Performance Research Reviews

May 2025

Baseball

A comparison of throwing arm kinetics and ball velocity in professional baseball pitchers with the fastest maximum joint and segment velocities. Journal of Shoulder and Elbow Surgery, Ahead of Print: 1-29, 2025.

Background: Significant associations have been established among individual maximum joint and segment velocities with throwing arm kinetics and ball velocity in baseball.

Methods: Professional (n = 338) pitchers threw 8-12 fastball pitches while evaluated with 3D-motion capture (480 Hz). Pitches (ideal and nonideal sequence order) were classified as 'High Velocity' for each segment/joint velocity subcategory or 'Population' with any pitch eligible for inclusion in multiple subcategories. Kinematic and kinetic parameters were compared among subgroups with post-hoc regression analysis.

Results: Population pitches in ideal sequence order (pitches: 71, pitchers: 19) had significantly faster ball velocity than population pitches in nonideal order (pitches: 3685, pitchers: 338) (39.0 ± 1.5 vs. 38.2 ± 2.2 m/s, respectively, $P < .001$). Irrespective of sequence, the lead knee extension velocity subgroup had faster ball velocity (38.9 ± 1.8 m/s), compared to population (38.2 ± 2.2 m/s) ($P < .001$, $d = 0.4$). For nonideal sequence pitches, for every 1091°/s increase in maximum shoulder internal rotation velocity, shoulder superior force increased by 3.67% body weight (BW). Pitches in ideal order, for every 1414°/s in maximum shoulder internal rotation velocity, there was an increase in shoulder superior force by 4.29% BW, elbow medial force by 5.33% BW, and elbow distractive force by 9.33% BW.

Conclusion: Proper sequence order plays an important role in maximizing ball velocity with minimal implications for throwing arm kinetics. When throwing nonideal sequence, increasing maximum lead knee extension velocity positively impacts ball velocity, while increasing other velocities has negative implications on throwing arm kinetics.

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Advanced analytic and pitch-tracking metrics associated with UCL surgery in Major League Baseball pitchers: A case-control study. The Orthopaedic Journal of Sports Medicine, 13(2): 1-10, 2025.

Background: Ulnar collateral ligament (UCL) injury rates have been rising steadily, while the recent development of advanced analytics and pitch-tracking analysis now drives player development and evaluation throughout Major League Baseball (MLB).

Purpose: To evaluate the association between several advanced analytic and pitch-tracking metrics on UCL surgery rates in MLB pitchers.

Study design: Case-control study.

Methods: Included in this study were MLB pitchers who underwent primary UCL reconstruction or repair from April 2018 to November 2023. Exclusion criteria were pitchers without 2 qualifying seasons of preoperative pitch-tracking data and those who previously underwent UCL surgery. Uninjured matched controls were identified in a 2:1 ratio using season, age, position, handedness, and pitch count as covariates. Advanced analytics (eg, FanGraphs wins above replacement [fWAR], expected fielding-independent pitching [xFIP], physical pitch qualities [Stuff+] strike-zone command [Location+], and overall pitching ability [Pitching+]) and various pitch-tracking metrics used commonly in MLB player evaluation were collected from public web sources sponsored by MLB and used in previous studies. Statistical analysis consisted of unpaired t tests comparing cases and controls and binary logistic regression.

Results: A total of 117 MLB pitchers who underwent primary UCL reconstruction or repair were compared with 234 matched controls. Cases had significantly superior pitch velocity, fWAR, xFIP, Pitching+, and Location+ compared with controls. There was no significant difference between cases and controls in pitch counts, spin, release points, release extension, approach angles, or overall pitch movement. Binary logistic regression identified velocity, Pitching+, and decreased fastball usage as being associated with UCL surgery ($P < .10$ for all).

Conclusion: In this analysis of several modern advanced analytic and pitch-tracking metrics, MLB pitchers who underwent UCL surgery threw harder with less fastball usage, and had superior overall pitching ability (Pitching+) and strike-zone command (Location+) than matched controls.

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Biceps tendoesis and SLAP repair show similar outcomes in overhead throwing athletes with baseball pitchers exhibiting worse rates of return to sport: A systematic review. Arthroscopy: The Journal of Arthroscopic and Related Surgery, Ahead of Print: 1-42, 2025.

Purpose: To compare clinical outcomes, return-to-play (RTP) outcomes, and incidence of postoperative complications in overhead-throwing athletes with SLAP lesions undergoing SLAP repair versus BT with minimum one-year follow-up.

Methods: Using the 2020 Preferred Reporting Items for Systematic Review and Meta-Analysis guidelines, a literature search was conducted on July 9th, 2024, by querying PubMed, Scopus, and EMBASE databases. Inclusion criteria consisted of Level I-IV human clinical studies reporting RTP rate, complications, and/or failure rates following SLAP repair versus BT for SLAP lesions in overhead-throwing athletes with minimum one-year follow-up. Study quality was determined using the MINORS criteria.

Results: A total of 16 studies from 2005 to 2023, reporting on 547 patients with a mean age ranging from 17.4-36.0 years and a mean follow-up ranging from 2.7-7.2 years, met inclusion criteria. Twelve studies (n=459 athletes) reported outcomes following SLAP repair and five (n=88 athletes) following BT. A total of 15 studies reported on baseball players, eight on softball players, and two on handball players. There were 220 pitchers who underwent SLAP repair compared to 34 pitchers who underwent BT. RTP rates for all throwers ranged from 37.5%- 94.7% following SLAP repair and 35.3%-93.1% following BT. The RTP rate for pitchers and position players following SLAP repair ranged from 40%-80% and 76.3%-91.3%, respectively, compared to 16.7% and 80%, respectively, following BT. Complication rates ranged from 0%-21.8% following SLAP repair compared to 0% following BT. Failure rates and revisions ranged from 7.5%-12.5% for SLAP repair versus 0% for BT.

Conclusion: In overhead-throwing athletes with SLAP tears, an analysis of 547 patients from 16 studies shows variable RTP rates following SLAP repair and BT, with baseball pitchers having lower RTP rates compared to position players for both procedures. Outcomes for both SLAP repair and BT exhibit massive variability when treating SLAP tears in overhead-throwers.

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Chronic structural adaptations of the shoulder and elbow are correlated in professional baseball pitchers. The American Journal of Sports Medicine, Ahead of Print: 1-8, 2025.

Background: Pitchers with deficits in total shoulder rotation range of motion (ROM) are 2.6 times more likely to experience an elbow injury. Despite the effects of shoulder ROM on elbow injury, it is currently unclear whether specific tissue adaptations of the shoulder relate to the tissue adaptations of the elbow in baseball pitchers.

Purpose/hypothesis: The purpose was to evaluate the relationship between chronic structural adaptations of the shoulder (humeral retroversion [HR], posterior capsule thickness [PCT], infraspinatus/teres minor pennation angle, and muscle thickness) and chronic structural adaptations of the elbow (ulnar collateral ligament [UCL] thickness, ulnohumeral joint laxity with valgus stress, and ulnar nerve cross-sectional area) in professional baseball pitchers. It was hypothesized that chronic adaptations of HR and PCT would relate to structural adaptations of the elbow.

Study design: Cross-sectional study; Level of evidence, 3.

Methods: Healthy minor league right-handed baseball pitchers from a single professional baseball organization were enrolled during 2022 preseason medical evaluations. Enrolled pitchers underwent bilateral shoulder ultrasound examination of HR, PCT, and posterior rotator cuff pennation angle and muscle thickness as well as bilateral elbow ultrasound examination of the ulnar nerve, UCL thickness, and ulnohumeral joint gapping using the Telos device. The difference in ulnohumeral joint gapping from stressed (150 N) to unstressed (ie, delta value) was calculated. Bilateral differences in every included measure were calculated and used for analysis to more closely isolate chronic adaptations. Multivariate stepwise regressions were performed to determine whether the chronic structural and clinical (strength and ROM) shoulder adaptations were related to structural adaptations of the elbow.

Results: Overall, 40 right-handed professional baseball pitchers with a mean age of 22 ± 3 years were included. A significant positive relationship was observed between preseason structural adaptations of UCL thickness and PCT ($R = 0.344$; $R2 = 0.118$; $P = .030$) as well as between chronic structural adaptations of ulnar nerve cross-sectional area and teres minor muscle thickness ($R = 0.387$; $R2 = 0.150$; $P = .020$). No statistically significant relationships were found between chronic structural adaptations of the shoulder and delta ulnohumeral joint gapping (all $P > .05$) or between chronic adaptations in clinical measures (strength and ROM) of the shoulder and chronic structural adaptations of the elbow (all $P > .05$).

Conclusion: Positive relationships between chronic adaptations of UCL thickness and PCT, as well as between ulnar nerve cross-sectional area and teres minor MT, were observed in asymptomatic minor league pitchers. However, no

significant relationships between adaptations in shoulder strength or ROM were related to chronic structural adaptations of the elbow.

Basketball

Comparative evaluation of recovery interventions-individually and in combination – on lactate clearance and physical performance metrics following 3 versus 3 basketball matches. Journal of Bodywork & Movement Therapies, 42: 431-440, 2025.

Objectives: The study evaluates the effects of active recovery, massage therapy, and foam rolling—both individually and combined—on recovery after 3v3 basketball matches, focusing on lactate levels, sprint performance, explosive strength, and agility to identify the most effective recovery strategy.

Design & setting: Using a within-within group design with repeated measures, the study recorded data on physiological and physical variables before, immediately after, and at 10- and 15-min post-match, including blood lactate, sprinting ability, explosive strength, and agility.

Participants: Twenty-one male basketball players, aged 18–25 years, were purposively selected from Haridwar district, Uttarakhand. All participants had prior competitive experience, having competed in either the INBL or Red Bull Half Court Tournament.

Results: Post-match lactate levels averaged 10.0 mmol/L, dropping to 4.4 mmol/L by 15-min. Active recovery combined with foam rolling improved lactate clearance and performance metrics more effectively than active recovery alone or with massage therapy, which showed better explosive strength recovery but less efficient lactate clearance.

Conclusion: Active recovery with foam rolling was more effective for immediate lactate clearance and agility compared to active recovery with massage therapy, highlighting the need for personalized recovery strategies due to individual variability in responses.

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Effect of acute performance fatigue on tibial bone strain during basketball maneuvers. Bone, 193: 117417, 2025.

Abstract - The tibia is one of the most common sites for bone stress injury (BSI) in active individuals. BSIs are thought to occur in response to damage accumulation from repetitive loading below the tissue's yield limit. The effect of fatigue on musculoskeletal biomechanics and tibial bone strain during athletic movements remains unclear. In this study, participant-specific finite element (FE) and musculoskeletal models in 10 collegiate-basketball players were used to analyze the effect of acute performance fatigue on joint kinematics and torques, ground reaction forces (GRFs), and the magnitude and distribution of tibial bone strains during select basketball maneuvers. Participants were fatigued by performing repeated exercises wearing a weighted vest until their vertical jump height decreased by 20 %. Fatigue reduced the vertical GRF during midstance of a jump task, and lowered hip and knee peak extension torques and ankle plantarflexion. However, fatigue had limited impact on tibial bone strain magnitude and distribution during jumping. In contrast, there was a shift in peak strain timing following fatigue during a lateral cut task and reduced strain at various times of stance during sprinting. The results suggest that fatigue was induced and, if anything, reduced tibial bone strain. As increased bone strain is thought to be associated with increased BSI risk, the reduced strain observed in the current study suggests that fatigue may actually be partly protective, possibly as a result of reduced muscle activation and force production.

Acute effects of the French contrast method and post activation potentiation on 3 x 3 basketball game demands and thermal asymmetry responses. Applied Sciences, 15: 678, 2025.

Abstract - This study aimed to determine the acute effects of the French contrast method (FCM) and post-activation potentiation (PAP) protocols on 3 × 3 basketball game demands and thermal asymmetry in male basketball players and to compare these effects between protocols. Eighteen male basketball players (mean ± SD; age: 21.7 ± 1.5 years, 10.6 ± 1.9 years of experience) visited the laboratory four times, 72 h apart. The players participated in three different protocols (baseline: 3 × 3 game; FCM + 3 × 3 game; PAP + 3 × 3 game; respectively). The players' internal and external loads were monitored, game profiles were analyzed, and thermography was applied during the protocols. The results revealed that FCM and PAP did not significantly differ in internal load; however, the significant highest total distance and distance in band 2 during the 3 × 3 basketball game was after the FCM. The 1-point attempt was significantly higher after the FCM, and turnover was significantly higher after PAP. Significant thermal asymmetry was observed in the

abdominals and lower back after the FCM and PAP. The results of this study provide coaches and practitioners with detailed information regarding the game demands that can be used to improve the playing profile of 3 × 3 basketball players.

Which factors define success during the basketball overtimes. International Journal of Sports Science & Coaching, Ahead of Print: 1-7, 2025.

Abstract - This study investigates how scoring before overtime and various contextual factors influence outcomes during overtime in three professional basketball leagues. We collected data from the National Basketball Association (NBA), Euroleague, and Spanish Professional League (ACB), consisting of n = 275, n = 37, and n = 59 games, respectively, and played in the seasons 2019–2022. Our analysis included variables such as the team that tied the score, game location, opponent strength, maximum point difference during the game, and the last five minutes of regulation play. Binomial logistic regression revealed that the team scoring the tying basket did not significantly affect overtime outcomes in any league. Notably, in the ACB league, game location and maximum point difference during the game were significant predictors, while in the Euroleague, keeping the game tight was crucial. In contrast, in the NBA, game location and opponent strength were pivotal. Our analysis of predictive accuracy showed differing results across leagues, with the ACB league exhibiting the highest accuracy. These differential results between leagues underscore the importance of tailoring coaching strategies to specific league dynamics, enabling teams to better prepare for the critical moments leading to overtime based on the influence of each contextual factor.

Impact and costs of injuries in professional basketball: Insights from a four-season analysis. Apunts Sports Medicine, 60: 100482, 2025.

Abstract - Injuries in professional basketball affect player performance and generate significant costs. This study analyzed the incidence and economic impact of 102 injuries in a team from the ACB League over four seasons, with an injury rate of 5.85 injuries per 1,000 hours, higher during games. Muscle injuries (42 %), mainly involving hamstrings and the Achilles tendon, were the most common. Although 68.6 % were minor (1-7 days), severe injuries (>28 days) accounted for the highest economic burden. Single-competition seasons exhibited a higher budgetary impact (6.5 %) compared to dual-competition seasons (4.5 %).

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The findings highlight the importance of preventive programs tailored to the competitive demands and player characteristics.

Football

Decreased isometric neck strength is a risk factor for head, neck and face injuries in professional rugby league players. Journal of Sports Sciences, Ahead of Print: 1-8, 2024.

Abstract - Head, neck and face injuries are a concern in contact sports. This exploratory study aimed to establish 1) injury risk factors for head, neck and face injuries and 2) clinical cut-off values related to strength, endurance and proprioception of the cervical spine in a team of professional rugby league players. Pre-season assessments of isometric strength of the flexor, extensor and lateral flexor muscles, endurance of the flexor muscles and joint position error were conducted. Injuries resulting in games missed were recorded. Cross-tabulations were used to determine the unadjusted odds ratios for the measures as risk factors for playing season injuries. The unadjusted odds ratio (OR) values indicated that if a player had weaker extensors of the neck (<36.4 kg, p = 0.014; <3.4N/kg, p = 0.014) or asymmetry of isometric strength of their lateral flexor muscles (left-to-right ratio <0.91, p = 0.005), their odds of games missed due to season head, neck and face injuries was increased (OR extensors = 8; 95% CI = 1.5-42.5 OR asymmetry of lateral flexor muscles OR = 12.6; 95% CI = 2.0-79.4). As muscle strength is modifiable, the clinical application of this study would involve targeting players in the team beneath the clinical cut-off value.

Effect of cold-water immersion treatment on recovery from exercise-induced muscle damage in the hamstring. European Journal of Sport Science, Online Nov. 27: 1-9, 2024.

Abstract - This study investigated the effect of five consecutive days of cold-water immersion (CWI) on recovery from exercise-induced muscle damage (EIMD) in the hamstrings following maximal eccentric contraction (EC) exercise. Eighteen healthy adult women were randomly assigned to a CWI group and a control group (CG) (n = 9/group). Participants performed 10 sets of 10 repetitions of isokinetic EC at 30°/second and underwent maximum voluntary isometric contraction (MVC), delayed onset muscle soreness (DOMS) assessment, straight leg raise (SLR) test, and plasma myoglobin (Mb) measurement. The CWI group received one 14-min session of CWI treatment (14°C) at 1, 25, 49, 73, and 97 h after the EC test, whereas the CG rested in a seated position at the same five time points without receiving treatment. (1) All the dependent variables in the CWI group and CG exhibited significant changes after the EC test (p <

0.05). (2) The recovery effect in the CWI group was significantly greater than in the CG in terms of the MVC, DOMS, SLR, and plasma Mb concentration results. MVC increased by 89.3 ± 2.0% on the fourth day ($p < 0.013$), DOMS decreased by 15.4 ± 1.5 mm on the second day ($p < 0.000$), SLR increased by 86.3 ± 1.1% on the second day ($p < 0.014$), and plasma Mb decreased by 436.3 ± 60.8% on the third day ($p < 0.014$). The study indicates that five consecutive days of CWI at 14°C significantly enhance recovery from exercise-induced muscle damage in the hamstrings.

Highlights

- CWI treatment was beneficial for recovery from EIMD after high-intensity exercise.
- All the participants exhibited similar and significant responses in their MVC, DOMS, SLR, and plasma Mb concentration results after the EC test.
- The CWI group demonstrated mostly superior recovery responses compared with the CG after receiving the CWI treatment on 5 consecutive days after the EC test.

Effects of thermal interventions on skeletal muscle adaptations and regeneration: Perspectives on epigenetics: A narrative review. European Journal of Applied Physiology, Ahead of Print: 1-25, 2024.

Abstract - Recovery methods, such as thermal interventions, have been developed to promote optimal recovery and maximize long-term training adaptations. However, the beneficial effects of these recovery strategies remain a source of controversy. This narrative review aims to provide a detailed understanding of how cold and heat interventions impact long-term training adaptations. Emphasis is placed on skeletal muscle adaptations, particularly the involvement of signaling pathways regulating protein turnover, ribosome and mitochondrial biogenesis, as well as the critical role of satellite cells in promoting myofiber regeneration following atrophy. The current literature suggests that cold interventions can blunt molecular adaptations (e.g., protein synthesis and satellite cell activation) and oxi-inflammatory responses after resistance exercise, resulting in diminished exercise-induced hypertrophy and lower gains in isometric strength during training protocols. Conversely, heat interventions appear promising for mitigating skeletal muscle degradation during immobilization and atrophy. Indeed, heat treatments (e.g., passive interventions such as sauna-bathing or diathermy) can enhance protein turnover and improve the maintenance of muscle mass in atrophic conditions, although their effects on uninjured skeletal muscles in both humans and rodents remain controversial. Nonetheless, heat treatment may serve as an important tool for attenuating atrophy and preserving mitochondrial

function in immobilized or injured athletes. Finally, the potential interplay between exercise, thermal interventions and epigenetics is discussed. Future studies must be encouraged to clarify how repeated thermal interventions (heat and cold) affect long-term exercise training adaptations and to determine the optimal modalities (i.e., method of application, temperature, duration, relative humidity, and timing).

Football (soccer) match-derived hamstring muscles residual fatigue can be monitored using early rate of torque development. European Journal of Applied Physiology, Ahead of Print: 1-13, 2024.

Purpose: The aim of this study was to determine whether a soccer match affects the rapid force-generating capacity of the hamstring muscles, given their key role in both horizontal ground reaction force production during sprint biomechanics, and in the deceleration of the shank during the late swing phase, where rapid force production is essential owing to time constraints. Therefore, the research objective was to determine soccer match-induced hamstrings residual fatigue and recovery through rate of torque development (RTD) and associated biochemical parameters.

Methods: The recovery kinetics of hamstrings RTD metrics by the $90°_{hip}$:$20°_{knee}$ test, together with serum biomarkers (creatine kinase, mitochondrial creatine kinase, transaminases, malondialdehyde, irisin), were assessed in 19 male, regional first-division soccer players (age = 20.9 ± 2.0 years, mass = 72.6 ± 11.9 kg, height = 175.9 ± 6.9 cm [mean ± SD]), before a soccer match (MD) and post-24 h (MD_{+1}), post-48 h (MD_{+2}) and post-72 h (MD_{+3}), through a repeated measures design.

Results: Early RTD to 50 ms ($p < 0.001$, $g = -1.24$) and 100 ms ($p < 0.001$, $g = -1.06$) remained unrecovered on MD+3 in both hamstring muscles. However, maximal voluntary isometric contraction (MVIC) torque of the dominant and non-dominant hamstrings was unrecovered on MD+2 ($p = 0.004$, $g = -0.91$; and $p = 0.002$, $g = -0.98$, respectively) and recovered on MD_{+3} ($p = 0.057$ and $p = 0.070$, respectively). Further, neuromuscular deficits were coupled with myocyte structural ($p = 0.002$, $g = 1.11$) and mitochondrial damage ($p = 0.004$, $g = 0.92$) biomarkers.

Conclusion: Based in the findings, early RTD_{0-50} and RTD_{0-100} monitoring, through the $90°_{hip}$:$20°_{knee}$ IPC test, is a cost-effective method for assessing soccer match-induced hamstring muscles residual fatigue and recovery. Overall, soccer match-induced hamstring residual fatigue is not recovered within a 3-day recovery period. Practitioners can use rapid force production metrics through isometric assessments, providing a simple, non-exhaustive tool, for assessing residual

fatigue status during congested competitive periods, to comprehensively balance muscle recovery with optimizing training.

Fractional tackles: Leveraging player tracking data for within-play tackling evaluation in American football. Scientific Reports, 15: 2148, 2025.

Abstract - Tackling is a fundamental defensive move in American football, with the main purpose of stopping the forward motion of the ball-carrier. However, current tackling metrics are manually recorded outcomes that are inherently flawed due to their discrete and subjective nature. Using player tracking data, we present a novel framework for assessing tackling contribution in a continuous and objective manner. Our approach first identifies when a defender is in a "contact window" of the ball-carrier during a play, before assigning value to each window and the players involved. This enables us to devise a new metric called fractional tackles, which credits defenders for halting the ball-carrier's forward motion toward the end zone. We demonstrate that fractional tackles overcome the shortcomings of traditional metrics such as tackles and assists, by providing greater variation and measurable information for players lacking recorded statistics like defensive linemen. We view our contribution as a significant step forward in measuring defensive performance in American football and a clear demonstration of the capabilities of player tracking data.

Gymnastics

The interplay between individual capacities and pair performance according to the experience in acrobatic gymnastics. Sports Biomechanics, Ahead of Print: 1-15, 2025.

Abstract - The interplay between individual capacities and group performance provides insights for different tasks and contexts. So far, little is known about the individual capacities of base and top gymnasts and mechanical efficiency during pair tasks of Acrobatic Gymnastics. This work aims to investigate: (1) the effect of the pair experience in the mechanical efficiency during a pair task; (2) the effect of the individual training experience in the gymnasts' individual capacities, and (3) the contribution of individual capacities and pair mechanical efficiency to the performance of a partner-assisted flight task. Twelve pairs from national first division and elite levels performed a pair task and individual tests and were divided into pair and individual experience levels. Results showed that experience improves the pair task efficiency and individual performances, with distinct implications for each role. Mechanical efficiency is crucial for partner-assisted flight, but the individual capacities of base and top gymnasts also have an important contribution,

followed by mass differences, and the pair experience. Coaches should focus on understanding how different experienced gymnasts can combine their capacities to collaborate efficiently. Also, considering the predictable increase in top gymnast's mass over time, to improve technical efficiency and individual physical condition.

Acrobatic gymnastics: The effect of experience, interpersonal coordination and variability in partner-assisted flight. Journal of Sports Sciences, Ahead of Print: 1-11, 2025.

Abstract - Acrobatic gymnastics demands inter-partner coordination during partner-assisted flights. This work aims to investigate (1) the effect of pair experience on inter-partner coordination and (2) on its variability and (3) the association between the flight phase and coordination modes during a pair task. Twelve pairs of acrobatic gymnasts performed 10 vertical throws in laboratory settings. The position and velocity of the center of mass were used for vector coding analysis to quantify the coordination modes into in-phase, anti-phase, base-phase and top-phase, and continuous relative phase to study the coordination variability. Pairs were grouped by the experience level and the trials by the top gymnast's height achieved. Results showed that more experienced pairs spend less time moving in-phase, more time in base-phase and use less parallel coordination. Coordination variability was similar between groups, but time-series differed in the time segment of 60.7%–78.7% of the task, during upward motion ($p < 0.05$). Trials that reached a greater height used coordination modes similar to more experienced pairs. These findings suggest that the experience level influences the inter-partner coordination, underscoring the potential for learning and adaptation in less experienced pairs and offering valuable information for training strategies aimed at achieving higher flight phases.

Golf

Associations between wearable-derived sleep and physiological metrics with performance in professional golfers. medRxiv, Ahead of Print: 1-30, 2025.

Purpose Consistently performing at the highest level in golf requires a complex interplay of physiological and psychological attributes, with success often defined by razor-thin margins. Sleep characteristics and cardiac autonomic function, reflected by resting heart rate (RHR) and heart rate variability (HRV), are key indicators of recovery and readiness to perform. Yet, their relevance to elite golf performance remains largely unexplored.

Methods We analyzed wearable-derived longitudinal data from 389 professional tour-level golfers across 521 competitive events (2017-2025), encompassing 35,140 nights of sleep and biometric monitoring. Key metrics included

sleep duration (7.2±0.7hrs), sleep consistency (69.1±6.9%), RHR (55.9±7.9bpm), HRV (64.2±28.1ms), and a composite Recovery score (59.1±9.9%). Golf performance (total score, great shots, poor shots, strokes gained) was extracted from a subscription-based database. Linear mixed-effects models assessed both between-person differences and within-person season-to-season changes, adjusting for age (34.1±9.1yrs), height (1.81±0.07m), and weight (83.2±10.6kg).

Results Golfers with superior sleep and biometric profiles consistently performed better, both between and within individuals (Ps<0.05). Between individuals, each additional hour of sleep was associated with a lower score (b=-0.522), as was a 10-percentage point increase in sleep consistency (b=-0.382), a 1bpm lower RHR (b=-0.038), and a 10-percentage point increase in Recovery (b=-0.476). Within athletes, season-to-season improvements in sleep consistency (b=-0.193 per 10-percentage points), HRV (b=-0.016 per 1ms), and Recovery (b=-0.238 per 10 percentage points) were also associated with lower scores (Ps<0.05).

Conclusions Sleep and measures of cardiac autonomic function are associated with performance in elite golf. Both individual differences and within-athlete improvements were linked to success, highlighting the potential role of sleep, resting heart rate, and heart rate variability in optimizing performance at the highest level of sport.

Cognitive, neurophysiological, and behavioral adaptations in golf putting motor learning: A holistic approach. Psychological Research, 89:59, 2025.

Objectives: Research indicates that the development of cognitive structures significantly influences motor learning. However, this perspective overlooks the broader nature of motor learning, which encompasses not only cognitive changes but also neurophysiological and behavioral factors. This study aims to simultaneously examine the intricate motor learning process through cognitive, neurophysiological, and behavioral lenses to achieve a more comprehensive understanding.

Methods: Thirty participants were randomly assigned to either a practice group (n = 15) or a control group (n = 15) and tested at pre-, post-, and retention tests. The practice group underwent an acquisition phase involving three practice days (3 × 100 trials of a golf putting task), while the control group did not participate.

Results: A hierarchical cluster analysis was conducted to group the basic action concepts into a coherent hierarchical structure, represented as a dendrogram. This dendrogram illustrated the relationships between basic action concepts. Analysis of mean group dendrograms revealed a significant increase in the organization of the cognitive structure within the practice group. EEG results indicated that the practice group's low and high alpha power increased significantly in

frontal, central, and parietal areas ($p < .05$). Repeated measures ANOVA revealed that the practice group's motor performance errors decreased significantly ($p < .05$), while no changes were observed in the control group.

Conclusions: Our findings suggest that motor learning involves simultaneous cognitive, neurophysiological, and behavioral adaptations. It appears that the motor learning process involves gradually constructing these structures over time, providing an extensive understanding of the motor learning process.

Hockey

Arena ice quality and perspectives on optimizing performance and addressing emerging challenges. Scientific Reports, 15: 13600, 2025.

Abstract - Maintaining optimal ice surfaces in arenas is essential for ensuring athlete performance and safety in sports such as hockey, figure skating, and curling. This study combines expert survey responses from 55 North American ice arena managers with existing literature to identify best practices for managing ice conditions. Key factors, including ice temperature, humidity, thickness, and water quality were examined to identify areas needing empirical validation. While expert opinions offer valuable insights, controlled experiments are necessary to determine how compressive strength, friction, and Total Dissolved Solids (TDS) influence ice performance. Lower ice temperatures improve compressive strength and durability for hockey, while slightly warmer temperatures offer better grip for figure skating. Maintaining humidity between 40% and 50% aligns with industry guidelines, balancing friction while limiting frost formation and sublimation. Water quality plays a critical role, yet conflicting recommendations highlight the need for further research to determine optimal TDS levels. Additionally, emerging contaminants such as microplastics and PFAS pose environmental concerns that warrant monitoring. Future research should bridge the gap between expert knowledge and scientific evidence to refine best practices and promote sustainable ice arena operations.

Perceptual training in ice hockey: Bridging the eyes-puck gap using virtual reality. Sports Medicine Open, 11(1): 38, 2025.

Background: Some cognitive and perceptual determinants of sports performance can be arduous to train using conventional methods. In ice-hockey, this is the case for the players' ability to identify the largest exposed area (LEA), i.e., the goal area that is the least covered by the goaltender from a puck perspective. We developed a virtual reality (VR) application to quantify and train the players' ability to identify the LEA from a wide range of shooting positions.

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Thirty-four professional ice-hockey players were tested. Between two test sessions, half of the players followed a specific feedback-based training (feedback group), whereas the other players practiced without feedback (control group).

Results: For the players of the feedback group, perceptual performance was significantly better after training, whereas it remained unaltered for the players of the control group. For both groups, perceptual performance decreased as the amplitude of the eyes-puck difference (i.e., the difference of perspective between the eyes and the puck) increased. This relationship vanished after training for the feedback group but not for the control group.

Conclusions: We took advantage of VR technology to assess and train the perceptual ability to identify the LEA from a puck perspective, which would be difficult using traditional methods. Only 15 min of specific feedback-based training significantly and substantially improved the perceptual performance of professional ice-hockey players, thereby evidencing the effectiveness of our application for training an important perceptual skill in ice hockey.

Lacrosse/Field Hockey

GPS external load metric data and game performance in NCAA Division 1 women's lacrosse athletes: A longitudinal study. International Journal of Exercise Science, 18(8): 13-146, 2025.

Abstract - This study investigates the relationship between GPS-derived external load metrics and game performance (win/loss) in NCAA Division I women's lacrosse athletes. Utilizing data from three seasons (2022-2024), the study analyzed 1,687 observations from 54 players to identify key performance indicators correlating with game outcomes. GPS metrics including Total Distance (TD), High-Speed Distance (HSD), Very High-Speed Efforts (VHSE), Total Player Load (TPL), High Inertial Movement Analysis (High IMAs), and Total Acceleration Load (TAL) were assessed. Multivariate logistic regression results indicate that VHSE is the most significant predictor of game success, with VHSE showing a positive correlation with winning outcomes ($p = 0.007$; OR = 1.017, 95% CI [1.005, 1.030]). Although other metrics like TD and TPL were significant in univariate models, their impact diminished in multivariate analysis, suggesting their effects are intertwined with other performance factors. The study highlights the importance of high-intensity efforts in game outcomes and provides insights for optimizing training strategies for female lacrosse athletes. These findings underscore the need for continued research into female athlete performance to better inform sport-specific training programs and enhance competitive success.

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A Comparison of External Loads in Division III Men's Lacrosse Between High Competition Matches and Low Competition Matches. International Journal of Exercise Science, 18(3): 158-169, 2025.

Abstract - Lacrosse is an open-field, invasion sport with limited knowledge of the physiological demands of gameplay at the Division III level. This study aimed to investigate the external loads of Division III men's lacrosse players during NCAA season games. Comparisons were made between the external loads placed on the athletes in high competition versus those placed on the athletes in low competition matches. High competition matches were defined as matches against teams that qualified for the NCAA tournament whereas low competition matches included teams that did not meet high competition requirements. The dependent variables measured included total distance, work rate, intensity, 2D load, and 3D load. Defensive players were found to have significantly higher external load values for total distance (m; p=0.003, d=1.43), work rate (m/min; p=0.006, d=1.34), 2D load (AU; p=0.039, d=1.03), and 3D load (AU; p=0.022, d=1.15), while there were no significant differences (p>0.05) for other positions between competition level. Competition level exerts a higher external load for defensive players, but not attack, midfield, or specialists (goalie, face-off). This may indicate the need for specialized conditioning or active load management to deal with potential fatigue based on position and playing time.

Soccer

Comparative effectiveness of multi-component, exercise-based interventions for preventing soccer-related musculoskeletal injuries: A systematic review and meta-analysis. 13: 765, 2025.

Background: Soccer is a high-intensity sport characterized by a considerable incidence of injuries, particularly among professional male players, with injury rates ranging from 5.9 to 9.6 per 1000 player-hours. Lower limb injuries, including those affecting the knee, ankle, hip/groin, and hamstring muscles, are particularly prevalent. Additionally, a history of prior injuries may exacerbate the risk of recurrence. In response to these concerns, various injury prevention programs have been developed and implemented, targeting different genders and age groups.

Methods: This systematic review and meta-analysis, conducted with the PRISMA guidelines, critically evaluated randomized RCTs across diverse genders and age groups to assess the efficacy of multi-component exercise-based injury prevention programs in reducing musculoskeletal injuries among soccer players. Comprehensive searches were

conducted in ClinicalTrials.gov, CENTRAL, EMBASE, PubMed, Scopus, and Web of Science, with no language restrictions applied.

Results: A total of 15 RCTs met the predefined inclusion criteria. The intervention programs were found to be significantly effective in reducing lower limb injuries, with a pooled RR of 0.73 (95% CI: 0.63 to 0.84, p = 0.035). Subgroup analyses further revealed a significant reduction in the incidence of hamstring, knee, and ankle injuries following the implementation of these programs.

Conclusions: Multi-component exercise-based injury prevention programs demonstrate considerable efficacy in reducing musculoskeletal injuries in soccer players, spanning various age groups and genders. These findings underscore the potential of such programs in professional soccer injury management and highlight their importance in the development of comprehensive injury prevention strategies.

Assessment of aerobic fitness and repeated sprint ability in elite male soccer: A systematic review of test protocols used in practice and research. Sports Medicine, Ahead of Print: 1-32, 2025.

Background: Soccer requires players to cover distances around 10-12 km, with numerous consecutive sprints throughout the 90-min game. As such, aerobic fitness and repeated sprint ability (RSA) are crucial physical qualities for the modern soccer player to cope with the demands of the game. However, a comprehensive and systematic search of aerobic fitness and RSA assessment procedures in elite soccer has yet to be conducted.

Objectives: The aims of this systematic review were to (1) identify the tests and outcome variables used to assess aerobic fitness and RSA of elite male soccer players, (2) provide normative values for the most common tests of aerobic fitness and RSA across different playing levels, and (3) report the reliability values of these aerobic fitness and RSA tests.

Methods: A systematic review of the academic databases MEDLINE, CINAHL, SPORTDiscus, Web of Science, and OVID for studies published until August 2023 was conducted, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Studies were eligible for inclusion if (1) they were original research studies, published in a peer-reviewed journal, and written in English language; (2) they had the primary aim of assessing aerobic fitness and/or RSA; (3) players were male and older than 17 years of age (i.e. mean age of the group); and (4) their playing level was defined as 'professional', 'international', or 'elite'.

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Results: For aerobic fitness testing, 124 studies and 35 different tests were identified. Of those, 26 tests (74%) were field-based, whereas only nine (26%) were laboratory-based tests. The incremental treadmill test to exhaustion was the most commonly used aerobic fitness assessment method (56 studies, 45%), with maximal oxygen consumption (˙VV˙ O_{2max}) (mL/kg/min) being the most prevalent outcome variable (49 studies, 87%). The YYIR1 and YYIR2 were also commonly used tests, identified in 22 (18%) and ten studies (8%), respectively. The most frequently reported outcome variable in both tests was distance in metres, reported in 20 studies (91%) for YYIR1 and in all ten studies (100%) for YYIR2. For RSA testing, 27 studies and 18 different tests were identified. Substantial variability in the identified RSA testing protocols was observed in terms of direction (linear vs. multidirectional), sprint repetitions (6-15), sprint distance (20-40 m), type of recovery (active vs. passive), and recovery duration (10-30 s). The 6 × 40-m shuttle sprint protocol with a 180° change of direction and 20 s passive recovery was the most common RSA test, employed in eight studies (29%).

Conclusions: This systematic review provides a comprehensive overview of the testing methods used to assess aerobic fitness and RSA in elite male soccer players. A total of 35 different aerobic fitness tests and 18 RSA tests were identified, highlighting the diversity in methodologies used. The most prevalent aerobic test was the incremental treadmill testing to exhaustion, with a median ˙VV˙ O_{2max} value of 58 mL/kg/min. Field-based tests were preferred due to their practicality, cost-efficiency, and ability to assess multiple athletes simultaneously. A substantial variability in RSA testing protocols was identified in terms of sprint directions, distances, repetitions, and recovery types. Future research should focus on establishing the diagnostic accuracy of the most commonly used aerobic fitness tests to inform their utility in practice and bridge the gap between current testing practices and optimal fitness evaluation.

Acute effects of different warm-up duration on internal load and external load responses of soccer players in small sided games. BMC Sports Science, Medicine and Rehabilitation, 17L 74, 2025.

Background: Soccer is a dynamic sport that involves high-intensity running, changes of direction, jumping and contact. Therefore, a proper warm-up duration is of great importance to optimize players' performance and minimize the risk of injury.

Methods: This study examined the responses of amateur young 16 players (age = 17.00 ± 0.81 years; height = 177.38 ± 5.50 cm; weight = 64.50 ± 5.45 kg) 25 min (min), 15 min and 8 min warm-up duration in 4 v 4 small-sided games (SSGs) with mini-goal formats. Participants are assessed using the Participant Classification Framework, they are categorized

under Tier 2: Trained/Developmental. The SSG interventions were randomly assigned to three training intervention groups. The features of SSG are determined as size; 25 × 32 m, bout; 4 × 4 min, resting; 4 min. Before the SSG, same protocol was applied at different times in all warm-ups. Warm-up protocols consisted of 13 sections. The intervention time in each section decreased parallel to the total 25 min, 15 min and 8 min warm-up times. The rating of perceived exertion (RPE), heart rate (HR) responses, distance covered and technical activities were consistently recorded during all SSG sessions. A one-way repeated-measures ANOVA was used to assess significant differences in performance among the different warm-up duration.

Results: After the interventions, HR, total player load (TPL), successful passes (SP), unsuccessful passes (USP), interceptions and lost ball results demonstrated significant difference between the 25-min, 15-min and 8-min warm-up durations ($p < 0.05$). Total distance, velocity, RPE and enjoyment results showed no significant difference between the 25-min, 15-min and 8-min warm-up duration ($p > 0.05$). Results indicate that a 15-min warm-up duration provides an optimal balance between physiological and technical preparation, leading to improved HR responses, SP and interceptions compared to the 25-min and 8-min warm-ups. The 25-min warm-up decreased USP and lost ball occurrences compared to the 15-min and 8-min warm-ups. The 8-min warm-up resulted in a lower TPL, indicating reduced physiological demands.

Conclusions: The 15-min warm-up duration emerged as an optimal protocol, offering a time-efficient approach that enhances both technical performance and physiological readiness while avoiding unnecessary fatigue. This finding provides practical implications for coaches and practitioners in designing warm-up routines that maximize match readiness without overexertion.

Dynamic Quadrant Model: A practical framework for monitoring and decision-making in soccer training. Sport Performance Science Report, 253: 1-10, 2025.

Overview - Human beings have an inherent need to exert control over their actions, seeking to understand and manage their environment through continuous feedback from multiple indicators. Naturally, football was never going to be the exception. In recent years, we have witnessed a technological revolution in the tracking and analysis of player movement. This evolution has provided a more precise and detailed understanding of both competitive contexts (Bradley et al., 2018; Chena et al., 2021; Hader et al., 2019; Lobo-Trivi˜no et al., 2024; Pi˜nero et al., 2023) and training environments (Chena et al., 2020; Chena et al., 2022; Clemente et al., 2019). Advanced technologies have unlocked the ability to conduct fine-grained analyses of athletes' individual needs, enabling the identification of personalized

performance profiles (Chena et al., 2020; Hader et al., 2019). Capturing as much real-time information as possible has become a priority in the pursuit of competitive success. The dynamic nature of team performance and injury epidemiology has highlighted the need for effective tools to support practical decision-making throughout the training process (Ekstrand et al., 2022; H¨agglund et al., 2013; Impellizzeri et al., 2020). However, despite technological advances and the growing volume of available data, much of the current research continues to rely on reductionist approaches, where interpretation is based on the isolated analysis of individual variables (Verhagen & Gabbett, 2019). Ignoring the complex interactions between contributing factors may lead to a fragmented and limited understanding of what is truly happening. Only through the strategic integration of goal-sensitive variables and a logical sequencing of events can we generate meaningful knowledge that is useful for decision-making in real-world performance settings (Campos-V´azquez & Jimenez-Iglesias, 2024; Gabbett, 2020; Verhagen & Gabbett, 2019).

Softball

Anthropometric characteristics with fielding skill among softball players. International Journal of Advanced Research and Development, 9(2): 83-87, 2024.

Abstract - The present investigation is a study that correlates many anthropometric, fitness, and mental health measures with the outcomes of male softball players. The research required collecting information on a variety of topics, including anthropometrics, physical fitness, psychological variables, and softball performance, among others the sport of softball is very popular and is played all around the globe. In the realm of softball, only a very small number of research have been conducted to investigate the many aspects that continue to contribute to good performance. In the sport of softball, there is a dearth of written material, and study and analysis are needed in a number of different areas. The study's primary objective Is to analyze the correlation between softball players' anthropometric profiles and physiological characteristics and their throwing performances. It is concluded that the Playing sports was formerly considered a leisure pursuit. Throughout history, sports have been deeply ingrained in many cultures. Sports have evolved into a highly serious profession in recent years.

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Biomechanics of fastpitch softball pitching: A practitioner's guide. Sports Health, Ahead of Print: 1-14, 2025.

Context: Despite fastpitch softball's growing popularity, there is limited evidence-based guidance to aid practitioners in developing pitching-specific injury prevention and performance enhancement strategies. This commentary describes the biomechanics across each phase of the softball pitch and provides explanation of common biomechanical errors during the pitch as well as training strategies and exercise recommendations to foster optimal pitcher development.

Evidence acquisition: A review of softball pitching biomechanics research available in electronic databases including PubMed, Medline, and EBSCO.

Study design: Clinical review.

Level of evidence: Level 4.

Results: The 4 primary phases of the windmill softball pitch include the wind-up, stride, acceleration, and follow-through.

Conclusion: Specific training strategies are recommended to combat the various flaws associated with each phase of the softball pitch. Evaluating body composition, functional characteristics like strength and range of motion of the shoulders, trunk, and hips, as well as assessing energy flow may result in improved performance and minimize risk of injury.

Swimming

Can the tumble turn performance be improved by aligning the push-off force vector to the centre of mass trajectory? Journal of Biomechanics, 185: 112694, 2025.

Abstract - The freestyle tumble turn is a critical element of competitive swimming, because an effective push-off from the wall combined with proper body alignment may contribute significantly to overall performance. Previous analyses have focused on variables like peak push-off Force (F_{peak}) and the Tuck Index (TI), ignoring force direction and body alignment. This study explored the hypothesis that exit velocity (v_{out}) and turn performance depend on the alignment between the push-off force vector and the centre of mass (COM) trajectory, resulting in better turn performance. High-speed synchronized video and force data (F_{peak}) were collected from seven trained swimmers performing 21 tumble turns at maximal effort. From these data the COM-force vector alignment was calculated and correlated with v_{out} and various force components. No significant correlation was observed between v_{out} and the average angle difference

between the force vector and COM trajectory, suggesting that precise alignment is less critical than anticipated. However, a strong correlation was found between v_{out} and the projection of the force vector onto the COM vector ($r = 0.76$, $p < 0.001$), indicating that effective force transfer to the COM is a major determinant of turn performance. Moderate correlations were also found between v_{out} and peak horizontal and vertical forces. These findings suggest that tumble turn performance may benefit more from efficient force transfer than precise vector alignment. To better understand the efficiency of swimming thrust, the role of vertical forces and phase-specific wall contact mechanics will have to be elucidated.

Elite collegiate swimmers do not meet sport nutrition recommendations during heavy training: Effects of sex and within-day nutrient timing. Journal of the International Society of Sports Nutrition, 22(1): 2494846, 2025.

Background: Compared to the general population, athletes experience high energy expenditures requiring increased energy and macronutrient intakes to sustain training and optimize performance. While the International Olympic Committee (IOC) and International Society for Sports Nutrition (ISSN) have established recommendations for nutrient intakes, many athletes do not meet the recommended daily allowance (RDA) for the general population, and sport and sex-specific differences are not well documented. Exploration of within-day energy balance (WDEB) shows athletes may achieve energy balance by the end of the day but may present with poor WDEB. Data support that female athletes are at greater risk of nutrient deficiencies than their male counterparts, and it is unclear whether swimmers meet sport-specific nutrient intake and timing recommendations. Following our previous WDEB analysis, the purpose of this investigation was to assess dietary macronutrient intake as related to RDAs (USDA and IOC/ISSN), within-day macronutrient timing, and associated sex differences in swimmers.

Methods: In elite male and female swimmers ($n = 25$; 18-22 yr), we assessed energy intake (EI), total daily energy expenditure (TDEE), macronutrient intake (fat (FAT), protein (PRO), carbohydrate (CHO)) and timing during heavy training. Frequency analysis was utilized to determine the number of athletes meeting general and athlete-specific RDAs. Repeated-measures ANOVA was used to assess nutrient timing across sex groups.

Results: When compared to IOC/ISSN daily recommendations, only 6/25 swimmers met FAT intake, 7/25 met CHO intake, and 24/25 met PRO intake IOC/ISSN daily recommendations. Males had greater EI and TDEE compared to females ($p < 0.05$). PRO consumption (% of EI) was a larger percentage of total intake in male vs females (28 ± 5% vs 23 ±

3%; F = 2.996; p = 0.014). No swimmers met CHO recommendations ($g \cdot kg^{-1}$) pre- or during exercise for the first daily training session. 13/25 met pre-exercise CHO recommendations, while 6/25 and 11/25 met during and post-exercise CHO recommendations for the second training session. Repeated measures ANOVA revealed effects of sex and time on intake ($g \cdot kg\ LBM^{-1} \cdot hr^{-1}$) for FAT (Sex; F = 5.659, p = 0.26; time; F = 12.068, p = 0.006) and PRO (Sex; F = 6.719, p = 0.016; time; F = 13.177, p = 0.011). There was a significant sex*time interaction for CHO consumption (F = 6.520, p = 0.017).

Conclusion: The results from this study demonstrate significant sex-differences, indicating that most swimmers meet athlete-specific recommendations for PRO, but not CHO or FAT intake. CHO timing for pre-, during, and post-exercise was met by only 52% swimmers. Results suggest that swimmers should prioritize CHO intake, emphasized around and during training bouts.

Tennis

The beneficial effects of a mindfulness program on self-efficacy, emotion management and tennis performance. ITF Coaching and sport science review, 32 (94), pp.26-33, 2025.

Abstract - This study aimed to test the effects of a mindfulness program on self-efficacy and performance in the short game of ball-throwing, as well as anxiety and the ability to manage emotions in an official match. Sixteen male players (M = 22.4 years) of regional level, ranked between 30/1 and 15/3 (FFT), volunteered to participate in this study. They were randomly divided into 2 groups: Control and Mindfulness, they carried out 3 experimental phases: Pre-test (30 forehands and backhands with a ball launcher + tournament match), acquisition (6-week program of mindfulness training or listening to music), and post-test (identical to the pre-test). Pre-competitive anxiety and self-efficacy scores, ball-throwing performance, and the number of positive and negative gestures and speeches during matches were recorded during the pre-and post-tests. The results of this study show that mindfulness training increases the feeling of self-efficacy and the performance of the ball thrower and reduces the number of negative gestures and speeches made by players in competition. Although the results of this experiment need to be confirmed, they show the value of developing tennis players' mindfulness skills.

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Assessing the impact of a virtual reality cognitive intervention on tennis performance in junior tennis players: Pilot study. JMIR Formative Research, 9: e66979, 2025.

Background: There is evidence that cognitive training interventions can positively impact executive functions, and that some studies have demonstrated that athletes typically exhibit greater accuracy and faster response times on select cognitive tasks. While the engagement of executive functions is suggested to be part of high-level sporting activities, it is unclear whether such training approaches could directly benefit athletic performance.

Objective: The objective of this study was to evaluate the impact of a combined virtual reality (VR)– and tablet-based cognitive training intervention on adolescent tennis players' performance. Here, we examined differences in Universal Tennis Rating (UTR) between players who supplemented their regular tennis training with a cognitive training intervention and a group that continued regular tennis training alone. This custom cognitive training program targeted specific cognitive control abilities including attention, working memory, and goal management.

Methods: Data were collected from a cohort of tennis players in a randomized controlled trial design led by the dedicated research team. Participants (N=23, age: mean 14.8, SD 2.4 years) from the Czech Lawn Tenis Klub (Prague, Czech Republic) were invited to participate in this study. These individuals were randomized into an intervention + training-as-usual group (n=13) or training-as-usual group (control group; n=10), with the change in UTR score being the primary metric of interest.

Results: There was no difference in UTR between the 2 groups at baseline (intervention: mean 8.32, SD 2.7; control: mean 7.60, SD 2.3). Following the treatment period, individuals in the intervention group showed a significant improvement in their UTR (an increase of 0.5; t_{12}=4.88, *P*<.001) unlike the control group (an increase of 0.02; t_9=1.77, *P*=.12). On comparing the change in UTR (posttraining UTR minus pretraining UTR) attained by each group, we found that the intervention group had a 38% greater improvement in UTR than the control group. An analysis of covariance revealed a significantly greater improvement in UTR for the intervention group than for the control group ($F_{1,20}$=8.82, *P*=.008).

Conclusions: The present findings suggest that training cognitive abilities through an immersive visual platform may benefit athletic performance, including tennis. Such a result warrants careful consideration, given the known difficulties in evidencing far transfer not only in cognitive studies but also in athletic activities. These preliminary pilot findings suggest that the Mastermind Cognitive Training program may be a viable tool for supplementing athletic training practices, although this result warrants further investigation and replication. However, many questions remain

unanswered, and further work is needed to better understand the potential utility and mechanisms underlying potential effects of such a platform.

Volleyball

Decreased hip flexion during spike jump-landings after fatigue is predictive of patellar tendinopathy in volleyball. Journal of Athletic Training, Ahead of Print: 1-34, 2025.

Context: Patellar tendinopathy (PT) is a highly prevalent overuse injury in volleyball. However, little is known if and how the risk for developing PT is increased through fatigue-induced alterations during repetitive jump-landing activities in volleyball.

Objective: The purpose of this study was to explore fatigue-induced risk factors for PT during a spike jump-landing task in volleyball.

Design: Prospective cohort study.

Setting: 3D biomechanical laboratory screening.

Patients or other participants: Seventy-nine adult, male volleyball players.

Main outcome measure(s): At baseline (pre-season), 3D full-body kinematics and kinetics were collected while performing a spike jump before and after a volleyball-specific fatigue protocol. Throughout the season, players were followed for the occurrence of PT and survival analysis with competing risks was performed to identify significant predictors for the development of PT ($p < 0.05$).

Results: During follow-up, 10 of the 79 players developed PT (13%). Players with significantly less hip flexion during the horizontal landing/push-off phase of the spike jump after fatigue were at higher risk for developing PT (HR = 0.898; 95% CI 0.826 to 0.977; p = 0.023) as well as players with a significantly more elongated rectus femoris muscle-tendon unit (HR = 3.258; 95% CI 1.136 to 9.343; p = 0.032).

Conclusions: Despite the low (injured) sample size of this study, preliminary research findings indicate less hip flexion and more elongated rectus femoris muscle-tendon units during landing after fatigue as potential risk factors for developing PT. Future prevention programs for PT may wish to focus on hip-specific exercises and technique modifications (e.g., more hip flexion during landing) under fatigued circumstances.

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Impact of Early Season Jump Loads on Neuromuscular Performance in Division I Volleyball: Analyzing Force, Velocity, and Power from Countermovement Jump Tests. Translational Sports Medicine, 7216781, 2025.

Abstract - The study investigated daily jump load variations on neuromuscular fatigue in nine NCAA Division I female volleyball athletes during the first 22 days of the season. Using force plates and inertial measurement units, data from 17 sessions were analyzed to assess relationships between jump loads and neuromuscular performance. Pearson's correlations were calculated to assess the relationships between force, velocity, and power force plate metrics and jump variables (duration in minutes, total jump counts, and jump counts greater than 38.1 cm (Jumps 38+) and 50.8 cm (Jumps 50+)). Nine out of 14 force metrics showed weak-to-moderate negative correlations with Jumps 50+, indicating as the highest intensity of jump counts increased and force production decreased (r ranges from -0.194 to -0.570; $p \leq 0.025$ for all). In contrast, nine out of 16 velocity and power metrics showed weak-to-moderate positive correlations with Jumps 50+ (r ranges from 0.175 to 0.466; $p \leq 0.044$ for all). In total, 29 out of 36 force plate metrics were significantly correlated to Jumps 50+, the highest intensity jump threshold assessed. Monitoring high-intensity jump loads provides a more accurate and nuanced assessment of neuromuscular performance and fatigue than total jump counts or session duration, with implications for optimizing athlete readiness and performance.

Wrestling/Combat Sports

A wrestler's nightmare: Pectoralis major tendon tear and its repair – A case report. Journal of Orthopaedic Case Reports, 15(4): 136-140, 2025.

Introduction: Pectoralis major tendon (PMT) tears are increasingly common, particularly among young, athletic individuals.

Case report: This case report discusses the management of a chronic PMT tear in a 24-year-old professional wrestler who sustained an injury during a wrestling match. Initially treated conservatively with immobilization and physiotherapy, the patient presented 1 year later with unsatisfactory functional outcomes. Clinical examination and imaging confirmed the retracted tendon, leading to a decision for surgical repair. An open repair of the PMT was performed using a standard clavipectoral approach with suture anchors to reattach the tendon to its anatomical insertion on the humerus. Post-operative rehabilitation focused on progressive range of motion and strength training, enabling the patient to return to pre-injury levels of athletic performance after 8 months.

Conclusion: The results highlight the importance of early diagnosis, prompt surgical intervention, and a structured rehabilitation plan in achieving optimal functional and cosmetic outcomes in young athletes with chronic PMT tears.

International Society of Sports Nutrition Position Stand: Nutrition and weight cut strategies for mixed martial arts and other combat sports. Journal of the International Society of Sports Nutrition, 22(1): 2467909, 2025.

Abstract - Following an extensive literature review, the International Society of Sports Nutrition (ISSN) has developed an official position on nutritional and weight cut strategies for combat sports. The type of combat sport, length of the fight camp, and time between weigh-in and competition are factors influencing nutritional and weight cut strategies. The following 16 points constitute the Position Statement of the Society; the Research Committee has approved them. 1. Combat sports have differing weight categories, official weigh-in times, and competition frequencies, influencing the nutritional and weight cut strategies for training and competition. 2. As the duration of a combat match increases, >4 min, contribution of the aerobic system can rise to >70%, yet anaerobic alactic pathways and anaerobic glycolytic pathways support high-output bursts. 3. During the off camp/general preparation phase, athletes should maintain a weight ranging 12% to 15% above the weight division requirement. 4. Supplements including creatine, beta-alanine, beta-hydroxy-beta-methylbutyrate, and caffeine have been shown to enhance performance and/or recovery during preparation phases, competition, and post-competition. 5. During fight camp, strategic decreases in calorie intake are necessary for an efficient longitudinal weight descent. Individual caloric needs can be determined using indirect calorimetry or validated equations such as Mifflin St. Jeor or Cunningham. 6. Protein should be prioritized during longitudinal weight descents to preserve lean body mass, and the timely delivery of carbohydrates supports training demands. Macronutrients should not drop below the following: carbohydrates 3.0-4.0 g/kg, protein 1.2-2.0 g/kg, and fat 0.5 to 1.0 g/kg/day. 7. Suitable losses in body mass range from 6.7% at 72 h, 5.7% at 48 h, and 4.4% at 24 h, prior to weigh-in. 8. Sodium restriction and water loading are effective for inducing polyuria and acute water loss. 9. During fight week, water-bound glycogen stores can be depleted through exercise and carbohydrate restriction, facilitating a 1% to 2% loss in body mass, with equivalent losses from a low-fiber intake of <10 g/day for 4 days. 10. During fight week, acute water loss strategies, including sauna, hot water immersion, and mummy wraps, can be used effectively with appropriate supervision (optimally ~2-4% of body mass within 24 h of weigh-in). 11. Post-weigh-in, rapid weight gain strategies are utilized to recover lost body fluid/mass before competition with the intent of gaining a competitive advantage. 12. Oral rehydration solutions (1 to 1.5 liters/h) combined with a sodium range of 50-90 mmol/dL should take precedence immediately post-weigh-in. 13. Fast-acting carbohydrates at a tolerable rate of ≤ 60 g/h should follow

oral rehydration solutions. Post weigh-in intake of fiber should be limited to avoid gastrointestinal distress. 14. Post-weigh-in carbohydrate intake at 8-12 g/kg may be appropriate for combat athletes that undertook significant glycogen depletion strategies during fight week. About 4-7 g/kg may be suitable for modest carbohydrate restriction. 15. Post weigh-in, rehydration/refueling protocols should aim to regain ≥10% of body mass to mitigate declines in performance and the negative effects of rapid weight loss. 16. The long-term effects of frequent weight cuts on health and performance are unknown, necessitating further research.

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