint injuries.

**097 THE MOST DANGEROUS SPORT? INJURIES RELATED TO HORSERIDING: AN EPIDEMIOLOGICAL STUDY AND FUTURE DIRECTIONS FOR PREVENTION**

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**Purpose:** To investigate the injury rate and injury pattern among recreational horseriders in Hong Kong, and possible preventive measures.

**Methods:** An injury questionnaire was sent to all riders in Hong Kong registered with the Hong Kong Equestrian Federation and/or riding schools. The mechanism of injury and the injured body parts were recorded, as well as emergency room attendance, hospital admission, operation undergone, and loss from school/work. Riders' perceived adequacy of medical support and suggestions on safety improvement were surveyed.

**Results:** In total, 124 riders reported 137 horseriding related injuries that were brought to medical attention over a 3 year period. Of these, 58% (72) had never had a significant injury but of those who did, 71% had more than one. There were more female riders in the study, but male riders had a higher incidence of sport related injury (51% v 35%). Most of the injuries that occurred during riding were outside competition times, but those that happened within competition tended to be more serious. The upper limb was the most common injured body part, followed by head and neck, then the lower limb, trunk and pelvis the least. Safety helmet, and protective gloves and footwear were universally used while mounted, but not safety vest. There was no fatality in the study period. Of the injuries reported, 36% required hospital admission and 20% needed a surgical operation; 24% reported loss from work/school for more than 1 week. Many riders commented that more effort should be spent on public and rider education, especially on aspects such as

horse behaviour and falling technique. Improvement in training and riding environment, first aid measures at riding schools, and emergency medical service at competitions were also suggested.

**Conclusions:** Equestrian sport is a dangerous one, and effective countermeasures aiming at reducing the incidence and severity of horseriding related injuries should be implemented.

**098 INJURY PATTERNS IN ALPINE SKIING AND SNOWBOARDING: A PROSPECTIVE STUDY IN BAQUEIRA BERET, SPAIN**

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**Purpose:** To evaluate the skiing injury patterns in the Catalan Pyrenees.

**Methods:** A prospective study during the 2002-03 and 2003-04 seasons at Baqueira Beret, the largest ski resort in this area, was performed. Data on all skiers injured seen in the medical centre situated at the base of the ski resort were collected and compared with the general population at risk. People skiing at the access to the lifts were counted. For all subjects, age, sex, and type of sport (alpine skiing, snowboarding) were documented, along with injury patterns for those injured.

**Results:** There was a general injury rate of 2.51 injuries per 1000 skier days for alpine skiing and 5.29 for snowboarding. When we looked at the type of injury, the most frequent were contusions followed by fractures, which were more common for snowboarders than for alpine skiers. In all types of sport, the lower extremities were the most frequently affected region. Injury patterns were different depending on the sport: for alpine skiing, knee sprains were the most frequent for the lower extremities followed by "skier's thumb" in the upper extremities, whereas for snowboarding knee and ankle sprains had similar frequencies in the lower extremities while wrist and forearm fractures were predominant in the upper extremities. Looking at the affected structure in the knee injuries, of 1202 people having knee injuries, 56.3% had injury to an isolated structure; 21.5% to the medial collateral ligament (MCL) and 5.1% to the anterior cruciate ligament (ACL).

Abstract 98

	Men	Women	Total
Alpine skiing	2.14	2.91	2.5
Snowboard	4.59	7.41	5.29

**Conclusions:** The binomial test showed that there are statistical differences between alpine skiing and snowboard for injuries affecting the proximal and medial parts of the MCL and ACL.

**099 USING THE LAW TO PREVENT INJURIES**

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The 1860 Act relating to the Municipal Health Service was the weapon health officers in rural districts in Norway could use to reduce illness and disease. From 1984, this Act added a responsibility to health officers to calculate the risk for serious injuries during various activities in their municipality, and allowing them to stop, or to demand alterations in the activity if necessary. A number of activities stopped according to this Act will be presented. In addition, activities changed from the original mode of activity because of the health officer's concern about injuries are reported. Examples of excellent cooperation with the ski centres to calculate injury risk are given. The Act relating to municipal health is an important tool for the health officer to reduce injuries if used as intended.

**100 LOW LOAD ECCENTRIC EXERCISE PREVENTS MUSCLE INJURY AND FREE RADICAL PRODUCTION IN HIGH LOAD ECCENTRIC EXERCISE**

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**Purpose:** To test the hypothesis that training by low load eccentric contractions can prevent muscle injury and free radical production associated with high load eccentric contraction.

**Methods:** Female Wistar rats (12 weeks old) were assigned to a control (CON), eccentric exercise (ECC) or low volume familiarised eccentric exercise group (LV+ECC). Samples of the quadriceps femoris muscles were obtained from the rats in each group. Before the study, the LV+ECC group performed running on a treadmill with variable velocity and inclination on a 15° incline at 10 m/min for 30 minutes every day for 1 week. The ECC and LV+ECC rats were then exercised by running on a 15° incline at 20 m/min for 150 minutes. Scavenging activity against superoxide anions in these specimens was determined by electron spin resonance (ESR) using a spin trapping agent (5,5-dimethyl-1-pyrroline-N-oxide).

**Results:** The scavenging activity converted into superoxide dismutase activity was significantly lower at 24 hours after ECC ( $p=0.0016$ ). No evidence of muscle damage was observed as a result of the bouts of low volume eccentric contraction. The scavenging activity converted to superoxide dismutase activity returned to the control level at 24 hours after LV+ECC. Morphological analysis (haematoxylin and eosin staining) showed significant polymorphonuclear cell infiltration into the damaged region at 72 hours after ECC. However, there was no polymorphonuclear cell infiltration at 72 hours after LV+ECC.

**Conclusions:** Low load eccentric exercise prevents muscle injury and free radical production in high load eccentric exercise.

### 101 METHODS INVOLVED IN CONDUCTING A LARGE SCALE INJURY SURVEILLANCE PROJECT

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**Background:** The Rugby Union Injury Surveillance Study (RUISS) examines injury by nature, body region, and event across multiple levels of play. It is supported by the ARU.

**Methods:** Rugby teams from the five main competition divisions in Australia (elite, grade, colts, country, and schoolboy) participate in the study, which commenced in 2000. It had grown in size from 241 participants and 320 games in its first year to 2776 participants in 1602 games in 2003. RUISS is unique in its aim to maintain the same injury and exposure definition across all levels of play in the cohort. A standard set of injury data are recorded at the game by club medical staff or trained recorders. Match participation is obtained from official match results sheets. The data are then entered into a database for management.

**Results:** During the study, data collection problems have arisen that are specific to each level of play. The lack of medical support at schoolboy and country levels makes it difficult to obtain injury data without a trained recorder. At other levels, forms have evolved to minimise demands on medical professionals, who voluntarily record for the project. The study methods provide flexibility in injury recording tools by offering a selection of paper forms or PC programme. Improvements in the usability of the forms have focused on assisting with record keeping at the club level and providing reliable data for RUISS. This has improved the reliability and quantity of the data and has been a factor in the study's growth. As the injury definition requires a player to miss a subsequent match with the injury, it is important that accurate reasons for absence are obtained in a timely fashion to verify a player's injury status. This function relies greatly on maintaining a database, and using it to identify absent players. The evolution of data collection procedures tailored to team conditions has improved the breadth and depth of RUISS. The study is now producing valuable assessments of injury risks in rugby.

### 102 RUGBY UNION INJURY SURVEILLANCE STUDY: RESULTS FROM 2002–2003

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**Purpose:** To identify the risk and patterns of injury across multiple levels of Rugby Union football.

**Methods:** Injury data from the 2002–2003 seasons were analysed by body region, nature, event, and level of play. The cohort included players from all levels of rugby, ranging from under 15 schoolboy teams to the Australian national team. Player match participation was recorded and the details of each injury were taken by club medical staff. Reasons for absences were tracked. An injury was defined as one that led to a player missing a subsequent match. Injury rates are reported per 1,000 player game hours.

**Results:** During 2002–2003, 4301 players played in 2646 games, resulting in 1031 injuries. The injury rates for each level were: elite (37/1000), grade (27/1000), colts (21/1000), schoolboy (19/1000). New

South Wales regional teams had the lowest injury rate. The knee and shoulder were most commonly injured, then the ankle and thigh. Sprains and strains made up 47% of all injuries (11/1000). Most sprains/strains occurred to the lower limb (63%) and shoulder (21%). Fractures (2.4/1000), mainly to the hand and fingers (27%), were most common in children and at the elite level. Superficial injuries (1.8/1000) to the thorax (21%) and knees (15%) were also common. The overall rate of concussions was 1.3, accounting for 6% of all injuries by nature.

**Conclusions:** Concussion rates are higher in junior rugby. The event of injury was recorded in approximately 70% of cases. These data are not normally taken by medical staff and are frequently hard to isolate due to the nature of rugby. For known events, tackling was the main cause of injury, causing a third of all injuries. Players were twice as likely to be injured being tackled than making a tackle. The rates and patterns of injury vary across different levels of play. Musculoskeletal injury accounted for the majority of missed games in rugby, with more serious injuries in the older players and a higher rate of concussion in younger players.

### 103 DYNAMIC VERSUS STATIC STRETCHING WARM UP: THE EFFECT ON POWER AND AGILITY PERFORMANCE

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**Purpose:** To compare the effect of a dynamic warm up (DWU) with a static warm up (SWU) on selected measures of power and agility.

**Methods:** In total, 30 cadets at the United States Military Academy completed the study (14 women, 16 men; aged 18–24 years). On three consecutive days, subjects performed one of the two warm up routines (DWU/SWU) or performed no warm up (NWU). The DWU consisted of 10 calisthenic and five agility drills performed continuously. The static stretching warm up consisted of 1 minute of running in place followed by nine stretches targeted at the major muscle groups. After 1–2 minutes of recovery, subjects performed three tests of power or agility. The three warm up protocols lasted 10 minutes each and were counterbalanced to avoid carryover effects. The order of the performance tests (T shuttle run, underhand medicine ball throw for distance, and five step jump) was also counterbalanced.

**Results:** Repeated measures one way analysis of variance revealed better performance scores after the DWU for all three performance tests ( $p<0.01$ ), relative to the SWU and NWU. There were no significant differences between the SWU and NWU for the medicine ball throw and the T shuttle run, but the SWU was associated with better scores on the five step jump ( $p<0.01$ ).

**Conclusions:** As the results of this study indicate a relative performance enhancement with the DWU, the utility of warm up routines that use static stretching as a stand alone activity should be reassessed. Our results support recent reports suggesting that traditional static SWU might not confer the presumed benefits of injury prevention and enhanced performance.

### 104 MUSCLE TIGHTNESS OF THE LOWER LIMB IN OSGOOD-SCHLATTER DISEASE

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**Background:** Osgood-Schlatter disease (OSD) occurs more frequently in athletic children or active adolescents. The quadriceps muscle may be inelastic or tight, and acts as an important aetiological factor in this disorder, but this finding in other muscles has not been considered so frequently.

**Purpose:** To evaluate the contribution of lower limb muscular tightness in OSD.

**Material and method:** Between 2001 and 2004, 74 patients (66 boys, 8 girls), mean age 12.1 years (range 10.2–15.6), with 92 knees affected by OSD, were observed and followed up at our clinic. The thigh muscle groups that might be most involved were clinically examined, using the Ely test for rectus femoris (quadriceps), tripod sign for hamstrings, and passive dorsiflexion of the ankle for triceps surae muscles. Any pre-existing deformity or neuromuscular diseases were excluded.

**Results:** We found tightness of the quadriceps, hamstrings, and triceps surae in 41 (44.5%), 36 (39.1%), and 15 (16.4%) of the cases, respectively, and it was noted that those patients with this sign were more symptomatic of pain and tenderness over the tibial tubercle.

**Conclusions:** The result for quadriceps muscle tightness was comparable with the literature, but for hamstrings and triceps surae, more case studies will be need. We recommend flexibility and stretching exercises



for the thigh and calf muscles in the child or preadolescent who wants to begin or participate in sport activities, to help prevent OSD and to control symptoms in those already affected with this condition.

### 105 EFFECT OF FEMALE SEX HORMONES ON COLLAGEN SYNTHESIS IN SKELETAL MUSCLE AND TENDON IN RESPONSE TO EXERCISE

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**Purpose:** To examine whether hormonal fluctuations during the menstrual cycle affects the fractional synthesis rate (FSR) of collagen in muscle connective tissue and tendon at rest and in response to strenuous exercise. The protocol was similar to our recently published study on men, which made a comparison between the sexes possible.

**Methods:** In total, 16 healthy women not using oral contraceptives were studied over 3 days after 1 hour of one legged kicking exercise at 67% of  $W_{max}$  in either the follicular phase (FP; n=8) or luteal phase (LP; n=8) of the menstrual cycle. FSR was measured by infusion of tracers (L-(1-13C)-leucine, L-13C-proline) followed by biopsy of the vastus lateralis 24 hours post-exercise and of the patellar tendon 72 hours post-exercise.

**Results:** Mean (SD) control FSR of muscle collagen was 0.024 (0.017)% per hour in the FP and 0.021 (0.006)% per hour in the LP. In the exercised leg muscle, collagen FSR increased to 0.073 (0.016) and 0.072 (0.015)% per hour in the FP and LP, respectively. By 72 hours post-exercise, the rates of tendon FSR was not different from resting values in either of the groups of women (control 0.025 (0.003) and 0.026 (0.001)% per hour; exercise group 0.027 (0.006) and 0.027 (0.005)% per hour for FP and LP) but lower compared with men (0.045 (0.008) and 0.058 (0.008)% per hour for control and exercise groups, respectively).

**Conclusions:** No difference in collagen FSR was observed between the phases of menstrual cycle. Like men, an increase in muscle collagen FSR was observed in response to exercise. However, tendon collagen FSR at rest and in the recovery phase after an acute bout of exercise was lower in women than had been earlier reported for men. The latter findings may partly explain the higher risk of sustaining certain type of sports injuries in women compared with men.

### 106 TRENDS IN SHOULDER INJURIES AMONG ELITE VOLLEYBALL PLAYERS IN THE USA

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**Background:** Many studies have demonstrated that shoulder injuries are common in volleyball players, but few have explored the nature of shoulder injuries in large populations of volleyball players training for elite competition.

**Purpose:** To evaluate the frequency and type of shoulder injuries in this population.

**Methods:** Data were collected over an 8 year period on 1371 athletes at three US Olympic training centre sites. Type of injury, athlete's birthdate and sex were recorded for each episode of injury. Athletes from the men's and women's national teams, junior and youth national teams, and training camps were evaluated. The data were analysed using standard statistical analysis.

**Results:** Over an 8 year period, 138 athletes presented for evaluation of shoulder injuries (10.1% injury rate); 67 women and 71 men. The shoulder was affected in 24.8% of injured players. The most common diagnosis was rotator cuff strain, followed by rotator cuff tendinosis and biceps tendinosis. Rotator cuff problems occurred equally among men and women (70 and 69, respectively) as did biceps tendinosis (10 men, 11 women). However, twice as many men as women returned with repeated episodes of rotator cuff or biceps tendon pain (19 men, 10 women). Sex differences were also noted for glenohumeral subluxation, which occurred in 10 women and only one man. No glenohumeral dislocations were recorded.

**Conclusions:** Shoulder injuries were common among volleyball players training for international competition. Rotator cuff disease appeared to affect both genders equally, yet men were twice as likely to return with rotator cuff symptoms as women. Glenohumeral subluxation showed a tenfold greater incidence among women than men. These findings may have implications for training recommendations, such as rotator cuff strengthening for females that could decrease the risk of shoulder injury in elite volleyball players.

### 107 PREVENTION OF SUPRAESPINATUS TENDON OVERUSE IN CANOEISTS

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**Background:** Repeated movements of the arm overhead can overuse the supraespinatus tendon. When this happens, the tendon becomes inflamed and swollen (tendonitis). This is a frequent overuse injury in paddle canoeists. We propose a change in the hilt of the paddle, in order to prevent this injury. The classic T shaped handle works with internal rotation, whereas our new handle produces an external rotation of the shoulder and changes the specific technical skill, with consequent reduction in risk of injury.

**Purpose:** To determine the average power and peak torque in the dominant shoulder, to investigate if there are differences between the usage of the two paddles, and to compare the results obtained by the canoeists injured with the two handles.

**Methods:** We prospectively evaluated 16 canoeists aged between 19 and 29 years; 6 with impingement syndrome and 10 without shoulder injury. Isokinetic strength assessment was performed using a Biodex System3Pro with test speeds of 60 and 180 degrees/s in diagonal movement away and towards the canoeist with the two handles. One way analysis of variance was used for comparison.

**Results:** Significant differences were not observed between the two handles. The data showed no differences between the dependent variables (average power, peak torque) using the two specific technical skill, but with the advantage that there was not overuse of the supraespinatus tendon with the new hilt.

### 108 THE EFFECTS OF PLYOMETRIC VERSUS DYNAMIC BALANCE TRAINING ON LANDING FORCE AND CENTRE OF PRESSURE STABILISATION IN FEMALE ATHLETES

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**Purpose:** To compare the effects of plyometric versus dynamic balance focused anterior cruciate ligament (ACL) intervention protocols on balance and landing force in female athletes.

**Methods:** In total, 18 high school female athletes were randomised into two different groups to participate in training three times weekly for 7 weeks. The dynamic balance (n=11) group performed dynamic balance exercises and the plyometric (n=8) group trained with maximum effort jumps. A single leg hop and balance test was performed a total of six times (randomised trials between sides) on an AccuPower portable force platform. Subjects initiated the movement while balancing on one foot and were instructed to hop forward 50 cm and balance for 10 seconds after the landing on the same foot. Measures of impact force and standard deviation of centre of pressure (COP) were recorded during a single leg hop and hold before and after training.

**Results:** The two groups demonstrated different effects of training on force dissipation during single leg landings. The percentage change from pre-test to post-test in vertical ground reaction force was significantly different between the two groups on the dominant side ( $p<0.05$ ). The dynamic balance group reduced their impact force by -7.0% while the plyometric group had an increase of 7.6%. Both groups decreased medial/lateral COP on their dominant side ( $p<0.05$ ) during landing onto a force plate from a single leg hop, which equalised pre-tested side to side (DOM to non-DOM) differences. Neither plyometric or dynamic balance training affected anterior/posterior COP during single leg landing on the portable force platform ( $p>0.05$ ).

**Conclusions:** The results of this study suggest that both plyometric or dynamic balance training are effective at increasing measures of dynamic balance and COP control. However, dynamic balance may be useful to improve single limb force attenuation. The results of this study warrant future investigation into the effects of dynamic balance versus plyometric training on lower extremity kinematics and kinetics in women.

### 109 ALARMING INCREASE IN ACL INJURIES AMONG FEMALE TEAM HANDBALL PLAYERS AFTER THE END OF SUCCESSFUL INTERVENTION STUDY: A 2 YEAR FOLLOW UP

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**Background:** To curb the high incidence of anterior cruciate ligament (ACL) injuries in female team handball, a 3 year intervention study was conducted during the 1997-2001 seasons using a 15 minute

programme with three different balance exercises focusing on neuromuscular control and planting/landing skills. The programme was highly successful; the risk of injury was reduced significantly among those who completed the ACL injury prevention programme.

**Purpose:** To monitor the rate of ACL injuries in female team handball for two seasons after the prevention study.

**Methods:** ACL injuries in the three top divisions (59 teams) were registered for two seasons after the end of the prevention study (when the programme had been implemented in the clubs through specially trained physical therapists hired by the research team), from 15 August 2001 to 31 May 2003. During the first follow up season, we also recorded how many of the teams and injured players who had continued using the prevention programme. During the second follow up season, we only recorded the number of ACL injuries among the same teams.

**Results:** In the intervention study, the number of injuries was reduced from 29 in the control season (1998–99) to 17 in the final intervention season (2000–2001); 13 reduced to 5 injuries in the elite division. In the 2001–2002 season, there were 20 ACL injuries, 10 in the elite division. Of the injured players, 15 (75%) had performed “none/little” of the neuromuscular programme, four (20%) had performed “some”, and one (5%) player had performed “a lot”. Of the teams, 36 (61%) had performed “none/little” prevention training, 16 (27%) “some”, and 7 (12%) “a lot”. In the 2002–2003 season, 32 ACL injuries were reported, 10 in the elite division.

**Conclusion:** When the focus on prevention was reduced, injury rate increased back to the pre-intervention level. The implementation of the intervention programme as a regular part of handball training has not been successful, and greater emphasis needs to be put on the education of coaches.

#### 110 SEX DIFFERENCES IN KINEMATICS DURING LANDING AND TRAINING EFFECT

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**Purpose:** To compare knee kinematics between men and women during a single limb drop landing and to test the effect of training programme on the kinematics.

**Methods:** In total, 10 healthy subjects (five men, five women; mean (SD) ages 25 (3) and 20 (2) years, respectively) with no history of musculoskeletal injury participated in this study. All subjects performed a drop landing from a platform 30 cm in height. Each trial was recorded using an optical motion capture system (VICON system, Oxford Metrics, Inc.). Data were processed using the point cluster technique with 24 markers on the stance limb. Internal/external rotation and varus/valgus rotation of the tibia with respect to the femur were analysed during the first 150 ms after toe contact. Some of the women conducted jump training programme for 6 weeks and these parameters were compared before and after training.

**Results:** All subjects experienced internal tibial rotation after toe contact. Maximum internal tibial rotation occurred approximately 50 ms after toe contact. The mean (SD) maximum internal tibial rotation was significantly larger for women (6.1 (1.2) degrees) than for men (3.3 (0.8) degrees) ( $p=0.002$ ). Almost all subjects experienced valgus rotation of the tibia after toe contact; however, there were no significant differences in valgus rotation of the tibia between women and men (4.1 (2.7)° and 4.9 (3.5)°, respectively). After training, internal tibial rotation tended to decrease.

**Conclusions:** This study has shown that the likely mechanism of non-contact anterior cruciate ligament (ACL) injuries that occur during single limb drop landing is internal tibial rotation combined with valgus rotation occurring at heel strike. One reason that women have a higher incidence of ACL injuries is that they land from a single limb drop with increased internal tibial rotation. Therefore, jump training may have an effect on knee stabilisation and prevention of knee injuries.

#### 111 RELATIONSHIP BETWEEN HYPEREXTENSION AND ROOF IMPINGEMENT

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**Purpose:** To examine the relationship between hyperextension and roof impingement of the anterior cruciate ligament (ACL).

**Methods:** In total, 40 subjects with unilateral ACL rupture were examined by fluoroscopy and magnetic resonance imaging (MRI). Under general anaesthesia, the precise lateral view of the knee at maximum hyperextension was determined with an image intensifier.

Hyperextension angle (HEA; the angle between the line of the anterior cortex of the femur and that of the posterior cortex of the tibia), roof femoral angle (RFA; the angle between Blumensaat's line and the anterior cortex of the femur), and roof plateau intersection ratio (RPIR; distance from the anterior margin of the tibia to the intersection between Blumensaat's line and tibial plateau/sagittal width of the tibia) were measured on each film. The tibial attachment ratio (TAR; distance from the anterior margin of the tibia to the anterior border of the tibial attachment of the ACL/sagittal width of the tibia) was then measured from the MRI of the injured knee and the impingement index (II; RPIR minus TAR) was calculated from RPIR and TAR. Simple regression analysis was used to determine the relationships between HEA, RFA, RPIR, TAR, and II.

**Results:** The averages of HEA, RFA, RPIR, TAR, and II were 13.9°, 41.0°, 24.7%, 28.3%, and -3.8%, respectively. There were direct positive relationships between HEA and RFA ( $R=0.64$ ) and between RPIR and TAR ( $R=0.49$ ), while no relationship was observed between HEA and II.

**Conclusions:** These results suggested that a larger hyperextension angle is associated with a more horizontal intercondylar notch roof and that tibial attachment of the ACL depends to some extent on the roof-plateau intersection point. Thus, the impingement index does not correlate with hyperextension angle—that is, hyperextension of the knee does not correlate well with roof impingement.

#### 112 THE PREVENTION OF CYCLING INJURIES: IDENTIFICATION OF POTENTIAL RISK FACTORS

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**Background:** Cycling injuries are increasingly seen with greater participation and higher competitive level. Risk factor identification is required. This study presents an analysis of factors contributing to cycling injuries, difficulties to prevention and recommendations for the future.

**Purpose:** To discover the main risk factors for injury in 261 federated cyclists in order to plan a preventive intervention in the future.

**Methods:** After an overview of causative factors that contribute to overuse and/or traumatic injuries in cyclists, we prepared and validated a questionnaire that was completed by 261 cyclists, chosen at random, from a group of 761 federated cyclists of the region of Murcia (K of 2e and error of +5).

**Results:** Poor biomechanics and faulty technique, combined with other risk factors (host, environment, or type of sport) were responsible for most injuries, with mechanical adjustment of the bicycle, physical condition, hygiene or dietetic factors, and protective equipment being most important.

**Conclusions:** If prevention measures are to meet the criteria of being prudent and effective, myriad factors make their prevention a great challenge for trainers, riders, and medical personnel. With this information, we can propose a plan to prevent the more frequent risk factors identified, and evaluate its effectiveness over time.

#### 113 ASSOCIATIONS BETWEEN LOWER EXTREMITY MISALIGNMENT, FLEXIBILITY, GENERALISED JOINT LAXITY, AND ANTERIOR CRUCIATE LIGAMENT INJURY HISTORY

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**Purpose:** To determine the associations between lower extremity misalignment, flexibility patterns, generalised joint laxity, and anterior cruciate ligament (ACL) injury history using a case-control design.

**Methods:** In total, 52 young adults with a history of ACL injury and 33 controls with no history of knee injury were studied. Participants gave a detailed injury history and then had measures of lower extremity misalignment, flexibility, and generalised laxity taken. Misalignments assessed included pelvic tilt, femoral anteversion, q angle, tibial varum, navicular drop, foot type, and Morton's toe. Flexibility tests included passive hip adduction (Ober's test), hip extension (Thomas test), knee extension (90–90 test), and ankle dorsiflexion. The Beighton generalised laxity scale was also used. A discriminant analysis was performed to identify which of these measures best differentiated limbs with a previous history of ACL injury from the uninjured side matched limbs of controls.

**Results:** The 12 dependent variables entered into the analysis as a group explained 35.2% of ACL injury history status. The model that best described the factors most related to ACL injury history were generalised laxity ( $r^2$  change=0.073), genu recurvatum ( $r^2$  change=0.069), and hip adduction flexibility ( $r^2$  change=0.069). Subjects with a history of

ACL injury were more likely to have greater generalised laxity, more genu recurvatum, and less hip adduction range of motion than those without such history. This model correctly predicted 67% of cases with and 70% of cases without ACL injury.

**Conclusions:** Increased generalised joint laxity, increased genu recurvatum, and diminished hip adduction range of motion were significantly associated with ACL injury history. This information may provide insight into the development and implementation of ACL injury prevention programmes in athletes demonstrating these characteristics.

#### 114 INJURY PATTERN IN YOUTH TEAM HANDBALL: A COMPARISON OF TWO PROSPECTIVE REGISTRATION METHODS

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**Background:** There is little consensus about the definition of a sports injury, and study designs vary, so it is difficult to compare injury rates between studies. No previous studies have compared different prospective injury registration methods, and no prospective data are available on the injury incidence and pattern of injuries in youth team handball in Norway.

**Purpose:** To examine the injury incidence and pattern of injuries in female and male youth team handball players using two different prospective registration methods.

**Methods:** Injuries in youth team handball were collected by two different prospective registration methods, match reports (90 teams, 1080 players) and coach reports (34 teams, 428 players), in the 17 years old division from eastern Norway during one league season.

**Results:** In total, 118 injuries were recorded by the coach reports, of which 93 (79%) were acute injuries (mean (SD) 0.9 (0.05) and 9.9 (0.04) injuries per 1000 player hours for incidence training and matches, respectively; rate ratio versus training: 10.8 (95% CI 7.0 to 16.6);  $p < 0.0001$ ) and 25 (21%) were overuse injuries. Knee (26%) and ankle (24%) injuries accounted for half of the acute injuries (0.5 (0.07) and 4.4 (0.07) injuries per 1000 player hours for training and matches, respectively; rate ratio versus training: 8.0 (95% CI 4.5 to 14.5);  $p < 0.0001$ ). No sex difference was found in the injury rate (rate ratio female versus male 1.3 (95% CI 0.8 to 2.1);  $p = 0.40$ ). Most of the injuries occurred in the attacking phase by back or wing players doing a plant and cut, landing, or turning movement, and more than half were in contact situations with the opponent. Similar results were observed for acute match injuries in the match report. However, this study suggests that it is impossible to estimate the severity by using match reports; in addition, the overuse injuries were missed.

**Conclusions:** The results indicate that the rate of injuries in youth team handball is as high as at the senior level and that prevention should focus on knee and ankle injuries. Coach reports seem to be the best method to register injuries in youth team handball.

#### 115 THE EFFECT OF SEX ON THE BIOMECHANICS OF THE INITIAL PHASE OF LANDING FROM A JUMP

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**Background:** Studies attempting to explain the increased incidence of anterior cruciate ligament (ACL) injury in women have focused on the peak values of biomechanical variables without regard to when the values occur within the landing cycle. Literature suggests that most ACL injuries occur at the beginning of the landing cycle (knee flexion 20–40°), whereas the commonly reported peak values of biomechanical variables tend to occur at the end of the landing cycle.

**Purpose:** To investigate the effect of sex on the biomechanics of the initial phase of landing from a jump.

**Methods:** In total, 32 recreational athletes (16 women) performed bilateral drop landings. Normalised electromyographic (NEMG) data of the rectus femoris, medial hamstrings, and lateral hamstrings; vertical ground reaction force (VGRF); and kinematic data for knee valgus and knee internal rotation (IR) were collected at 25° and 40° of knee flexion. A repeated measures MANOVA was used to determine the effect of sex and knee flexion angle on the biomechanical variables.

**Results:** Sex ( $p = 0.015$ ) and knee flexion angle ( $p = 0.000$ ) had a statistically significant effect but the interaction of sex × angle was not significant ( $p = 0.763$ ). Women exhibited greater knee valgus ( $p = 0.007$ ) and medial hamstrings NEMG ( $p = 0.01$ ). Knee flexion angle had a significant effect ( $p < 0.042$ ) on knee IR, knee valgus, VGRF, rectus NEMG, and lateral hamstrings NEMG.

**Conclusions:** Women had greater knee valgus and medial hamstrings activity than males in the early phase of landing, but did not have significantly higher values of rectus NEMG, knee IR, and VGRF as commonly cited in other studies using peak value methods. Future research should focus on a more complete analysis of the entire landing cycle to better differentiate those variables most likely contributory to ACL injuries. ACL injury prevention programmes for women may benefit from a focus on training the control of knee valgus at the beginning of landing.

#### 116 HEADING AND SOCCER BALL IMPACT WITH A FLAT SURFACE

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**Purpose:** To begin to develop, through analytical and experimental methods, an understanding of the biomechanics of heading a soccer ball and whether or not repeated heading causes musculoskeletal or neurocognitive damage.

**Methods:** The impact of a soccer ball with a flat surface was considered. An analytical impulse–momentum model was developed, and experimental data were collected by dropping a ball onto a force plate. Analytical and experimental results of force versus time, peak force, duration, and impulse were collected. For the model, it was assumed that friction and bending stiffness of the carcass are negligible, compression of the gas is adiabatic, and impact between the carcass and the surface is plastic. The resulting equations were numerically integrated. A Baden S150 soccer ball (mass 0.42 kg, pressure 62 kPa and radius 0.11 metres) was dropped from 14 heights on a Kistler piezoelectric force plate. Bioware data acquisition software was used at 10 000 Hz. The impact velocity was determined from the drop height neglecting air friction.

**Results:** Analytical and experimental results correlated well for the range of velocities tested (0–13.9 m/s). For example, when the impact velocity was 13.9 m/s, the peak force was found analytically to be 1672 N and experimentally to be 1939 N, the duration was found analytically to be 0.00956 s and experimentally to be 0.00880 s, and the impulse was found analytically to be 10.04 s and experimentally to be 9.46 Ns.

**Conclusions:** It was found analytically and experimentally that the force versus time for the impact of a soccer ball with a flat surface is determined primarily by the ball mass, pressure, radius, and initial velocity. Agreement between the analytical and experimental results demonstrates that the impulse–momentum model is a good representation of the impact of a soccer ball with a flat surface. This approach could possibly be developed to model heading.

#### 117 ACTIVE LIVING AND RISK OF KNEE INJURIES

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**Purpose:** To compare the risks of knee injuries in various physical activities.

**Methods:** A cohort of 3657 persons was randomly selected from all the 15 to 74 year old Finns, of which 92% ( $n = 3363$ ) of the subjects agreed to participate in the 1 year follow up. To collect the information, the study subjects were interviewed by phone by the educated personnel of the Statistics Finland three times, at 4 month intervals.

**Results:** Of all reported injuries in the cohort, 15% ( $n = 321$ ) affected the knee. The risk of knee injury per 1000 exposure hours was 0.44 (95% CI 0.39 to 0.50) in recreational and competitive sports, 0.06 (95% CI 0.04 to 0.09) in commuting activities, and 0.04 (95% CI 0.03 to 0.06) in lifestyle activities. The highest knee injury rates per 1000 exposure hours were seen in squash (5.4), judo (2.2), rinkball (2.1), floorball (2.0), wrestling (1.8), volleyball (1.4), skating (1.1), soccer (1.1), and ice hockey (1.1). The risk of knee injury was higher in women than in men in commuting activities (hazard ratio (HR) = 5.99, 95% CI 1.40 to 25.6), endurance sports (HR = 1.40, 95% CI 0.98 to 2.01), and power and contact sports (HR = 2.10, 95% CI 1.03 to 4.29).

**Conclusions:** The individual risk of knee injury per exposure hours is almost 10 times higher in recreational and competitive sports than commuting or lifestyle activities. In recreational and competitive sports, the knee injury risk is highest among 15 to 25 year olds, especially in various team sports and ball games. However, at population level, low to moderate intensity activities such as recreational walking and skiing, are widely practised, producing a rather high absolute number of knee injuries. Therefore, preventive efforts are needed not only in the high risk and competitive sports, but also among less physically demanding activities.

### 118 INCIDENCE, TYPE OF INJURIES, AND RISK FACTORS IN FEMALE FLOORBALL PLAYERS

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**Purpose:** To examine retrospectively the incidence and nature of sports injuries in female floorball players, and to identify possible risk factors associated with injuries.

**Methods:** In total, 394 female players from 28 teams participated in the study. All players completed a questionnaire about background information, use of preventive measures, previous injuries, sports participation, and injuries during the period October 2003 to September 2004. An injury was defined as any traumatic or overuse injury occurring during a floorball game or practice making the player unable to participate the following game or practice session in the next 24 hours.

**Results:** Players reported 319 injuries and 55% of players were injured. The overall injury incidence per 1000 practice and game hours was 2.1 (95% CI 1.9 to 2.3). During the floorball competition season, incidence was 2.6 per 1000 practice and game hours (95% CI 2.2 to 2.9). Goalkeepers had the highest incidence 4.4 (95% CI 3.0 to 5.8) during the floorball competition season. Of all injuries, 61% were traumatic and 39% were from overuse. The most commonly injured sites were the ankle (35%) and knee (23%), and the most common injury type was sprain (37%). Variables significantly increasing the risk of injuries included previous injury, weakness, or disability caused by previous injury, abnormalities of menstrual cycle, practice time, number of games, and field position.

**Conclusions:** The overall injury rate in floorball is quite low per practice and playing hours. Injury prevention programmes should focus on ankle and knee injuries, but more exact knowledge on the epidemiology of floorball injuries is needed before initiation of well planned prevention trials.

### 119 THE TRAINING EFFECT OF "NORDIC" HAMSTRING LOWERS DEPENDS ON PRE-EXERCISE OPTIMUM LENGTH

J. Richardson, P. Percival, D. Morgan, U. Proske. *Monash University, Melbourne, Australia*

**Background:** It has been proposed that muscle length-tension properties can help predict the susceptibility of the hamstring muscles to damage<sup>1</sup> and that a regular programme of mild eccentric exercise can protect against recurrent hamstring injury.<sup>2</sup>

**Purpose:** To seek evidence of a training effect, as measured by changes in optimum angle for peak knee flexion torque, using a 6 week training programme of hamstring lowers.

**Methods:** In total, 14 subjects (mean (SD) 23 (6) years) were randomly assigned to control (n=6) or hamstring lowers (HL) (n=8). Knee flexion torque angle curves were constructed from maximum voluntary isokinetic concentric contractions of the knee flexors in a seated position at 60°/s, before and 7–9 days after completion of the training. Training consisted of weekly HL and progressed from 2 sets of 6 repetitions to 2 sets of 15 repetitions over 6 weeks. Subjects completed visual analogue scale soreness rankings 2 days after each training session.

**Results:** For the HL group, there was a shift in optimum angle to longer muscle lengths, dependent on pre-exercise optimum (p=0.0002), greater for shorter optima. Soreness was correlated with a shorter pre-exercise optimum, more for shorter optima (p=0.008), and with shift in optimum, though this was not significant (p=0.052).

**Conclusions:** These results support the idea that damage, soreness, and adaptation all occur when muscles are subjected to eccentric exercise beyond optimum length. More adaptation may be produced by exercises that further extend the hamstring muscles by flexing the hip or by further extending the knee.

1. Brockett CL, et al. *Med Sci Sports Exerc* 2004;**36**:379–87.
2. Proske U, et al. *Clin Exp Pharmacol Physiol* 2004;**31**:546–50.

### 120 PREDICTORS OF SPORT INJURY IN ADOLESCENTS

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**Purpose:** To examine risk factors for sport injury in adolescents.

**Methods:** A retrospective survey was conducted in a random sample of students (n=2873) from 24 Calgary and area high schools, in

Alberta, Canada. Students completed an anonymous, in class questionnaire in March 2004.

**Results:** The overall injury rate was 67.5 injuries per 100 adolescents per year. There were no significant differences in injury rate by age, sex, smoking, or drinking behaviour, or parental education. The final multivariate logistic regression model included two interactions, between seasonal exposure and between location of primary sport played and location of residence. The odds of injury steadily increased with increasing weekly exposure, with students who participated over 15 hours/week having a greater risk of injury than those who played less than 1 hour a week (odds ratio (OR)=5.51, 95% CI 3.58 to 8.49). Only students with high seasonal exposure who lived in small towns had a lower risk of injury than those living in Calgary (OR=0.65, 95% CI 0.44 to 0.86). For students with low seasonal exposure, students who played for fun had lower risk than those playing in organised sport (OR=0.49, 95% CI 0.28–0.83). For students with high seasonal exposure, both students participating in school sports and for fun had a lower risk of injury than those participating in organised clubs. Non-white students had a lower risk of injury than their white counterparts (OR=0.68, 95% CI 0.51 to 0.90). Students with a higher body mass index (>23) had a higher risk of injury (OR=1.42, 95% CI 1.24 to 1.61).

**Conclusions:** In summary, the highest risk of injury was found in white students living in Calgary, with a higher BMI (> 23) playing for more than 12 person months per year in organised clubs for more than an average of 2 hours a day. Future research should focus on prevention strategies targeting the highest risk populations.

### 121 CAN A PHYSICAL TRAINING PROGRAMME PREVENT INJURIES IN ELITE JUNIOR AUSTRALIAN FOOTBALL? EVALUATION OF AN INJURY PREVENTION STRATEGY

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**Purpose:** To evaluate a pre-season physical training programme teaching landing, falling, and recovery skills, and its effect on the injury profile of junior elite Australian football (ARF) players.

**Methods:** In total, 723 male players participating in the national junior under 18 elite competition (TAC cup) were studied prospectively over two consecutive football seasons. Three teams comprised the intervention group (n=114) and 11 teams comprised the control group (n=609). Baseline tests of landing skills revealed there were no significant differences between the groups prior to intervention. The eight session intervention programme taught players six landing, falling, and recovery skills, which were considered to be fundamental for safe landing in typical Australian football game situations.

**Results:** Midseason video evaluation of the same subset of intervention and control players revealed that both teams had improved in landing skills but the intervention group improved significantly more than the control group (p=0.001). The time to first injury was significantly less for the intervention group (95% CI 6.45 to 8.47 weeks, p=0.04) compared with the control group. The intervention group sustained significantly fewer non-contact injuries (95% CI 2.11 to 2.33, p<.01) and injuries from landing and falls (95% CI 0.73 to 0.21, p<0.025, RR=0.054) compared with the control group. There were no differences between the groups for injury incidence, prevalence, injury nature or diagnosis, site or severity.

**Conclusions:** The results of this study demonstrate that landing can be trained and provide evidence for a positive relationship between improving landing and falling skills in elite junior football players and injury prevention.

### 122 PREVALENCE AND SEVERITY OF INJURIES IN THE NETHERLANDS

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**Purpose:** To estimate the actual injury load in the NL between 2000 and 2003 with a nationwide survey, using a sampling method based on the prevalence of injuries.

**Methods:** During the period 2000–2003, using random digit dialling, 10 000 subjects (minimum age 4 years) were investigated each year in a national survey (ObiN). They were interviewed by telephone on sports activities, accidents and sports injuries, and medical care. If subjects were younger than 11 years, a proxy interview was applied. New injuries were defined as occurred within a 3.5 month recall period. Old injuries were defined as having occurred more than 3.5 months before

the date of the interview. Data were analysed using descriptive statistics. Results were extrapolated to the total population in the Netherlands ( $n = 16.2$  million).

**Results:** Each day 550 000 subjects (95% CI 528 000 to 566 000) were hampered by sports injuries. Main contributions came from outdoor soccer ( $n = 135$  000), tennis ( $n = 48$  000), skiing and snowboarding ( $n = 34$  000), jogging ( $n = 34$  000), and volleyball ( $n = 31$  000). About 61% of all injuries were old injuries. Most of the injuries (33%) were located at the knee. Only 17% of all injuries were not treated, nor by medical nor by non-medical personnel. At the moment of recall about 91.000 injuries (17%) still needed medical care. Absenteeism from work had occurred in 14% ( $n = 77$  000). Current work absenteeism was found in 5% of all cases ( $n = 27$  000). Of all injuries, 17% ( $n = 93$  000) had to stop the sports activity, of which sports have not been resumed by about 9% ( $n = 50$  000).

**Conclusions:** Estimates of the actual injury load in a society can be improved using the prevalence instead of the incidence of sports injuries, because the former will include both new and old injuries. Based on the prevalence of sports injuries, each day 3% of the total population in the Netherlands is hampered by an old or new injury.

### 123 PREVENTION STRATEGIES IN PROFESSIONAL HANDBALL

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**Background:** Professional handball players receive the second highest level of injuries (behind soccer) of all professional sportsmen in Germany.

**Purpose:** To collect and analyse data to provide a basis for the development of prevention strategies for professional handball players.

**Methods:** The database consists of 1636 professional handball players (85.2% male, 14.8% women) who received an injury in the 2002/2003 season. Of these, 224 men and 74 women were additionally surveyed using a specific questionnaire that contained questions about for example, injury situation and mechanism.

**Results:** Of the players, 97.9% of the men and 96.2% of women played in the three highest German leagues. Mean (SD) age was 26.2 (4.7) years for men, and 24.4 (4.5) years for women. Men played 50 (10.3) and women 45.9 (12.9) games/year, with a competition break of 12 (6.6) and 11.4 (6) weeks and trained 11.4 (4.5) and 10.2 (2.9) h/week with a training break of 4.6 (1.6) and 5.2 (2.7) weeks/year, respectively. Most (85% for men and 74% for women) of the injuries occurred in competitive situations; 55.8% and 51.9% of the injured players were attacking and 31.1% and 25% were defending when the injury occurred. Most common injury situations were collisions (men 36.8%, women 34.6%), landings (men 24.2%, women 25%), running (men 12.6%, women 15.4%), and falls (men 9.9%, women 11.5%). Most frequently injured body parts were knee (men 24.9%, women 49.1%), ankle (men 18.9%, women 17%), hand/wrist (men 14.1%, women 13.2%), and head (men 10.3%, women 7.5%). Situations and mechanisms causing injuries varied between the different playing positions. Most of the injuries took place in the central offence and defence zone, for example, backcourt attackers were frequently pushed backward during jumpshots and landed without control. Knee and ankle injuries were common consequences.

**Conclusions:** Injury patterns differ noticeably between professional and amateur handball. Besides the specific injury patterns and sex differences, preventive measures for professional handball players should take into account differences between playing positions concerning specific playing actions, injury mechanisms, and injury situations.

### 124 INJURIES IN PORTUGUESE FEMALE HANDBALL PLAYERS: A PROSPECTIVE STUDY COVERING TWO SEASONS

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**Purpose:** To identify the nature of the injuries and examine their specific circumstances and consequences in Portuguese female handball players competing in the premiere Portuguese league, during the 2001–2002 and 2002–2003 seasons.

**Methods:** We developed a questionnaire validated by specialists and properly tested. The sample comprised 112 athletes who answered and returned the completed questionnaire (from a total of 153 sent).

**Results:** We found 233 injuries over the studied seasons (an incidence of 3.7 injuries per 1000 player hours). The lower limbs showed the

highest number of traumatic pathologies (59%), specifically at joint level, revealing that ankle and knee sprains were the most frequent occurrence. Of the group, 10% suffered injuries in the anterior cruciate ligament (ACL), a very significant value considering that this type of injury causes severe functional restrictions and could interrupt or finish the player's career. Tendinous injuries associated with movement overuse were also significant; we noted a 33% occurrence in the total of the reported injuries. The most affected tendinous structure was the supraspinatus tendon, resulting in chronic shoulder pain, about half of the cases. We also observed that athletes in the backcourt attack area are more likely to suffer traumatic injuries (59%), following by wingers (21%), goalkeepers (13%), and, lastly, circle runners (8%). The injuries mostly took place in attack situations (73%) and in ball possession (56%), and were usually without physical contact (57%).

### 125 SLIPPERY SLOPES: INJURY RISK PERCEPTIONS OF SKIERS AND SNOWBOARDERS IN RELATION TO FATIGUE, ALCOHOL, AND DRUG MISUSE

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**Purpose:** To examine the knowledge and beliefs that snowfield visitors have about their perceived injury risk in relation to fatigue, alcohol and drug misuse.

**Methods:** Visitors to the snowfield region of New South Wales Australia completed a survey about fatigue, drug and alcohol use, and injury risk perception. Participants stated their ability to ski/snowboard and drive safely following a lack of sleep, drug use, and alcohol use. Overall safety attitude scores were calculated. Group means were compared using independent samples *t* tests, while comparative safety attitudes were assessed using non-parametric Wilcoxon signed rank tests.

**Results:** In total, 478 snowfield visitors were surveyed over 8 weeks of the 2004 winter snow season. The majority were skiers (39.8%) and snowboarders (35.3%). Overall, they reported that they generally sleep less and drink more alcohol than usual while visiting the snowfields. On comparison, participants believed that driving posed a greater injury risk than did skiing or snowboarding ( $p < 0.001$ ). Participants consistently ranked other people as being more negatively affected by alcohol use than themselves, whether during driving or during snowsport ( $p = 0.003$ ). The lowest perceived injury risk was attributed to fatigue, particularly while skiing or snowboarding.

**Conclusions:** These results identify a need to raise awareness among snowfield visitors about the contribution of fatigue, drug use, and alcohol use to snowsports and transport related injury risk.

### 126 NON-WEIGHT BEARING ANTERIOR KNEE LAXITY IS RELATED TO ANTERIOR TIBIAL TRANSLATION DURING TRANSITION FROM NON-WEIGHT BEARING TO WEIGHT BEARING

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**Purpose:** To examine the relationship between non-weight bearing anterior knee laxity (AKL) and anterior translation of the tibia relative to the femur (ATT) when transitioning from non-weight bearing to weight bearing.

**Methods:** The right knee of 21 subjects (mean (SD) age 25.3 (4.0) years height 170.4 (11.5) cm, weight 72.4 (16.9) kg) was measured for AKL and ATT on 2 days (~24–48 hours apart). AKL was measured at 133N with the KT-2000™, and ATT was measured with the Vermont Knee Laxity Device (VKLD; University of Vermont, Burlington, VT, USA). The VKLD allows controlled loading of the tibiofemoral joint by creating a zero shear load condition across the knee while it is unweighted to establish an initial neutral position of the tibia relative to the femur, then applying a compressive load of 40% body weight through the ankle and hip axes to simulate weight bearing. Electromagnetic position sensors attached to the patella and the proximal tibia measured A-P displacement of the tibia relative to the femur. The average of three trials for each measure was analysed. Intraclass correlation coefficients (ICC<sub>2,k</sub>) and standard error of measurement (SEM) confirmed day to day measurement reliability, and linear regression examined the relationship between AKL and ATT.

**Results:** Means (SD) for AKL and ATT respectively were 7.4 (2.6) mm and 7.2 (2.3) mm for day 1, and 7.5 (2.3) mm and 6.5 (2.5) mm for day 2. Reliability was high for both AKL (ICC = 0.97; SEM = 0.44 mm)

and ATT (ICC = 0.88, SEM = 0.79 mm). Linear regression indicated that AKL predicted 35.3% of the variance in ATT ( $p = 0.005$ ), using the equation of  $Y_{ATT} = 3.22 + .531(X_{AKL})$ .

**Conclusions:** Increased AKL is associated with increased anterior displacement of the tibia relative to the femur as the knee transitions from non-weight bearing to weight bearing conditions (for example at the foot strike phase of gait). The potential for disruption of normal knee biomechanics during activities such as landing from a jump, or the foot strike phase of gait deserves further study.

### 127 ISOKINETIC STRENGTH IN PROFESSIONAL SOCCER AND VOLLEYBALL PLAYERS

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**Purpose:** To evaluate and to compare isokinetic strength profiles of soccer and volleyball players respect to peak torque, bilateral strength differences and antagonist/agonist ratio.

**Methods:** Using an isokinetic dynamometry (Biodex System 2) professional soccer (n=18) and volleyball (n=28) players were evaluated. Maximal gravity corrected concentric peak torque of knee extensors and flexor muscles were measured using five repetitions at  $360^\circ/s$  (6.28 rad/s), and a three repetition protocol at  $90^\circ/s$  (1.57 rad/s).

**Results:** For soccer players the mean (SD) bilateral difference at  $360^\circ/s$  was 7.1 (6.3)% for extensors and 12.3 (8.4)% for flexors. For the same group at  $90^\circ/s$ , the mean difference was 7.1 (6.3)% for extensors and 10.6 (8.0)% for flexors. For volleyball players the mean bilateral difference at  $360^\circ/s$  was 7.2 (5.8)% for extensors and 14.2 (8.4)% for flexors. For the same group at  $90^\circ/s$  the mean difference was 10.1 (6.9)% for extensors and 6.9 (5.5)% for flexors. The H/Q ratio was at  $90^\circ/s$  for the dominant size in 57.4 (6.7)% and 50.4 (7.2)%, for soccer and volleyball players respectively. The H/Q ratio was at  $90^\circ/s$  for the non-dominant size in 56.1 (6.7)% and 50.5 (6.4)%, for soccer and volleyball players respectively.

**Conclusions:** In summary, the specific demands of soccer and volleyball do not induce significant bilateral strength unbalance. However, concerning H/Q ratio, known as an injury risk factor, soccer players show a relative high injury risk in the non-dominant leg, suggesting the importance of compensation training programmes. The low H/Q ratio value found in volleyball players should be carefully observed in order to evaluate if this low value can be seen as a risk factor, as in soccer, or if it is a sport specific muscle adaptation.

### 128 MONOPHASIC ORAL CONTRACEPTIVES DO NOT AFFECT LOWER LIMB MUSCULOTENDINOUS STIFFNESS

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**Background:** Recent evidence suggests that women not using oral contraceptives exhibit significantly altered musculotendinous stiffness (MTS) at ovulation. This may increase the risk of traumatic non-contact knee injury. However, it is unknown whether women using oral contraceptives exhibit the same changes.

**Purpose:** To investigate the effect of monophasic oral contraceptives on MTS.

**Methods:** In total, seven women who were using monophasic oral contraceptives volunteered for this study. Subjects were assessed for MTS using a unilateral hop test. Testing occurred weekly across the 4 weeks of a single menstrual cycle. Repeated measures one way analysis of variance was used to identify the effect of menstrual cycle phases on MTS.

**Results:** Mean (SD) MTS was 13 139 (1710) N/m at menstruation (week 1) and 12 858 (2037) N/m at week 2. At week 3, (ovulation) MTS was 13 016 (1370) N/m, and at week 4 MTS was 12 492 (2073) N/m. Repeated measures one way analysis of variance revealed no statistically significant difference in MTS stiffness across the menstrual cycle ( $p > 0.05$ ).

**Conclusions:** Women using monophasic oral contraceptives do not undergo the menstrual cycle induced changes in MTS observed in those not using monophasic oral contraceptives. The resultant reduction in electromechanical delay as a result of a stiffer system may have implications for the prevention of ACL injuries.

### 129 THE PERFORMANCE EFFECT OF AN INJURY PREVENTION PROGRAMME: A 10 WEEK INTERVENTION WITH F-MARC 11 IN ADOLESCENT FEMALE FOOTBALL PLAYERS

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**Background:** The injury rate in football is high, and effective injury prevention methods are needed. F-MARC 11 is a 15 minute warm up programme that has recently been designed based on other studies in order to prevent the most common injury types in football: ankle, knee, hamstring and groin injuries. However, the effect of such programmes on performance is not known.

**Purpose:** To test the effect of 10 weeks of training with the F-MARC 11 programme on a battery of performance tests.

**Methods:** In total, 33 female junior football players (age 16 to 18 years), representing two sports high schools, participated in the study. The players were randomly assigned, stratified by school, to either a training group (n = 18) or a control group (n = 15). The training group used the F-MARC 11 programme three times weekly as a warm up for football training over a 10 week period during the second half of the season. The programme includes 10 exercises for core stability, lower extremity strength, balance, and jumping ability. The control group warmed up as usual with ball based technical exercises. All training was supervised and registered. Performance tests before and after the intervention period included vertical jump tests, isokinetic and isometric strength protocols for the quadriceps and hamstrings, isometric hip adduction and abduction strength, 40 metre sprint, and soccer skill tests (shuttle run, distance kick). The results were analysed using a two way (time, group) analysis of variance.

**Results:** The training group completed 22 (10 F-MARC 11 sessions) during the intervention period. However, we observed no time or group effect in any of the tests.

**Conclusions:** Based on these findings, there was no advantage in using a 10 week F-MARC 11 programme over regular warm up exercises in a group of adolescent girls, even though we observed an apparent improvement in the intensity and performance of the exercises themselves during the training period.

### 130 THE INCIDENCE AND NATURE OF EPIDEMIOLOGICAL INJURIES TO SOUTH AFRICAN CRICKET PLAYERS: A LONGITUDINAL STUDY

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**Purpose:** To determine the frequency and nature of injuries sustained by elite cricketers during a five season period in order to identify evidence of any injury patterns associated with these injuries.

**Methods:** In total, 40 physiotherapists and 14 doctors working with 11 provincial and the South African national teams completed a questionnaire for each cricketer that presented with an injury during each of the five seasons in order to determine: (a) anatomical site of injury; (b) month of injury during the season; (c) the diagnosis and (d) mechanism of injury; (e) whether it was a recurrence of a previous injury; (f) whether the injury had recurred again during the season; and (g) biographical data.

**Results:** The results over the five seasons showed that 689 cricketers sustained 1330 injuries. Bowling (41%), fielding and wicket keeping (30%), and batting (16%) accounted for the majority of the injuries. The injuries occurred primarily during first class matches (29%), limited overs matches (25%) and practices (21%), and were most likely to occur during the pre-season and early season (47%). The younger players (up to 24 years) sustained 48% of the injuries. Most injuries were acute (65%), with the others being acute on chronic (22%) and chronic (13%) injuries. The lower limbs (50%), upper limbs (22%), and back and trunk (23%) were most commonly injured, with 5% of the injuries to the head and neck. The injuries were mainly soft tissue injuries (muscle strains (31%), tears (5%), spasms (6%) and haematomas (5%)), tendonitis (7%) and ligament tears (3%), joint (14%) and facet joint (3%) injuries and fractures (4%) and stress fractures (3%), particularly in the lower back. Muscle injuries (27%) were the most likely first time injury, with the main mechanism being bowling (16%), fielding (16%), and overuse (10%). Similarly, muscle injuries were the most likely recurrent injuries from the previous season (10%) and most likely to re-occur again during the seam season (5%). The primary mechanism of injury was the delivery and follow through of the fast bowler (26%), fielding (23%), overuse (17%), ball impacts (7%), training (4%), and other sports (3%).

**Conclusions:** The results indicate a pattern of cause of injury, with the young fast bowler most likely to sustain an acute injury to the soft tissues of the lower limb while participating in matches and practices during the pre-season and early season.

### 131 HELMETS REDUCE THE RISK OF HEAD INJURIES IN ALPINE SKIING DISCIPLINES AND SNOWBOARDING

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**Background:** The incidence of head injuries is high among alpine skiers and snowboarders. The use of a protective helmet is assumed to reduce the risk of head injuries, but this effect has not been shown conclusively.

**Purpose:** To evaluate the effect of a protective helmet on the risk of head injury, while correcting for other potential risk factors in a multivariate model.

**Methods:** Injuries were recorded by ski patrols at nine major Norwegian ski resorts during the 2002 winter season. In total, 3256 injured skiers were treated, and injury type was recorded, in addition to helmet use and other risk factors (age, sex, nationality, skill level, equipment, and ski school attendance, rented or own equipment). As a control group, 3013 random visitors were interviewed at the bottom main ski lift in the same ski resorts. A multivariate logistic regression analysis was used to assess the relationship between individual risk factors (including helmet wear) and injury risk.

**Results:** Head injuries accounted for 17.9% of all injuries (n=581), and the distribution was similar between the different disciplines; (snowboard 17.8%, alpine skiing 17.9%, telemark skiing 18.2%). However, the risk for head injury was higher among snowboarders than for alpine skiers (odds ratio (OR) 1.48; 95% CI 1.19 to 1.85), corrected for other risk factors), while the risk for telemark skiers was lower than for alpine skiers (OR=0.62; 95% CI 0.42 to 0.94)). The use of a protective helmet resulted in a 61% reduction of the risk of head injury (OR=0.39; 95% CI 0.29 to 0.52), corrected for other risk factors). Children and adolescents had a threefold higher risk of head injury than adults, beginners a twofold higher risk compared with experienced skiers, and women a 34% lower risk than men.

**Conclusions:** The use of a protective helmet reduces the risk of head injuries in snowboarding and alpine skiing disciplines. Beginners, youth, and snowboarders are more prone to head injuries than others.

### 132 EFFECT OF BRACING ON THE PREVENTION OF ANTERIOR KNEE PAIN: A PROSPECTIVE RANDOMISED STUDY

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**Background:** There have been numerous reports about the use of knee braces to prevent traumatic knee injuries. Despite the frequent use of braces, very few prospective studies have been performed to study the effect of knee braces for preventing anterior knee pain syndrome (AKPS).

**Purpose:** To assess the effectiveness of a dynamic patellofemoral brace (On-Track System, dj Orthopedics) in the prevention of AKPS.

**Methods:** In total, 167 military recruits without history of knee pain were randomised into two groups prior to the start of their 6 week basic military training (BMT) programme. The first group (brace group) consisted of 54 recruits who wore the braces for all physical activities during these 6 weeks. The control group comprised 113 recruits, and followed the same 6 week strenuous training programme.  $\chi^2$  statistics (Fisher exact test) were used to compare the number of AKPS patients in the brace group and in the non-brace group.

**Results:** Our results indicated that recruits in the brace group appeared to develop significantly less anterior knee pain compared with the recruits in the control group (p=0.020). Out of the 54 recruits in the brace group, 10 (18.5%) developed anterior knee pain during this study. In the control group (n=113), 42 recruits (37%) developed anterior knee pain.

**Conclusions:** We conclude that the result of the present study suggests that the use of a dynamic patellofemoral brace is an effective way to prevent the development of anterior knee pain in persons undergoing a strenuous training programme.

### 133 EFFECT OF 6 WEEKS PATELLOFEMORAL BRACING ON QUADRICEPS STRENGTH: A PROSPECTIVE STUDY

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**Background:** In a previous study[1] we observed a diminished incidence of anterior knee pain in recruits wearing a patellofemoral brace during a 6-week strenuous training. However, it remains unclear how this diminished incidence is achieved.

**Purpose:** To gain a better insight in the effect of bracing on quadriceps strength.

**Methods:** In total, 139 freshmen of the Belgian Royal Military Academy without history of knee pain volunteered for this study. Each volunteer underwent an isokinetic test prior to the start of a 6 week strenuous training programme (approximately 8-12 hours/day). The isokinetic test consisted of concentric contractions of the knee extensors at 60°/s and 240°/s. A detailed history and clinical examination of the patellofemoral joint was performed on each recruit. Recruits who developed anterior knee pain were excluded (n=39). We used the global linear model with repeated measures to analyse the parameters before and after the training and between the braced (n=34) and non-braced recruits (n=61).

**Results:** No significant differences between both groups were observed before the training (p=0.352). However, after the 6 week training programme, a significantly lower peak torque value at 60°/s was observed in the non-braced group compared with the braced group (p=0.016).

**Conclusions:** Although the non-braced individuals showed no clinical signs and symptoms of an anterior knee pain syndrome, they showed significant decrease in quadriceps strength after the 6-week training programme. Previous research[2] suggests that lower quadriceps strength can be seen as a risk factor in the development of anterior knee pain. Regarding the results of this study, the preservation of the quadriceps muscle function is one of the suggested mechanisms of preventive patellofemoral bracing.

### 134 THE INFLUENCE OF SOCKS ON THE INCIDENCE OF FOOT BLISTERS DURING STRENUOUS TRAINING

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**Background:** Foot blisters are a very common overuse injury during strenuous training.

**Methods:** In total, 173 freshmen participating in the basic military training (6 weeks) of the Belgian Royal Military Academy were randomly divided in three groups. The first group (n=48) wore polyester socks (88% Coolmax® polyester) during the 6 week intensive training. The second group (n=58) wore a thin inner polyester sock (45% Vilo® polyester, 45% viscose) and a wool/cotton outer sock (40% wool, 40% cotton), and the third group (n=63) served as a control group by wearing the standard wool (65%) and/or cotton (60%) military socks.

**Results:** Most blisters appeared at the end of the training. Recruits had then to complete a 60 km hike with a 25-30 kg backpack in a strict time schedule, which is physically demanding. Blister formation was reduced in both intervention groups 1 (27.7%) and 2 (37.8%) compared with controls (84.1%) (p<0.001 and p=0.015, respectively). No significant difference was observed between groups 1 and 2 (p=0.104). Binary logistic regression analysis revealed that none of the risk factors indicated in the literature<sup>1,2</sup> was withheld in the model. Only the type of sock worn seemed to be predictive for the incidence of foot blisters.

**Conclusions:** With simple intervention, the incidence of foot blisters could be diminished. The sock is only the interface between the foot and the sole and the boot/shoe, so a more global approach of the whole foot-sock-sole-shoe system should be even more effective to prevent foot blisters and other overuse injuries. Wearing proper socks is an important and easy preventive measure to take in order to avoid foot blisters.

1. Knapik JJ, Hamlet MP, Thompson KJ, et al. *Mil Med* 1996;161:594-8.
2. Knapik JJ, Reynolds K, Barson J. *Mil Med* 1999;164:92-7.

### 135 INJURIES AMONG ELITE SNOWBOARDERS (FIS SNOWBOARD WORLD CUP)

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**Background:** Snowboarding is developing as an athletic sport, with extreme tricks and more demanding snow installations. A recent

Norwegian study from the national elite level shows that the injury risk is high and that injuries among competitive snowboarders differ from those seen in recreational snowboarders, with fewer wrist injuries and more knee and back injuries.

**Purpose:** To describe the incidence and spectrum of injuries among female and male snowboard athletes at the international elite level.

**Methods:** Retrospective interviews during the last race of the season of the FIS Snowboard World Cup (91% response rate). Injuries resulting in medical assistance or missed participation were recorded. The registration period was from April 2002 (end of season) until March 2003. Exposure was recorded as the number of runs in all disciplines, and the incidence was calculated as number of injuries per 1000 runs.

**Results:** The 258 athletes interviewed reported 3193 competition days ( $n=46879$  runs) in all disciplines. In total, 135 acute injuries were recorded; 62 (46%) during competition. The distribution of acute injuries was: knee 24 (18%), shoulder 18 (13%), back 17 (13%) and wrist 11 (8%). The overall incidence during competition was 1.3 injuries per 1000 runs; 2.3 for big air ( $n=10$ ), 1.9 for halfpipe ( $n=21$ ), 2.1 for snowboardcross ( $n=20$ ), 0.6 for parallel giant slalom ( $n=8$ ), and 0.3 for parallel slalom 0.3 ( $n=3$ ). The severity of injuries was graded with time loss (27.4% >21 days) and AIS (39% AIS1 and 61% AIS 2). There were 123 overuse injuries; 38 (31%) to the knee.

**Conclusions:** The injury risk for the big air and half pipe disciplines is as high as for alpine ski racing, while that for the alpine snowboard disciplines is lower. The injury pattern is different from recreational athletes with a greater share of knee injuries. Compared with the national level the injury risk is lower at the World Cup level, which is in accordance previous findings from alpine skiing.

### 136 CERVICAL SPINAL CORD INJURY IN FOOTBALL PLAYERS: REPORT OF TWO CASES

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**Background:** We report two male football players who sustained injury to the cervical spinal cord and developed tetraplegia as a direct result of the sport.

**Case reports:** Patient 1 was a 21 year old fit and healthy football player, who was tackled from behind while running with the ball. He lost his balance and landed on his head. This resulted in a burst fracture dislocation of C5/C6 associated with immediate onset of complete tetraplegia. (ASIA A). Patient 2 was a 24 year old fit and healthy football player, who collided, head first, with his own team goalkeeper. The accident happened as he was running full speed back to his net and dived for a cross ball. As he was in full extension, heading the ball away, his forehead collided with the thigh of the goalkeeper, causing hyperextension to the neck. He developed motor complete tetraplegia at C5 level, with some sensation sparing below the level of injury (ASIA B).

**Conclusions:** These two cases illustrate that playing football, a very popular sport, may cause injury to the cervical spinal cord with dire consequences, albeit rarely. Patient 2 was entitled to a maximum compensation of only £1000. Patients with C5 tetraplegia require physical assistance for their activities of daily living, for their entire life. We believe that steps need to be taken to provide adequate insurance to cover football players. These two cases raise another important question. Should there be a review of the rules of the game and refereeing? Which type of tackling should be allowed in football? Should players be discouraged to use their head while playing football? Many people may not be aware of the potential danger of neck injury when the players use their head to hit the ball. We should remember that during evolution, nature did not devise our neck bones for this purpose of heading the ball with great force.

### 137 ASSOCIATIONS BETWEEN BIOMECHANICS PATTERN CHANGES AND MUSCLE FATIGUE DURING PROLONGED PARALLEL HALF SQUAT SERIES

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**Background:** The common effects of muscular fatigue are loss of the contractile force and disturbance to the timing of muscle activation, which may lead to joint instability and alterations in the biomechanics of the task.

**Purpose:** To determine kinematics and muscle activity pattern changes during prolonged parallel half squat (PHS) series, as well to observe the association between this variables.

**Methods:** In total, 12 healthy men who used the PHS in their conditioning programmes, served as subjects. Each subject performed a PHS series for 92 s (40 reps/min), while EMG and kinematic data were recorded. The EMG from rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), gluteus maximus (GM) and erector spinae (ES) was measured with single differential active electrodes at 1000 Hz, and kinematic data were registered by two video cameras at 50 Hz. The RMS was calculated between the 4th and 10th, and the 34th and 40th repetitions. For the same intervals, the maximum and minimum angular velocity, the range of angular displacement and the maximum and minimum angle of the trunk and knee were calculated.

**Results:** Prolonged PHS resulted in a significant increase of RMS of all muscles, over time ( $p<0.001$ ). We also observed significant increase of knee and trunk kinematics parameters ( $p<0.001$  and  $p<0.05$ , respectively). The RMS changes of RF, VL, and BF were associated with kinematics changes of knee ( $p<0.05$ ). The increase in trunk bent was strongly associated with RMS changes of BF, ES and GM ( $p<0.05$ ).

**Conclusions:** The results reflect an increase in the amount of excitation of the motor neurone pool to maintain the performance, over time. This indicates that subjects developed muscle fatigue during prolonged PHS series. In addition, we observed kinematics alterations on the movement pattern that were associated with increase in muscle activity. This could be interpreted as a biomechanical adaptation to the muscle fatigue, which could represent a factor risk for injury.

### 138 BONE MINERAL DENSITY IN MALE LIGHTWEIGHT ROWERS: INFLUENCE OF TESTOSTERONE LEVELS?

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**Background:** Reduced bone mineral density (BMD) may be a risk factor for development of rib stress fractures.

**Purpose:** To investigate if a relationship between BMD and testosterone levels could be indicated in elite male lightweight rowers.

**Methods:** In total, 13 male lightweight national team rowers had their BMD of total body, lumbar spine (L2-L4), femoral neck and distal radius measured in a DEXA scanner. Plasma concentrations of testosterone (T), free testosterone (FT), dihydrotestosterone (DHT) and sex hormone binding globulin (SHBG) were measured in blood samples drawn in the morning. Measurements of other parameters related to bone health such as parathyroid hormone, 25-hydroxyvitamin D3 and calcium were performed to exclude abnormalities.

**Results:** Plasma concentrations of the selected hormones were within or very close to the normal range. Large variations in both BMD and hormone concentrations were observed. Median BMD: total body 1.23 (range 1.16 to 1.34), L2 to L4 1.27  $\text{g}/\text{cm}^2$  (1.11 to 1.57), femoral neck 1.09  $\text{g}/\text{cm}^2$  (0.84 to 1.45) and radius 0.44  $\text{g}/\text{cm}^2$  (0.31 to 0.48); hormones: T 14.3 nmol/l, (11.6 to 29.7) FT nmol/l 0.35 (0.25 to 0.51) and DHT 0.98 nmol/l (0.55 to 1.60). Significant correlations between T and total body BMD as well as L2 to L4 BMD were observed ( $r_s$  0.56,  $p=0.046$  and  $r_s$  0.63,  $p=0.021$ , respectively). Moreover, L2 to L4 BMD and FT was correlated ( $r_s$  0.62,  $p=0.024$ ). After controlling for training experience by calculation of partial correlation only a trend towards correlation between L2-L4 BMD and T remained ( $r_s$  0.61,  $p<0.1$ ).

**Conclusions:** Both BMD and testosterone levels may be influenced by training experience in male lightweight rowers. However, an interesting trend for correlation between L2-L4 BMD and testosterone after controlling for training experience was observed and prospective investigations of energy balance, training load, BMD and testosterone are needed to elucidate potential causal relationships.

### 139 REDUCED BMD: A POTENTIAL RISK FACTOR FOR EXERCISE INDUCED RIB STRESS FRACTURES IN ELITE ROWERS?

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**Purpose:** To investigate if reduced bone mineral density (BMD) could be suggested as a potential risk factor for exercise induced rib stress fractures in elite rowers.

**Methods:** The present study investigated BMD in seven Danish national team rowers with a total of 17 previous rib stress fractures (RSF) and seven controls matched for sex, age, height, weight and training experience. Total body scan and specific scans of the lumbar spine (L2-L4), femoral neck (bilaterally) and distal radius (dominant side) were performed using a DEXA scanner. Results were expressed both as



g/cm<sup>2</sup> and as % of a young adult reference population. Between group comparisons were performed with the Wilcoxon signed ranks test for paired samples.

**Results:** The RSF subjects showed significantly lower L2–L4 BMD: median (range) RSF 1.19 g/cm<sup>2</sup> (1.02 to 1.37) (median and range) compared with controls 1.41 g/cm<sup>2</sup> (1.27 to 1.57) ( $p=0.028$ ). The corresponding values presented as % of a young adult reference population were 96% (85 to 111) and 114% (108 to 127). Moreover, reduced BMD was also observed in the remaining scanned regions in the RSF subjects: total body RSF 1.19 g/cm<sup>2</sup> (1.10 to 1.31) compared with controls 1.30 g/cm<sup>2</sup> (1.17 to 1.34); femoral neck (average of both sides) RSF 1.05 g/cm<sup>2</sup> (0.88 to 1.12) compared with controls 1.11 g/cm<sup>2</sup> (0.84 to 1.45); and distal radius 0.37 g/cm<sup>2</sup> (0.25 to 0.48) compared with controls 0.47 g/cm<sup>2</sup> (0.35 to 0.48).

**Conclusions:** The present results suggest that low bone mineral density may be a potential risk factor for the development of exercise induced rib stress fractures in elite rowers. However, prospective investigations in larger materials are needed to confirm the present preliminary results. Comparison of BMD with a young adult reference population could potentially be used to identify individual athletes at risk and enable early interventions to increase BMD and minimise other potential risk factors.

#### 140 EXERCISE INDUCED RIB STRESS FRACTURES: POTENTIAL RISK FACTORS RELATED TO THORACIC MUSCLE CO-CONTRACTION AND KINETIC MOVEMENT PATTERN

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**Purpose:** To investigate thoracic muscle activity, movement patterns, and maximum muscle contraction strength in elite rowers with and without previous rib stress fractures.

**Methods:** In total, seven national team rowers with a history of rib stress fracture (RSF) and seven controls matched for sex, age, height, weight, and training experience participated. Two dimensional video analysis was performed during ergometer rowing while EMG signals were sampled from the serratus anterior (SA), obliquus externus abdominis (OEA) and trapezius middle and lower fibres (TM and TL). Maximum elbow flexion and knee extension strength was measured using an isokinetic dynamometer (Biodex). Between groups comparisons were performed with the Wilcoxon signed ranks test for paired samples.

**Results:** RSF displayed a higher velocity of the seat in the initial drive phase (median (range) RSF 0.25 m/s (0.15 to 0.33) v controls: 0.18 g/cm<sup>2</sup> (-0.11 to 0.29);  $p=0.028$ ). Further, RSF had greater co-contraction of SA and TL in the mid drive phase (RSF 48.5% (35.8 to 60.2) EMG signal overlap v controls 27.0 (11.2 to 61.6)%;  $p=0.043$ ). In addition, RSF subjects showed a reduced knee extension to elbow flexion strength ratio (RSF: 4.3 (3.5 to 5.1) v controls: 5.0 (4.2 to 5.3);  $p=0.043$ ), indicating stronger arms relative to legs compared with controls.

**Conclusions:** Rowers with previous rib stress fractures displayed increased thoracic muscle co-contraction in the mid drive phase and higher velocity of the seat in the beginning of the drive phase as well as stronger arms relative to legs compared with controls. Stress forces on the ribs may be elevated by increased co-contraction and further increased in rowers with relatively stronger arms compared with legs. Higher velocity of the seat in the initial drive phase could give rise to increased contraction forces of the thoracic muscles. Consequently, these may all be potential risk factors for development of rib stress fractures but need to be confirmed in larger prospective investigations.

#### 141 A PROSPECTIVE INVESTIGATION OF SHOULDER PAIN IN AUSTRALIAN COMPETITIVE SWIMMERS

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**Background:** To examine, using a prospective cohort study, shoulder pain incidence and predictive value of several intrinsic risk factors for shoulder injury in 74 competitive swimmers at club to elite level.

**Methods:** At baseline shoulder internal (IR) and external rotation (ER) at 90 degrees abduction, abduction in internal rotation (ABIR) and combined elevation (CE) range were measured by Dualer inclinometer. Shoulder anterior to posterior laxity was measured with a modified KT1000 arthrometer. Intratester reliability of these measures assessed in 13–17 swimmers was good to excellent (range: intraclass coefficient (ICC) 0.90 to 0.96, laxity: ICC 0.79–0.94). Participants were followed (e-mail, telephone, diary) fortnightly for 1 year and self reported

shoulder pain documented. Injury definitions were (a) significant interfering shoulder pain (SIP) and (b) significant shoulder injury (SSI): SIP of  $\geq 2$  weeks' duration. Relationships between each risk factor and SIP and SSI were examined. Factors at  $p<0.15$  were retained for a final logistic regression model to determine independent predictors of injury ( $p<0.05$ ).

**Results:** SSI incidence was 23% (17/74) and SIP 38% (28/74). Shoulder ER and a history of shoulder pain in prior 12 months were independent predictors of SIP and SSI (ER  $p=0.02$  and  $p=0.01$ ). Participants with less ER range were 32 and 13 times more likely to experience SSI ( $p=0.01$ , 95% CI 3 to 390) and SIP ( $p=0.002$ , 95% CI 2.5,62) respectively than those with mid range ER. Participants with high ER range were 35 and 8 times more likely to experience SSI ( $p=0.01$ , 95% CI 3 to 441) and SIP ( $p=0.01$ , 95% CI 1.5 to 42), respectively, than those with mid range ER. Participants with a past history of shoulder pain were 11 and 4 times more likely to sustain SSI ( $p=0.001$ , 95% CI 3 to 48) and SIP ( $p=0.02$ , 95% CI 1.3 to 3) respectively. Shoulder IR, ABIR, CE, and laxity were not associated with injury outcome.

**Conclusions:** These findings can be used to identify swimmers at risk of shoulder injury during a swim season.

#### 142 DEVELOPING A PROTOCOL FOR ANKLE SPRAIN REHABILITATION IN ELITE COURT SPORTS

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**Background:** The frequency of ankle injuries in court sports and the potential of significant days lost in training provided the necessity to examine the incident rate and injury management processes at the Australian Institute of Sport (AIS).

**Methods:** Retrospective analysis formed a baseline measure for the prospective analysis of an improved prevention programme and a new formalised rehabilitation programme. To determine the incidence of ankle injuries, a retrospective study examined three AIS court sports: netball, men's basketball, and women's basketball. Data collected by the treating physiotherapist throughout an athlete's injury and return to sport were tabulated and examined.

**Results:** During 2001, there were 41 total ankle injuries (netball 13, men's basketball 19, women's basketball 9), with 223 days lost in training. The average return to full training for athletes was 5.7 days (netball 6.7, men's basketball 4.3, women's basketball 6.0). Within a 5-month period, there was a recurrence of 13 ankle injuries (32%). Two strategies were implemented: (a) increased prevention education and emphasis on balance training and (b) a 21 day rehabilitation programme post-injury. In the first year, total ankle injuries dropped by 49% to 21% (netball 8, men's basketball 7, women's basketball 6) corresponding to a 47% decrease in training days lost to 119. Average return to full training varied minimally (5.6 days) and the injury recurrence rate was 24%. Improvements continued in the following year, when total ankle injuries dropped to 17 (netball 6, men's basketball 8, women's basketball 3), with an associated 92 training days lost and injury recurrence rate of 18%. The average return to full training for athletes again varied minimally (5.9 days).

**Conclusions:** Use of a rehabilitation programme and prevention strategies have accounted for a reduction in ankle injuries (41, 21,17) and injury recurrence rates (32%, 24%, 18%). This specific ankle prevention and rehabilitation programme has been implemented as part of the training structure and has good athlete compliance. The two interventions have proven successful in reducing ankle injury and re-injury rates.

#### 143 A 6 MONTH PROSPECTIVE STUDY OF INJURY AND ASSOCIATED RISK FACTORS IN GAELIC FOOTBALL

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**Purpose:** To determine the injury rate in Gaelic footballers at club level, to build a profile of the injuries experienced and to establish the most common mechanisms of injury.

**Methods:** The study was prospective in nature and was based on the RIPP method (Waller *et al.*). Information was collected from players at seven clubs in three different counties by means of a pre-season questionnaire and a monthly questionnaire via telephone interview, every month for six consecutive months. Data were collected regarding training and playing hours and methods, injury type, mechanisms, and chosen management.

**Results:** Of the 88 players who signed up for the study a total of 83 completed the 6 month interview process with a total of 90 injuries reported. The injury rate (IR) per 1000 hours exposure was calculated at 13.52. (IR per 1000 hours training 5.79 and IR per 1000 match hours 51.19). Of the injuries, 48% were "moderate" in severity (7–14 days modified activity). The most common injuries suffered by players were bruise/contusion (27.78%), muscle strain (23.33%), and ligament sprain (17.78%). The most common areas of the body to be injured were the ankle (13.3%), anterior thigh, and posterior thigh (both 12.2%). Over a quarter of injuries reported occurred in the tackle (tackling 10%, being tackled 17.8%). Sprinting (13%) and turning (12%) were also common causes.

**Conclusions:** This pilot study has set out an injury rate and injury profile in club Gaelic Footballers and has set out a framework for future and much needed research into injuries in Gaelic Football.

1. Waller AE, Feehan M, Marshall SW, et al. The New Zealand Rugby Injury and Performance project: 1. Design and methodology of a prospective follow-up study. *Br J Sports Med* 1994;**28**:223–8.

#### 144 A 12 MONTH PROSPECTIVE STUDY OF INJURY AND ASSOCIATED RISK FACTORS IN ROWING

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**Purpose:** To establish a profile of injury in rowing and to examine risk factors over a 12 month period.

**Methods:** In total, 20 international rowers completed a baseline questionnaire and were contacted once a month via telephone interview. Details were collected regarding training type, hours and intensity as well as injuries and subsequent treatment sought. The methodology was based on that used by Waller et al.<sup>1</sup>

**Results:** All rowers completed the study; one did not complete the season because of a lumbar spine injury and one because of illness. The cohort consisted of 12 men and 8 women, mean age 26.25 years. A mean injury rate of 1.33/1000 hours of training was demonstrated, with the mean number of injuries being 2.2 per athlete in the 12 month period. The highest month for injuries was December, with 31.8% of injuries occurring in this month. This month was also the highest training volume in terms of time spent training (mean of 64.9 hours). The lowest number of injuries was in July and August when no injuries were sustained (47.55 and 25.3 mean training hours respectively). The commonest site for injury was the lumbar spine, with 27.2% of injuries occurring in this region, followed by the knee (15.9%) and the cervical spine (11.36%). The mean number of racing hours in the 12 month period was low at 4 hours.

**Conclusions:** The peak period for injury in rowers is in November to April when training is more intensive in terms of hours. Lumbar spine injury is common, with over a quarter of all injuries accounted for in this region. As there have been very few prospective studies of rowing injury and risk factors, this study provides a suitable methodology to be employed in a large cohort.

1. Waller AE, Feehan M, Marshall SW, et al. The New Zealand Rugby Injury and Performance project: 1. Design and methodology of a prospective follow-up study. *Br J Sports Med* 1994;**28**:223–8.

#### 145 TREKKING POLE SUNBURN: A REPORT

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**Background:** Over the past two decades, trekking poles have been increasingly used by visitors to mountainous regions. Despite their popularity, the recent British DERA Expedition to Cerro Aconcagua (6959 m), the tallest mountain in South America, identified a potential problem with their use. During the approach to the mountain, 12 members of the expedition walked from Cassa Del Piedra (3200 m) to Plaza Argentina (4000 m) using either one or two trekking poles. The journey took between 6 and 9 hours and was completed in a light breeze, broken skies, and temperatures of up to 28°C. Despite at least one application of sunblock (SPF 15–50), 6 of the 12 members sustained sunburn to the dorsal aspect of the wrist, hand, and fingers. This led to blistering, oedema, and local cellulitis (requiring antibiotics) in two cases and a persistent urticarial reaction in one case.

**Conclusions:** Trekking poles present an unwitting area of stretched and exposed skin to ultraviolet light for long periods of time, causing sunburn and significant complications in an unusual distribution. This risk can be reduced by repeated applications of high factor sunblock, or eliminated by wearing thin, lightweight cotton gloves.

#### 146 DISTRIBUTION OF INTRACELLULAR SODIUM IN SINGLE FIBRE MODEL SUBJECTED TO STRETCH INDUCED MUSCLE DAMAGE

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**Background:** Stretch induced muscle damage (or eccentric contraction) is among the most common muscle injuries in athletes. The primary event appears to be mechanical in nature with localised regions of sarcomere inhomogeneities. It is agreed that the injury includes both structural disorganisation and changes to ionic regulation of the muscle fibres. One possible contributor to the increased membrane permeability following muscle damage is the involvement of stretch activated channels. These are non-selective stretch activated cation channels that pass  $Ca^{2+}$  and  $Na^{+}$  ions.

**Methods:** Single fibres were dissected from the flexor brevis muscle of mice. Muscles underwent either ten isometric tetani (controls) or eccentric tetani, during which a 40% stretch of the optimal length ( $L_0$ ) was applied. Intracellular sodium ( $Na^{+}$ ) was measured in these fibres following stretches with the fluorescent indicator SBFI or sodium green. The reduction in force was used as an indicator of the extent of muscle damage.

**Results:** Isometric tetani had no detectable effect on  $Na^{+}$ ; (mean (SD) 7.2 (0.5) mmol/l), whereas eccentric contractions increased  $Na^{+}$  to 16.3 (1.6) mmol/l. Confocal images showed a uniform increase in  $Na^{+}$  after eccentric tetani, whereas tears in the membrane might be expected to cause focal increases. Given the failure to detect localised  $Na^{+}$  entry, a blocker of stretch activated channels ( $Gd^{3+}$  or streptomycin) was applied for 10 minutes following stretch induced damage. Not only did the blockers prevent the increase of  $Na^{+}$  after the stretch protocol but it also prevented part of the force deficit. We hypothesise that stretched contractions open stretch activated channels and allow influx of  $Na^{+}$  and  $Ca^{2+}$  ions. The consequent rise in  $Na^{+}$  activates the  $Na^{+}/K^{+}$  pump and the efflux of  $Na^{+}$  and  $H^{2}O$  through the T-tubules, triggering changes in the excitation-contraction coupling. The increased  $Ca^{2+}$  may contribute to activation of proteases and phospholipases and to the ensuing cell damage and inflammation.

#### 147 PREVENTION TRAINING PROGRAMME IN FEMALE TEAM HANDBALL PLAYERS: THE GERMAN EXPERIENCE

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**Purpose:** To evaluate the effects of a prevention programme on the incidence of injuries in female European team handball players in a prospective controlled study.

**Methods:** In total, 10 female handball teams (134 players) took part in the prevention programme, which comprised information about injury mechanism, balance board exercises, and jump training; while 10 other teams (142 players) were instructed to train as usual. Over one season all injuries were documented weekly.

**Results:** Ankle sprain was the most frequent diagnosis in both groups with 11 ankle sprains in the control group and seven ankle sprains in the intervention group (odds ratio: 0.55, 95% confidence interval: 0.22 to 1.43). The knee was the second frequent injury site. In the control group, five of all knee injuries were anterior cruciate ligament ruptures (incidence: 0.21 per 1000 hours) in comparison to one in the intervention group (incidence: 0.04 per 1000 hours). Odds ratio was 0.17 with 95% confidence interval of 0.02 to 1.5.

**Conclusions:** This study confirms that proprioceptive and neuromuscular training is appropriate for the prevention of knee and ankle injuries among female European team handball players.

#### 148 KITESURFING INJURIES: PREVENTION WITHOUT DECREASING THE FUN FACTOR?

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**Purpose:** We hypothesised that pattern and rate of kitesurfing injuries in a prospective study will be comparable to that of contact sports such as football and soccer.

**Methods:** The study was conducted over a 6 month period of one season and included 235 kitesurfers.

**Results:** The number of self reported injuries was 124, for an overall self reported injury rate of 7 per 1000 hours of practice. One fatal accident (polytrauma) and 11 severe injuries occurred during the study period (two knee ligament injuries and nine fractures at various sites). The most commonly injured sites were the foot and ankle (28%), skull (14%), chest (13%), and knee (13%). Over half (56%) of the injuries were attributed to the inability to detach the kite from the harness in a situation involving loss of control over the kite. There was a tendency for athletes using a quick release system to sustain fewer injuries than athletes without such a release system.

**Conclusions:** Kitesurfing can be considered a high risk sport. The use of a quick release system that enables the surfers to detach the kite in case of an accident might aid in the prevention of injuries.

#### 149 A PROSPECTIVE COHORT STUDY OF INJURY RISK FACTORS IN AMATEUR AND PROFESSIONAL BOXING

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**Background:** The medical community has criticised the sport of boxing, claiming a high frequency of serious injury despite the lack of prospective data evaluating the risk of modern day boxing.

**Purpose:** To describe the injury incidence in Australian amateur and professional boxers and to identify risk factors for these injuries, with a focus on head injury.

**Methods:** The project involved a survey of boxers in Victoria with follow up of 1 year. Follow up outcome measures included recording of exposure time and injuries sustained during both training and bouts. Medical diagnoses were confirmed by accessing medical records maintained by the amateur and professional governing bodies. The definition of an injury was any physical damage occurring to the head, neck, arms, or trunk brought to the attention of a fight doctor, preventing the continuation of a fight or training session, and/or requiring some type of medical treatment.

**Results:** In total, 13 professional and 34 amateur boxers were recruited, with a mean age of 25.9 years (range 15.1 to 37.1). At the end of the 6 months of data collection, an estimated 5550 hours of training and 8.7 hours of competition time had been completed. In total, 14 injuries (11 in competition and 3 in training) were reported, corresponding to an overall injury rate of 2.5 per 1000 hours of boxing participation. Nine of the competition injuries occurred as a result of being punched in the head (six concussions, two broken noses, and one eyebrow laceration). The remaining two competition injuries were both hand/finger fractures caused during the act of punching an opponent. Head injuries occurred at a rate of 1.6 per 1000 hours.

**Conclusions:** Definitional issues and the culture of the sport appear to have affected reporting of injuries. That being said, when exposure time in training is taken into account, preliminary analysis indicate that the overall injury rate in boxing is comparable with that reported in other sports.

#### 150 BRAIN MRI SCANS: A USEFUL SCREENING TOOL FOR COMBAT SPORTS?

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**Background:** Pre-participation medical screening has been widely used in many sports to assess athletes for conditions that may predispose them to injury or death.

**Purpose:** To evaluate the use of magnetic resonance imaging (MRI) brain scans as a screening tool to determine participants potentially at risk of brain injury in combat sports.

**Methods:** Since June 2001, the Professional Boxing and Combat Sports Board of Victoria (PBCSBV), Australia, has required all of its licensed combat sports participants to undergo MRI brain scans at registration and at 3 yearly license renewals. Scans were assessed independently by two neuroradiologists using a standardised assessment tool reporting on 17 different parameters.

**Results:** Since the introduction of screening, 96 combat sports participants have had an MRI scan completed. Despite a lack of formal evaluation, boxers found to have significant abnormalities may have their license revoked by the PBCSBV. Three boxers to date have been found to have abnormal results; one had a frontal cavernous haemangioma, one had a small pontine glioma, and one had a diffuse white matter abnormality that was not further diagnosed as the participant did not attend for follow up investigations. None of the reported abnormalities was the result of participation in any of the combat sports.

**Conclusions:** MRI brain scans have previously been used in combat sports to evaluate the presence of cumulative brain damage. The relatively young age of active participants of these sports limits the likelihood of chronic brain damage being reported, but their use as a screening tool for prevailing conditions may identify participants whose registration in the sport should be further investigated, and as such may limit the risk for both the participants and the governing bodies of these sports.

#### 151 SEX DIFFERENCES IN PROXIMAL MUSCLE ACTIVATION STRATEGIES DURING LANDING

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**Purpose:** To determine whether sex differences exist in EMG activity of hip stabilising muscles during single leg landing.

**Methods:** In total, 22 healthy NCAA Division I collegiate athletes were studied (13 women, mean height 180.6 cm, mean weight 76.5 kg; 9 men, mean height 180.6 cm, mean weight 76.5 kg). All subjects read and signed an informed consent approved by the university institutional review board. The subjects were asked to perform drop landings from both 30.5 and 45.8 cm heights. Surface EMG was used to examine relative muscle activity during the maneuver from 200 ms prior to initial contact to 250 ms post contact). Peak and mean values for each muscle (gluteus maximus, gluteus medius, tensor fascia lata, rectus femoris, medial and lateral hamstrings, and hip adductors) in each time epoch were combined in a single (group  $\times$  height) multiple analysis of variance. Post-hoc 2 $\times$ 2 analyses of variance were performed to determine significance of the univariate analyses. The alpha level was set at  $p < 0.05$ .

**Results:** Women demonstrated significantly less gluteus maximus peak ( $p = 0.019$ ) and mean ( $p = 0.018$ ) muscle activation during the post contact phase of landing compared with their male counterparts. Furthermore, women demonstrated greater peak rectus femoris activity during the pre-contact phase of landing ( $p = 0.029$ ). As expected, a significant positive effect of drop height on relative activity of all muscles was observed during both the pre-contact and post-contact phases of the landing manoeuvre ( $p < 0.05$ ).

**Conclusions:** Inadequate hip stabilisation (that is, decreased gluteal activity) and increased quadriceps activity in women may be responsible for positioning the lower extremity in femoral internal rotation, adduction, and dynamic valgus. By contributing to this misaligned position, decreased hip stabilisation and quadriceps dominance may be important factors in the increased susceptibility of female athletes to non-contact anterior cruciate ligament injuries.

#### 152 THE EFFECT OF ACUTE FATIGUE ON NEUROMUSCULAR ACTIVATION PATTERN DURING SIDE CUTTING MANOEUVRE IN FEMALE ELITE HANDBALL PLAYERS

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**Purpose:** To investigate if muscle fatigue induced by a simulated handball match causes altered leg muscle motor patterns during side cutting movements in female handball players.

**Methods:** Neuromuscular activity (EMG) was recorded (vastus lateralis and medialis, rectus femoris, biceps femoris, semitendinosus) in 14 female handball players during a standardised side cutting manoeuvre, before and after a simulated handball match. EMG activity was registered both before and after landing on a forceplate. Furthermore, EMG was obtained during maximum isometric quadriceps and hamstring contraction (MVC). EMG activity during side cutting was normalised to peak EMG amplitude recorded during MVC. The simulated handball match consisted of a series of intermittent exercises mimicking handball match activity (50 minutes).

**Results:** The simulated handball match caused a marked decrease in quadriceps (-21%) and hamstring (-16%) MVC. Likewise, neuromuscular activity in the semitendinosus muscle was reduced by 38-42% in the pre-landing phase (100, 50 and 10 ms before toe down) and 47-55% post-landing (10, 50, 100 and 200 ms after toe down). Notably, total hamstring EMG activity (sum ST+BF) remained unaltered despite the decrease in semitendinosus EMG activity.

**Conclusions:** This study indicates that acute fatigue induced by handball match play, involving substantial eccentric and rotational forces, causes changes in the neuromuscular motor pattern during a side

cutting manoeuvre. Despite the substantial decrease in semitendinosus EMG activity, total hamstring activity remained unchanged. Non-contact rupture of the anterior cruciate ligament (ACL) typically involves the knee in valgus, the foot fixed and pronated, resulting in external rotation of the tibia. As the semitendinosus muscle also functions as an internal rotator of the tibia, the selective decrease in EMG activity in response to match induced fatigue may potentially represent a risk factor for ACL injury in female handball players.

### 153 KINEMATIC AND KINETIC DIFFERENCES OF THE HIP AND KNEE IN FEMALE AND MALE ATHLETES DURING TWO FUNCTIONAL MANOEUVRES

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**Purpose:** To identify kinematic and kinetic differences at the hip and knee while male and female subjects performed a single legged squat and single legged landing.

**Methods:** Data were collected on 16 male and 19 female intercollegiate athletes who had no previous history of lower extremity surgeries or current pathology.

**Results:** Results indicated that during the single legged squat the women demonstrated significantly greater knee adduction (mean (SD)  $6.6 (3.0)^\circ$  for women;  $3.9 (2.6)^\circ$  for men) and hip internal rotation ( $26.8 (6.6)^\circ$  v  $19.6 (6.3)^\circ$ ) and an increased velocity with knee flexion ( $120.5 (25.4)^\circ/\text{sec}$  v  $94.1 (30.4)^\circ/\text{sec}$ ). Kinetically, men exhibited an increased hip extension moment compared with women ( $0.16 (0.02) \text{ Nm/BW}$  v  $0.21 (0.04) \text{ Nm/BW}$ ). During the single legged landing, a significant difference was noted in joint velocity measurements, with the women moving at a greater velocity into knee flexion ( $372.2 (86.5)^\circ/\text{sec}$  v  $355.0 (65)^\circ/\text{sec}$ ) and into hip internal rotation ( $181.3 (80.3)^\circ/\text{sec}$  v  $129.5 (49.5)^\circ/\text{sec}$ ). Data also indicated that women had a greater, although statistically non-significant, amount of hip flexion ( $6.2^\circ$  difference) and hip adduction ( $1.2^\circ$ ) and less knee flexion ( $2.4^\circ$ ) than did men during the single legged squat. During the single legged landing, women exhibited greater, although statistically non-significant, knee adduction ( $2.3^\circ$ ), hip flexion ( $3.8^\circ$ ), and hip internal rotation ( $3.9^\circ$ ) angles.

**Conclusions:** These results indicate that men and women exhibit differences at the hip and knee during a single legged squat and a single legged landing, which may result in greater amounts of stress placed on the knee joint. Further research related to the timing and position of the knee at the time of injury may provide a greater understanding as to whether these differences at the hip are clinically important.

### 154 INJURY RISK FACTORS IN PROFESSIONAL VOLLEYBALL DURING ON SEASON

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**Purpose:** To investigate the incidence of injury and the risk factors for those specific injuries sustained by the first and second leagues of the Turkish Volleyball Federation during season.

**Methods:** Injuries sustained by 131 volleyball players were retrospectively recorded on a standardised database by a physiotherapist by an interview throughout the questionnaire. Data recorded included information on injury localisation, extrinsic risk factors during injury, recurrence of injury, and the presence of first aid and rehabilitation and of the healthcare staff who deal with the injury in the team.

**Results:** In all, 125 injured players and 312 injuries were recorded throughout the study. The injury incidence rate for the players during training (62.4%) was higher than that during competition (26.4%). The ankle (29.6%), knee (21.6%), shoulder (19.2%), lower back (11.2%), and fingers (7.2%) were the most frequently injured. Re-injury accounted for 69 cases (55.2%). The onset of injury was sudden in 78 of the players (62.4%) while the others happened gradually. First aid was performed by a doctor in 41 cases (29.9%), a physiotherapist in 45 cases (33.1%), a masseur in 25 cases (18.5%), and teammates or coaches in 25 cases (18.5%). Rehabilitation was applied to the 40.5% of the injured athletes by a physiotherapist. There were no significant difference with regard to re-injury between rehabilitated and the non-rehabilitated groups ( $p > 0.05$ ) despite a decrease in the number of re-injuries in the rehabilitation taking group.

**Conclusions:** It can be concluded that inadequate first aid and rehabilitation are major predisposing factors that cause a re-injury. Analysis of risk factors for injury and the development of prevention programmes to reduce the injury and re-injury incidence are of utmost importance.