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### MONITORING MOVEMENTS WITH HIGH TRUNK ACCELERATION DURING BADMINTON GAMES: AN APPROACH COMBINING A MICROSENSOR UNIT AND VIDEO ANALYSIS

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**Background** Stiff landing is associated with increased anterior cruciate ligament (ACL) injury risk, especially in young female athletes. As an alternative to a force platform, a tri-axial accelerometer is a useful tool to reflect the magnitude of the ground reaction force exerted during games.

**Objective** To clarify the movements that require high trunk accelerations and their frequency during badminton games.

**Design** Observational study.

**Setting** Youth athletes, local tournament levels.

**Participants** Forty-five female badminton players [17 junior high school (JHS) and 28 high school (HS) athletes].

**Assessment of Risk Factors** Movements that generated >4G resultant acceleration were assessed as a risk for ACL injury.

**Main Outcome Measurements** Frequency and characteristics of the movements that generated >4G acceleration during singles games of badminton.

**Results** A total of 6,306 movements generated >4G acceleration during an 896-min game duration (7.04 cases/min; 95% confidence interval (CI), 6.87–7.21 cases/min). HS players (7.27 cases/min; 95% CI, 7.05–7.48 cases/min) had a higher incidence of great trunk acceleration compared with JHS players (6.58 cases/min; 95% CI, 6.29–6.87 cases/min). The top three most frequent movements were landing after an overhead stroke (JHS, 1.13 cases/min; HS, 1.58 cases/min), lunging during an under-/side-hand stroke (JHS, 0.98 cases/min; HS, 1.27 cases/min), and cutting from a split stepping (JHS, 0.96 cases/min; HS, 1.29 cases/min).

**Conclusions** HS athletes had an opportunity to incur exposure to high-loading movements during badminton games, which supports an epidemiological survey's results that the incidence rate of ACL injury in HS athletes is six times higher than that in JHS athletes. In addition, previously reported mechanisms of ACL injury in badminton (i.e. single-leg landing after an overhead stroke and plant-and-cut manoeuvre after a lunge stepping) were revealed as the high-frequency movements that generated >4G acceleration. This study suggests that video analysis with micro-sensor technology can individually detect the high-loading movements during game-play situations, which contribute to identifying the high-risk athletes from the on-court/field perspective.

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### ABSTRACT WITHDRAWN

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### A DYNAMIC WARM UP PROGRAMME REDUCES KNEE AND ANKLE INJURIES AMONG YOUTH MALE SUB-ELITE FOOTBALL PLAYERS

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**Background** Dynamic exercises appear to be more practical in preventing football-related injuries.

**Objective** To evaluate effects of a dynamic warm up programme including dynamic stretch, strength and plyometric exercises (DSP) on prevention of injuries.

**Design** Prospective non-randomized controlled trial.

**Setting** Competitive level.

**Interventions** Two volunteer teams of Iranian U21 league were assigned to control (n=29,18.5±1.2) and DSP (n=25,18.7±1.5) groups. Over a football season (2018), the DSP performed the specific warm up lasting 15 min three times weekly with a progression of intensities over time. The control group followed its routine warm up including football drills and physical warm ups without a specific prevention approach. Injuries and time exposure were recorded according to the FIFA consensus statement. Data were analysed by Chi-Square Test while the level of significant was set as p ≤0.05.

**Main Outcome Measurements** Injury incidence and risk ratio for ankle and knee.

**Results** In total, 7020 h of training and competition and 37 lower extremity injuries were recorded; about 65% in the control group. The injury incidence for DSP and control were 1.8 and 3.4 respectively. Incidences of knee and ankle injuries for DSP and control were 1.0, 0.9, 2.3 and 1.3, respectively. The risk ratio for knee and ankle injuries was higher in the control group by 2.3 and 1.5 times, respectively. Chi-square testing indicated a significantly lower knee injury incidence for the DSP group (p=0.03). Despite a 30% lower injury incidence, the difference of ankle injuries between the groups was not significant (p=0.52).

**Conclusions** Applying DSP as regular warm up significantly reduced the incidence of knee injuries in youth footballers, which is assumed to be due to a better stimulation of the control mechanisms of the postural system followed by performing the programme. For the ankle, exercises that are more specific should be applied though the limited small sample size may also affect the results.

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### EFFECTS OF THE FIFA 11+ INJURY PREVENTION PROGRAMME ON PHYSICAL AND TECHNICAL PERFORMANCE, BIOMECHANICAL MEASURES AND PHYSIOLOGICAL RESPONSES

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**Background** Performance aspects of the FIFA11+ programme have not been generally reviewed.

**Objective** To synthesize the literature on the effects of the FIFA 11+ on the performance

**Setting** Systematic review

**Participants** Football players

**Search procedure** We searched five online databases for the period from 2006 to May, 2021, using five predefined keywords in conjunction to sub-keywords. Totally, 461 potential references recorded through Endnote and imported. Out of the 117 potential titles and abstracts screened by two independent researchers through Covidence, 54 full-text assessed for eligibility of which, 28 were included. Quality of studies and risk of bias were then assessed.

**Results** Studies carried out in 4 continents and 14 countries while recruiting female and male players aging range from 9 to 30. These indicate that the 11+ has been investigated worldwide. Quality of studies was moderate to high and except an unclear amount of bias for blinding outcome assessment; risk of bias for all domains was low. Excepting lower extremity stability, ankle evertors time latency and proprioception improvement, application of the 11+ at long-term (a complete football season) appeared to be successful in improving a variety of performance tests e.g. agility, sprinting, balance, jumping, cutting maneuvers etc; physiological responses and a majority of biomechanical measures. Vice versa, that the 11+ causes acute negative impact on the physical performance and technical abilities compared to the dynamic warm ups was highlighted in two studies.

**Conclusion** Application of the 11+ as warm up routine during trainings at long-term with higher adherence can be recommended for improving performance. However, caution must be observed while recruiting the 11+ for warming up before competitions as it may acutely decrease physical performance and technical abilities. Given the contradictory nature of the literature, further studies should evaluate short-term effects of the programme.

#### 208 WHAT ABOUT BMX? A SCOPING REVIEW OF INJURIES, RISK FACTORS, AND PREVENTION STRATEGIES

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**Background** Bicycle motocross (BMX) was officially added to the Olympics in 2008. Participation has increased over the last decade and is listed as a top sport for injury rates in multisport studies. Before effective prevention programs can be designed and implemented, it is important to understand injury risk, risk factors and potential prevention strategies.

**Objective** To examine the evidence on injury incidence, prevalence, risk factors, prevention strategies, and prevention implementation in BMX.

**Methods** Five electronic databases were systematically searched in July 2020 for studies that included BMX injury as the main topic or subtopic. Two reviewers screened all studies and extracted data independently. Conflicts were resolved via consensus and a third reviewer.

**Results** Of the 1615 unique articles screened, 36 met the inclusion criteria. Most injury surveillance based studies were conducted at elite competitions (e.g. BMX Cycling European Championship, Olympic Games, UCI BMX World Championship) or using data from the emergency department. The most common BMX injuries were fractures, lacerations, abrasions, and contusions. Risk factors included age, sex, number of riders per race, history of injury, and bicycle characteristics. Prevention strategies are limited and have not been appropriately evaluated; one study found that wearing a neck brace may reduce the number and magnitude of rotational accelerations at the head during BMX racing, but this was not evaluated for its effect on injury rates.

**Conclusions** Most BMX studies focus on injury characteristics and do not use appropriate injury surveillance methodology. Studies based on emergency room data may underestimate less severe injuries and do not provide adequate measures of sport exposure. Reducing the number of riders per race may be a promising modifiable risk factor that requires further examination. More rigorous community-based prospective studies examining injury rates, risk factors, and prevention strategies are needed to inform widespread evidence-based prevention strategies.

#### 209 PERFORMANCE OF INERTIAL MEASUREMENT UNITS TO CLASSIFY DIFFERENT UPPER LIMB ACTIVITIES IN ELITE WOMEN'S WATER POLO: A CROSS SECTIONAL STUDY

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**Background** Water polo had the highest injury incidence of all team sports at the 2016 Rio Olympics. Injuries have been linked to external load in training and competition (Mountjoy *et al*, 2015, Wheeler *et al*, 2013). External load monitoring is likely instructive in managing loads to optimise performance while minimising injury risk. Inertial measurement units and machine learning techniques have shown promise in other sports in monitoring external load.

**Objective** To investigate the performance of a decision tree model using peak resultant acceleration (RAcc<sup>PEAK</sup>) and angular velocity (AngVel<sup>PEAK</sup>) variables during water polo activities - high intensity throwing (HIT), low intensity throwing (LIT), blocking with ball contact (BWBC) and swimming (SWIM) compared to video analysis.

**Design** A cross-sectional study

**Setting** A sports institute pool.

**Participants** We recruited ten elite female water polo players - 21.2 (SD 4.8) years old, 8.7 (SD 4.6) training years.

**Interventions** Two Blue Trident<sup>TM</sup> inertial measurement units were applied to each athlete to collect kinetic variables during a standardised baseline test. Each test was recorded using a digital video recorder and coded for activity verification. R-Studio was used to analyse the data and calculate the predicted volume of each activity compared to the coded video verification.

**Main Outcome Measurements** RAcc<sup>PEAK</sup> and AngVel<sup>PEAK</sup> values in abovementioned activities and model accuracy.

**Results** Each of the activities showed distinct bandwidths of RAcc<sup>PEAK</sup> and AngVel<sup>PEAK</sup>. The model recorded the following activity volume (N) with 6 false positive errors with a 96% accuracy - HIT (32) LIT (34), BWBC (22) and SWIM (70).

**Conclusions** This method shows potential to identify different upper limb activities in water polo. These activities most likely load the upper limb differentially and would be critical to measure in monitoring external training load. External load measurement may assist in optimising training planning.