



## Performance Research Reviews

September 2025

### Baseball

***A context-enhanced deep learning approach to predict baseball pitch location from ball tracking release metrics. Sports Engineering, 28: 16, 2025.***

**Abstract** - Ball tracking systems are becoming ubiquitous in sport, creating an unprecedented opportunity for big data applications to optimize human health and performance. These applications are especially common in baseball, a sport known for analyzing ball flight data to quantify performance. However, few studies adopt more advanced techniques such as deep learning to conduct these analyses. We aimed to fill this gap by developing a multi-output deep neural network to predict final pitch location using ball tracking release metrics and contextual ball flight information (i.e., projectile motion predictions) from over 2 million pitches thrown during the National Collegiate Athletic Association Division I games. Predictions from the deep neural network were compared to previously reported machine learning models, and permutation-based feature importance was used to investigate the most important features for predicting pitch location. Euclidean distance errors with the deep neural network were approximately 15 cm, outperforming linear regression models by 33% (6 cm). A post hoc analysis revealed that a deep neural network trained without projectile motion predictions performed 17% (2.8 cm) worse than the optimal model, suggesting the context helped the model learn the underlying physics principles that govern ball flight. Moreover, the most important ball tracking metrics for predicting pitch location were lateral release position and spin rate, which are under direct control of the pitcher and have been tied to performance and injury outcomes. Thus, this model provides an enhanced framework to analyze pitcher performance, and future applications may use additional context to predict other performance metrics from ball tracking data, such as throwing arm biomechanics.



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***Current state of baseball interval throwing programs: A systematic review of content, structure, and variability of published throwing programs. Sports Health, Ahead of Print: 1-11, 2025.***

**Context:** There is need for an up-to-date comprehensive review of baseball interval throwing programs in the literature.

**Objective:** To (1) understand the origin and basis of interval throwing programs; (2) evaluate the content of programs in the peer-reviewed literature including target audience, initiation criteria, throwing specifics, arm care, and performance evaluation metrics; (3) classify these variables as well defined, ambiguous, or missing; and (4) analyze variability in key aspects including starting criteria, length, progression, and completion criteria.

**Data sources:** Medline, Embase, Cochrane Reviews, Web of Science, and ScopusStudy Selection: The full text of studies, in English, had to be available. Included studies had to contain a complete interval throwing program designed for baseball players.

**Study design:** Systematic review.

**Level of evidence:** Level 4.

**Data extraction:** Initial screening was conducted based on article title and abstract. Full text of the remaining articles was evaluated for fulfillment of inclusion criteria.

**Results:** Nine studies initially met inclusion criteria. The programs' comprehensiveness was poor, with a mean Interval Throwing Program Checklist score of 20 (range 14-23) on a scale of 0 to 30. There were a variety of components, including progressive long toss, weighted ball, and throwing mechanics exercises. The programs identified had significant heterogeneity in duration, intensity, progression, and focus. Overall, there was a significant lack of attempts at validation or formal study of efficacy for published throwing programs.

**Conclusion:** Current published interval throwing programs are mostly variations of an original program published many years ago and were based on principles of progressive loading with pain as sign of injury that should be monitored carefully. However, these programs have minimal clinical validation and objective measures to quantify their effectiveness. This work identifies several limitations in the current literature and can serve as a foundation for future development of evidence-based interval throwing programs.



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### ***Data-driven approaches for predicting Tommy John surgery risk in Major League Baseball pitchers. Journal of Big Data, 12: 87, 2025.***

**Abstract** - Injury management is critical in all sports, directly impacting player performance. Baseball players are particularly susceptible to injuries, as players often compete in 5 to 7 games per week, placing continuous strain on their bodies. Among various injuries, Tommy John Surgery (TJS) poses a notable risk for Major League Baseball (MLB) pitchers. Traditional TJS prediction methods required sensors or video-based motion capture, which are impractical during actual games and limited in making predictions too close to the injuries, such as within 30 pitches. To address these challenges, this study proposes a deep learning (DL) framework that utilizes both classification and regression tasks. Using MLB pitching data (2016–2023), the classification model detects injury risk up to 100 days in advance with a high prediction performance of 0.73 F1-score, while the regression model estimates the time remaining until the player's last pre-surgery game with R2 of 0.79. In addition, to enhance our model's applicability, we employ an explainable artificial intelligence technique to analyze the impacting mechanical features, such as a lowered four-seam fastball release point, that accelerate UCL deterioration, increasing TJS risk. These findings provide a practical foundation for early intervention strategies, potentially preserving pitcher health and reducing the need for complex surgical procedures.

### ***Shoulder internal and external rotation strength assessment in baseball pitchers: Normative data and reliability. Journal of Strength and Conditioning Research, 39(5): e634-e638, 2025.***

**Abstract** - Rotator cuff strength assessments are valuable for monitoring throwing athlete injury and performance status. Portable technology enables "in-field" assessment and, therefore, increases utility. The purpose of this study was to quantify the reliability of strain gauge technology for measuring shoulder rotator strength and provide normative strength values for high school and college pitchers. Subjects (n = 15) participated in 3 testing sessions consisting of 5 maximal isometric shoulder internal rotation (IR) and 5 external rotation trials separated by 7 days. Variables of interest included peak force (Fmax), peak torque (Tmax), rate of force development, and rate of torque development. Coefficients of variation ranged from 4.3 to 5.8% for peak values and 16.0-28.5% for rate measures. Intraclass correlation coefficient estimates ranged from 0.79 to 0.89 for peak values, and 0.80-0.91 for rate measures, with IR typically marginally better than ER. Although practitioners need to be mindful of managing error (e.g., through familiarity), peak measures of rotator cuff strength assessed using portable strain gauge are promising for simple field-based monitoring of shoulder health for throwing athletes.



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**Practical Applications** - Measuring IR and ER strength can inform shoulder health (4,13) and performance (1). Given the acceptable reliability for Fmax, it would seem that this technology is a cost-effective option for practitioners to use in the field. Notably, the protocols were easily implemented and given the device portability. Practitioners could use such technology to measure shoulder rotation Fmax or Tmax, appreciating that rigorous standardization and familiarization of athletes is needed. The information can be used in a myriad of ways. For example, monitoring IR strength 48 hours after game could inform recovery status between competitive appearances. Similarly, determining IR and ER force outputs and associated ratios could be used to guide return from injury, assist in training prescription, and provide normative values to guide thresholds for training.

### Basketball

***Can different small-sided game formats impact physiological, physical, technical, and tactical demands in basketball players? A systematic review with meta-analysis. *Biology of Sport*, 42(3): 283-302, 2025.***

**Abstract** - This systematic review with meta-analysis aimed to compare the effects of different game formats (1v1, 2v2, 3v3, 4v4, 4v3, 3v3+1, and 5v5) on basketball players' physiological, physical, technical, and tactical responses during SSGs. The data sources utilized were PubMed, Scopus, SPORTDiscus, and Web of Science. Eligibility included basketball players of any age or sex, competing in tier 2 or higher, exposed to at least two different formats. Studies had to report on physiological responses, physical demands, technical performance, and tactical behaviors. Methodological quality was assessed using the MINORS scale. The search identified 4,967 titles, with 16 articles eligible for the review and meta-analysis. Results indicated that extreme SSGs (e.g., 1v1, 2v2) elicited significantly higher cardiovascular demands, as reflected by greater mean and peak heart rates, compared to larger SSGs (e.g., 3v3, 4v4), with a moderate effect size favoring extreme formats (Hedge's  $g = -0.47$ ,  $p = 0.02$ ). In terms of perceived exertion (RPE), no significant differences were found between extreme and larger SSGs, suggesting similar subjective effort across formats. For technical performance, extreme SSGs (e.g., 1v1, 2v2) exhibited a higher frequency of actions, such as passes and shots, compared to larger formats, with a moderate effect size favoring smaller formats (Hedge's  $g = -0.78$ ,  $p < 0.01$ ). No significant publication bias was found, though high heterogeneity was noted in RPE comparisons. This meta-analysis showed that extreme SSG formats elicit higher cardiovascular demands and more frequent technical actions than larger formats, highlighting their potential for targeting specific physical and technical demands in basketball training.



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### ***Comparison of landing biomechanics in male amateur basketball players with and without patellar tendinopathy during simulated games. Journal of Human Kinetics, 96: 69-81. 2025.***

**Abstract** - This study compared male amateur basketball players with asymptomatic patellar tendon tendinopathy (ASYM) to healthy controls (CON) during simulated games to explore the differences in patellar tendon force (PTF) and related metrics. Data on kinematics, kinetics, and electromyography were collected from 24 participants, comprising 12 in the ASYM group and 12 in the CON group, performing a stop-jump task in four stages (1st, 2nd, 3rd, 4th). A musculoskeletal model was used to calculate PTF, and Orthogonal Partial Least Squares Discriminant Analysis (OPLS-DA) identified significant variables. In the first three stages, the ASYM group showed significantly greater PTF and the ankle discrete relative phase (ADRP) than the CON group, with differences of 0.98, 0.79, 0.81kg·BW<sup>-1</sup> ( $p < 0.001$ ) and 7.34°, 11.24°, and 2.49° ( $p < 0.05$ ), respectively. In the last three stages, the ASYM group had a higher knee co-activation index (KCAI) than the CON group, with differences of 0.33, 0.28, and 0.25 ( $p < 0.05$ ). Correlations between PTF and the ADRP and between PTF and the KCAI were the highest, at 0.58 and 0.61, respectively. The OPLS-DA model effectively distinguished between the groups, suggesting potential applications in tendon health monitoring. The findings suggest that elevated PTF may be linked to tendinopathy in male amateur basketball players, highlighting the importance of comprehensive strategies, such as improving ankle symmetry and optimizing muscle coordination to mitigate tendon load and injury risk.

### ***Effects of partial-body cryotherapy on athletic performance and sleep quality in Division 1 collegiate basketball athletes. Journal of Human Kinetics, 96: 187-199, 2025.***

**Abstract** - This study examined the effects of short-term partial-body cryotherapy (PBC) on athletic performance and sleep quality in Division I collegiate basketball athletes. A crossover, counter-balanced design was employed with twelve collegiate basketball athletes randomly assigned to five days of a post-exercise PBC condition or a control condition. Athletic performance was assessed using six standardized tests from the Korean Basketball League (KBL) Draft combine. Objective and subjective sleep quality were measured using actigraphy and three validated sleep questionnaires, respectively. The number of pull-ups performed significantly increased after the PBC condition ( $9.2 \pm 4.59$  vs.  $11.9 \pm 4.77$  reps,  $p < 0.05$ ), whereas no improvements were observed in other performance measures, including the maximum repetitions of the 75-kg bench press, sprint speed, vertical jump height, and agility. Subjective and objective sleep quality were not enhanced after the PBC condition. These findings suggest that a short-term (5-day) application of PBC



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has only a limited effect on athletic performance and no effect on sleep quality. Future studies with longer intervention periods are needed to better understand the effects of PBC on athletic performance and sleep quality.

### ***Etiology and recovery of knee extensor muscle fatigue following simulated basketball match-play. *Biology of Sport*, 42(3): 327-334, 2025.***

**Abstract** - This study investigated the etiology and recovery of knee extensor muscle fatigue following simulated basketball match-play. Thirteen adult male competitive basketball players (age:  $25 \pm 4$  years, stature:  $185 \pm 9$  cm, body mass:  $86 \pm 14$  kg, body fat:  $13 \pm 4\%$ ) completed a simulated match-play (i.e., the Basketball Activity Simulation Protocol) consisting of standardized specific match-based basketball activities. Before (PRE) and immediately after (POST) the match-play, the neuromuscular function of the knee extensors was evaluated to determine the amount of muscle fatigue and its origin. Assessments were also repeated 24 h (POST24) and 48 h (POST48) after the match-play to evaluate muscle fatigue recovery. The main outcomes were maximal voluntary contraction (MVC) torque, voluntary activation estimated through superimposed stimuli, electrically evoked twitch and doublet peak torque (PT), and the 10:100 Hz doublet ratio. The Total Quality Recovery (TQR) scale was used to assess the perceived recovery status at PRE, POST24 and POST48. Time-related changes (oneway repeated measures ANOVA) were observed for MVC torque (main effect:  $P = 0.002$ , moderate; post hoc:  $POST < PRE$ , small), twitch and doublet PT ( $P < 0.001$ , strong;  $POST < PRE$ ,  $POST24$  and  $POST48$ , moderate-to-large) and 10:100 Hz doublet ratio ( $P < 0.001$ , strong;  $POST < PRE$ ,  $POST24$  and  $POST48$ , large;  $POST48 > PRE$ , moderate). Voluntary activation and TQR were not affected at the different time-points ( $P = 0.060$  and  $P = 0.455$ , minimum, respectively). In conclusion, basketball match-play significantly reduced knee extensor MVC strength, with baseline levels being restored within 24 h. Muscle fatigue was accompanied by a significant pre-to-post match reduction of electrically-evoked torque responses, indicative of peripheral fatigue (and evidence of low frequency fatigue), while no signs of central fatigue were noted.

### ***Exploring the most demanding scenarios in elite youth basketball: A comprehensive analysis across playing positions and time windows. *Biology of Sport*, 42(4): 37-47, 2025.***

**Abstract** - This study aimed to examine the Most Demanding Scenarios (MDS) in elite youth basketball players, focusing on position-specific differences across various time windows. Data were collected from 31 players (20 males, 11



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females) across two seasons during 40 official games using a 20-Hz Local Positioning System and 100-Hz accelerometer. Metrics included total distance, high-speed running distance, accelerations, decelerations, jumps, and changes of direction. Peak Demands (PD), High-Intensity Periods (HIP), and Very High-Intensity Periods (VHIP) were calculated using rolling averages over 10, 30, 60, and 120-second windows. Mixed linear models compared PD across time intervals and between playing positions (frontcourt vs. backcourt). Shorter time windows showed higher relative peak values for both males and females. Relative distances declined with longer intervals, from  $251.34 \pm 23.46$  m·min<sup>-1</sup> (10 s) to  $113.61 \pm 13.52$  m·min<sup>-1</sup> (120 s) for males ( $p < 0.001$ ;  $d = 7.20$ , nearly perfect effect), and from  $237.37 \pm 24.16$  m·min<sup>-1</sup> to  $114.52 \pm 11.7$  m·min<sup>-1</sup> for females ( $p < 0.001$ ;  $d = 6.47$ , nearly perfect effect). Male backcourt players (BC) had higher PD than frontcourt players (FC) across most variables and windows, except for changes of direction. Female BC showed significantly higher PD in acceleration ( $10.26 \pm 2.28$  m vs.  $9.07 \pm 2.83$  m;  $p = 0.04$ ;  $d = -0.45$ , small effect) and deceleration distance ( $11.9 \pm 2.39$  m vs.  $10.12 \pm 3.9$  m;  $p = 0.02$ ;  $d = -0.53$ , small effect) over 120 s. Additionally, male FC were more frequently exposed to HIP over 10 s ( $p = 0.011$ ;  $d = 0.20$ , trivial effect) and VHIP over 30 s ( $p = 0.001$ ;  $d = 0.26$ , small effect) for distance covered, whereas female BC consistently demonstrated more frequent passages in VHIP for sprint durations across all time windows. These findings highlight significant position-specific differences in the MDS of elite youth basketball players. Understanding these demands emphasizes the need for tailored, position-specific training and conditioning programs to optimize performance.

### Football

#### ***Application of the British Athletics Injury Classification in collegiate football athletes: A retrospective, observational study. Sports Health, Ahead of Print: 1-8, 2025.***

**Background:** Lower extremity muscle tears are common sports injuries. The British Athletics Muscle Injury Classification (BAMIC) may provide clinical guidance for tears although its value in American football and college athletes is unknown.

**Hypothesis:** Clinical outcomes, specifically time to return to play (RTP) (TRTP), in college American football athletes with activity-related hamstring (HS) and quadriceps (QD) tears will be associated with BAMIC.

**Study design:** Retrospective cohort study.

**Level of evidence:** Level 3.



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**Methods:** American football college athletes who sustained a HS or QD tear and underwent magnetic resonance imaging within 7 days at 1 institution during the 2023 season were included. TRTP and reinjury rate (RIR) for HS and QD tears classified by BAMIC and injury characteristics were evaluated.

**Results:** Of the 24 HS and 10 QD tears in 21 (17.3%) of 121 athletes ( $20 \pm 1.2$  years; 100.0% male), most (60.0%) were BAMIC 2a-3b. Most (89.3%) injuries occurred before the season, and all occurred in practice. Overall median TRTP was 26 days (interquartile range, 17.8-33.0), translating to about 4 weeks missed play. The RIR was 19.0% (4/21). Most (75.0%) reinjuries occurred before RTP. There was no significant relationship between BAMIC and TRTP, although TRTP was less for grade 0 injuries and greater TRTP for injury site "c," albeit with small effect sizes.

**Conclusion:** Activity-related HS and QD tears are common in American football college athletes, particularly in preseason and practice. Injured athletes missed about 3 to 4 games, regardless of BAMIC, with 1 in 5 athletes suffering a reinjury. There was no relationship between BAMIC or muscle group and TRTP.

**Clinical relevance:** This appraisal of BAMIC in college and American football athletes highlights the prevalence of muscle tears and the need for prevention. Although BAMIC lacked value in this study, larger studies are needed to evaluate BAMIC in this population.

***Distribution of position-specific head impact severities among professional and Division 1 collegiate American football athletes during games. BMJ Open Sport & Exercise Medicine, 11: e002365, 2025.***

**Objective:** To compare the severity of head impacts between professional and Division I (D-I) collegiate football games for the purpose of improving protective equipment.

**Methods:** A total of 243 football players from the National Football League (NFL) and from D-I of the National Collegiate Athletic Association (NCAA) were equipped with instrumented mouthpieces capable of measuring six degrees-of-freedom head kinematics. Head impacts were processed using a custom algorithm and combined with game period descriptors to produce a curated dataset for analysis. Head impact severity distributions for several kinematic-based metrics were compared within position groupings between leagues.

**Results:** A total of 11 038 head impacts greater than 10 g from 1208 player-games were collected during 286 player-seasons (2019-2022). No significant differences were found between leagues in the distributions of kinematic-based

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metrics for all investigated position groupings ( $p \geq 0.320$ ). The median and IQRs for peak linear acceleration for NFL and NCAA were 17.2 (9.3) g and 17.0 (8.6) g for linemen, 20.7 (13.8) g and 20.0 (13.5) g for hybrid and 21.0 (17.0) g and 20.8 (15.5) g for speed position groupings, respectively.

**Conclusion:** The absence of statistically significant differences in the distributions of head impact severity between professional and D-I collegiate football players indicates that these data can be combined for the purpose of understanding the range of loading conditions for which new protective equipment, such as position-specific helmets, should be designed. This observation underscores the potential for knowledge transfer regarding biomechanical factors affecting head loading across professional and D-I college football, highlighting crucial implications for innovation in protective equipment.

***Implementing the reverse acute to chronic workload ratio model to improve movement capacity and roster availability: An example using data from the NFL. International Journal of Strength and Conditioning, 5(1): 1-9, 2025.***

**Abstract** - American football athletes require the development of workload capacity for repeated high-intensity efforts, and successful athletes are adept at accelerating, decelerating, and changing directions. The prescription of appropriate training volume stimulus can be difficult to determine, as there are very few guidelines for prescribing sport-specific acceleration, deceleration, and maximum velocity efforts. Preparatory training stimulus has to closely match in-game demands, but at the same time, practitioners need to avoid excessive workloads and undertraining to mitigate workload progression-related injuries and maximize roster availability. The acute-to-chronic workload ratio (ACWR) approach is based upon the fitness: fatigue ratio, which allows practitioners to monitor workloads. New technology allows for in-game positional tracking and these advancements are accessible to the public. By measuring in-game movement, coaches can quantify key metrics like the number of accelerations and average distance covered. These metrics provide a snapshot of in-game demands and performance requirements. Using a reverse engineering approach, coaches can utilize ACWRs to calculate predefined targets to ensure athletes are adequately prepared for gameplay. Here we use the ACWR concept and previously reported in-game data derived from the National Football League to show how to reverse engineer the targeted number of efforts and distances to assist in preparatory pre-season training program design. This approach, which we term the Reverse ACWR Method, can be used to set guidelines for training volumes and workload progressions and provides a systematic, quantitative approach that complements periodization. As such, the Reverse ACWR Method allows practitioners to calculate target sport-specific workloads and training progressions derived from



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scientific-grounded methodology, which may enhance performance, readiness, and roster availability. Although this paper presents an example of how to use positional in-game data to prescribe American football training workloads, this model can be applied to any sport and team that has access to positional in-game movement data.

### ***Injury scenarios of ankle sprains in the National Football League: External rotation and eversion mechanisms. The American Journal of Sports Medicine, Ahead of Print: 1-10, 2025.***

**Background:** Ankle sprains in American football resulting from external rotation and eversion (EE) mechanisms remain a persistent injury that often involves player-to-player contact. Currently, there is little research that describes the frequency or source of this contact in American football and what scenarios are responsible for these injuries across different player positions.

**Purpose:** To identify injury scenarios of ankle sprains that result from EE mechanisms in the National Football League (NFL).

**Study design:** Descriptive epidemiology study.

**Methods:** Ankle sprains reported during NFL games over 4 consecutive seasons (2017-2020) were identified through a query of the NFL Electronic Medical Record by an independent epidemiological company based on a set of clinical impression codes. Injuries with available video to view the injury enabled the identification of ankle sprains that resulted from EE mechanisms. Standardized terminology was developed to systematically describe and categorize each injury.

**Results:** A total of 257 ankle sprains resulting from EE mechanisms were identified from a review of 670 ankle sprains and grouped into 8 standardized injury scenarios. Direct contact to the injured player's foot, ankle, or leg from a large external mass, such as an opponent's pelvis, accounted for 79% of reviewed injuries. Direct contact from a large external mass was the most common scenario for all positions except safeties, and 83% of running back injuries were the result of a tackle. Only 15% of injuries reviewed resulted from injury scenarios in which injurious loading was transmitted solely through the cleat-surface interaction. Safeties and cornerbacks were more commonly involved in these nondirect injury scenarios, such as change of direction, where current interventions may prove more effective.

**Conclusion:** EE ankle sprains were observed to occur from 8 different injury scenarios that varied by player position. Interventions through training, bracing, or changing cleat-surface interaction may not be effective for all injury scenarios. Tackling technique may be a unique intervention for running backs.



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***Introducing the Novel Deceleration Threshold Method: Comparative reliability to previous sprint deceleration analysis methods in team-sport athletes. European Journal of Sport Science, 25: e12278, 2025.***

**Abstract** - Pre-planned deceleration assessments are vital for profiling team sport athletes as they provide a measure of the athletes' ability to implement effective performance and protection strategies to tolerate the substantial mechanical forces. Although task requirements of these linear assessments are generally consistent, current research employs low sampling technology, which limits the ability to define the deceleration start point and subsequently the reliability. Therefore, this study compared the intra- and inter-day reliability of three deceleration assessment analysis methods: set distance, peak velocity, and the novel deceleration threshold, using a motorized linear encoder device. Ten female and 10 male subjects performed three maximal effort 30 m sprint deceleration trials over two testing days. Each trial was filtered and analyzed using a customized code to calculate key deceleration metrics: distance-to-stop (DTS), time-to-stop (TTS), and average deceleration ( $DEC_{ave}$ ) for each analysis method. Intraclass correlation coefficients (ICC) using two-way fixed effect models, coefficients of variation (CV%), and standard errors of measurement (SEM) were calculated to determine the intra-day reliability across all three trials of the first testing day, and inter-day reliability using the: best, average of best two, and average of all trials. The deceleration threshold method using the average of the best two trials from each testing day, exhibited excellent inter-day reliability for the key metrics (TTS: ICC = 0.93, CV% = 6.4; DTS: ICC = 0.97, CV% = 5.3;  $DEC_{ave}$ : ICC = 0.92, CV% = 7.1). To optimize reliability and sensitivity of detecting a meaningful change in sprint deceleration performance practitioners should consider using the average of two best trials analyzed with the deceleration threshold.

### **Gymnastics**

***Circulating growth hormone, cortisol and testosterone in relation to vitamin D status – Influence of lower and upper body wingate anaerobic test in elite artistic gymnasts. BMC Sports Science, Medicine & Rehabilitation, 17(1): 252, 2025.***

**Background and study aim:** It is well known that professional physical training may be one of the factors modifying circulating serum level of growth hormone, testosterone and cortisol. However, the effect of high-intensity upper and lower body Wingate Anaerobic Test (WAnT) on the serum hormone levels in association to vitamin D status still remains unspecified. The aim of the current study was to verify hypotheses that a longstanding background in elite gymnastics



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training induces adaptive changes in hormonal homeostasis during upper- and lower-body WAnT, and that these changes are modulated by muscle group engagement and vitamin D status.

**Materials and methods:** Fifteen elite male artistic gymnasts ( $21.3 \pm 3.4$  years-old) and 14 physically active men (the control group,  $20.2 \pm 1.1$ ) voluntarily participated in this study. Blood was collected using venipuncture procedures (antecubital vein) in three timepoints: before, immediately and 60 min after WAnT. Hormone measurements consisted of levels of free human growth hormone (hGH), testosterone and cortisol in blood serum. Measurement was made using chemiluminescence method. Vitamin D active metabolites, 25-hydroxyvitamin D<sub>2</sub> [25(OH)D<sub>2</sub>] and 25-hydroxyvitamin D<sub>3</sub> [25(OH)D<sub>3</sub>], as a proportion of the total serum concentration of 25-hydroxyvitamin D [25(OH)D], were analysed using the commercially available Total 25OH Vitamin D ELISA kits.

**Results:** Significantly higher performance during upper-body WAnT were observed in professional gymnasts' groups, for mean power normalized to body mass. Furthermore, gymnasts showed higher serum concentration for hGH, and testosterone immediately after upper-body WAnT. An inverse relationship was observed in cortisol, whose concentration changes were greater in the control group. Additionally, in control group, baseline vitamin D positively correlated with cortisol changes post lower-body WAnT but negatively with testosterone changes immediately after lower-body WAnT.

**Conclusions:** Gymnastic training affects anaerobic performance and hormonal status by altering the serum concentrations of hGH, cortisol, and testosterone in response to anaerobic exercise. Moreover, hormonal status is associated with vitamin D concentration, and shows its significant regulating properties in post exercises response.

### ***Prevention and treatment outcomes of low back pain in competitive gymnasts – A systematic review. Journal of Orthopaedics, 69: 229-235, 2025.***

**Purpose:** Artistic gymnasts perform skills that involve repetitive flexion, hyperextension, and compressive loading, placing significant biomechanical stress on the lumbar spine. These demands contribute to the high prevalence of low back pain in this population. Despite its prevalence, there remains a need for targeted treatment strategies that address the sport-specific challenges faced by gymnasts.

**Methods:** Studies related to the prevention and treatment outcomes of LBP in gymnasts published before October 7, 2024 were searched and screened from the PubMed/Medline, Embase (OVID), and Web of Science databases. Four studies met inclusion criteria and were included in this review.

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**Results:** Across the three studies assessing conservative treatment for LBP, 50-100 % of gymnasts reported improvement in LBP while 50-67 % of gymnasts reported resolution of symptoms. In one case series, outcomes after surgical intervention were variable with one gymnast returning to gymnastics within 6 weeks postoperatively and the other gymnast failing to return to gymnastics.

**Conclusions:** Conservative interventions, including trunk muscle endurance training, physical therapy, and segmental control exercises appear effective in reducing low back pain in artistic gymnasts. It is difficult to draw conclusions regarding surgical intervention in the gymnastic population due to the low number of high quality studies. Future studies should attempt to stratify various exercise regimens to further improve outcomes in this population.

### Golf

#### ***Warm-Up Program for Adolescent Golfers Reduces Low Back Pain: A Double-Blind, Randomized Controlled Trial. Translational Sports Medicine, 10: 6993582, 2025.***

**Introduction:** Low back pain (LBP) is common in golfers. While numerous injury prevention programs exist for youth athletes, there is a significant lack of such programs to prevent LBP in adolescent golfers.

**Objective:** To ascertain the impact of an LBP prevention program on the incidence of LBP among adolescent golfers.

**Design:** A double-blind, randomized controlled trial.

**Participants:** Forty-five high-school golfers participated (age,  $16.0 \pm 0.7$  years).

**Interventions:** Participants were randomly allocated to either a Golfer's Low Back Pain Exercise Prevention program (GLEP) group ( $n = 23$ ) or a Sham group ( $n = 22$ ). Both groups were instructed to implement each intervention before playing golf for 12 weeks.

**Outcome Measure(s):** The primary outcomes were the number of people with LBP and number of LBP incidents. Secondary outcomes included the trunk motion direction associated with LBP and the golf swing phase during which LBP occurred. A chi-square test was employed to compare the number of people with LBP. Poisson regression analysis was performed to compare the number of LBP incidents and secondary outcomes between the two groups.

**Results:** There was no significant difference between groups in number of people with LBP over the 12-week period (GLEP:  $n = 5$ ; Sham:  $n = 8$ ; odds ratio = 0.486,  $p=0.279$ ). However, the number of LBP incidents was significantly lower in the GLEP group (GLEP: 16 incidents; Sham: 100 incidents; odds ratio = 0.157,  $p < 0.001$ ). Secondary outcomes showed



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that the GLEP group had a significantly lower number of LBP incidents during trunk extension and rotation, as well as in all golf swing phases except for the address phase ( $p < 0.05$ ).

**Conclusions:** The GLEP for adolescent golfers over a 12-week period reduced the incidence of LBP. Regular use of GLEP program can be recommended for high-school golfers in LBP prevention.

### ***Recovery for professional and elite amateur golfers: A scoping review of evidence-based methods. Sports Medicine, Ahead of Print: 2025.***

**Abstract** - The lifestyle and athletic demands of a professional or elite amateur golfer are both physically and mentally challenging. Players need to withstand large forces during the swing, frequently travel between time zones, and often cycle through a variety of training and competition environments for large portions of the competitive season. Thus, with numerous factors contributing to physical and cognitive stress, optimising recovery for golfers is paramount. The primary objective of this scoping review was to evaluate different evidence-based recovery methods for professional and elite amateur golfers and assess where the current research gaps lie. A three-step search strategy identified relevant primary and secondary articles, in addition to the grey literature, using a total of five online databases (SPORTDiscus, Scopus, Web of Science, ProQuest Central and PubMed), which retrieved articles from January 2000 to May 2024. Data were extracted using a standardised tool to create a descriptive analysis and a thematic summary. Studies were included if they focused on nutritional and hydration methods, laboratory and controlled environment methods, sleep and jet lag management, independent methods or adjunct recovery methods, in relation to golf or other sporting populations. The initial search found 4862 relevant articles from the selected databases, with 39 studies meeting our criteria for the scoping review. Limited investigations have been conducted examining effective recovery methods for golfers. However, some preliminary evidence supports the use of targeted nutrition and hydration strategies, massage, and regular mobility and flexibility exercise. In addition, though, a more fundamental focus on sleep and jet lag management strategies is required, given the lifestyle challenges often faced by professional and elite amateur players. If golfers want to improve their chances of consistently competing at the highest level, strategies that focus on optimising recovery for superior health and well-being are essential for helping to sustain performance over time.



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### Hockey

***Resisted Sprint Training Improves Overground Sprint, Jump, and Isometric Mid-Thigh Pull Kinetics and Kinematics in Male Youth Ice Hockey Players: A Randomized Control Trial. Journal of Human Kinetics, 98: 117-131, 2025.***

**Abstract** - This study investigated the effects of an on-ice resisted sprint training (RST) intervention, an overground RST intervention and a traditional training control condition on measures associated with ice skating completion time. The vertical jump, the broad jump, the isometric mid-thigh pull, and overground sprint completion times, along with sprint kinetics and kinematics were obtained prior and at the conclusion of the 8-week training intervention. There was a 7% increase in jump height ( $p < 0.05$ ), a 9% increase in the jump peak force ( $p < 0.05$ ), a 10% increase in jump peak power and a 21% increase in broad jump distance ( $p < 0.001$ ) across all groups. Only the overground RST group significantly improved by 12% ( $p = 0.007$ ) in the isometric mid-thigh pull peak force. All groups decreased 9.14-m completion time (-3%), 36.58-m completion time (-4%), and flying 30-m top speed completion time (-9%) ( $p < 0.05$ ). The on-ice RST group improved by 22% in theoretical maximal horizontal force, 24% in theoretical maximal horizontal power, and 7% in the maximal ratio of force ( $p < 0.05$ ). The step rate decreased by -2%, and the trunk angle increased by 48% at the touchdown and 30% at the toe-off for the overground RST group ( $p < 0.05$ ). RST and bodyweight training induced comparable changes across most overground athletic performance measures associated with ice skating. Coaches desiring to improve overground predictors of ice-skating performance in ice hockey players may benefit from incorporating RST as a component of a well-rounded strength and conditioning program.

***High rates of return to play and no deterioration in performance following ankle fractures in National Hockey League players. Journal of Orthopaedics, 29: 331-335, 2025.***

**Background:** Ankle fractures are common injuries in high-impact sports but have not been extensively studied in professional hockey. Given the high-speed, collision-heavy nature of the National Hockey League (NHL), ankle fractures may significantly affect player performance and team resources.

**Purpose:** To investigate the incidence, management, and impact of ankle fractures on return-to-play (RTP) and performance metrics among NHL players.



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**Methods:** A retrospective review of NHL players from 2013 to 2023 identified 30 athletes who sustained ankle fractures. Injury data, treatment intervention (surgical vs. non-surgical), and mechanism of injury were recorded from an online database. Performance metrics were compared between pre- and post-injury seasons using non-parametric statistical methods.

**Results:** The calculated rate of occurrence was 0.52 ankle fractures per 10,000 athlete exposures. All players returned to NHL play, with a mean time to return of  $1.8 \pm 1.0$  months. There were no significant differences in performance metrics, including goals, assists, points, time on ice, or shooting efficiency, between pre- and post-injury seasons. Surgically treated players had a longer recovery time (2.7 vs. 1.4 months;  $p = 0.007$ ) but missed a similar number of games compared to non-surgically treated players ( $16.6 \pm 14.5$  vs  $16.2 \pm 12.1$  games missed,  $p = 0.756$ ). Puck impact injuries were more likely to require surgery than contact-related injuries ( $p = 0.038$ ). No player sustained a refracture.

**Conclusion:** This study found that ankle fractures are a rare injury sustained by NHL players but do not lead to statistically significant deterioration in player performance metrics. All NHL players successfully returned to play at the NHL level at a mean time to RTP of 1.8 months. Taken together, these findings indicate that ankle fractures in NHL players have minimal effect on their ability to return to and maintain pre-injury performance levels.

### Lacrosse/Field Hockey

***The relationship between external and internal load, sleep, and wellness during an off-season phase in women's collegiate NCAA Division 1 lacrosse athletes. Journal of Strength and Conditioning Research, Ahead of Print: 1-7, 2025.***

**Abstract** - The relationship between external and internal load, sleep, and wellness during an off-season phase in women's collegiate NCAA Division I lacrosse athletes. J Strength Cond Res XX(X): 000-000, 2025-The purpose of this study was to investigate the bidirectional associations between workload, recovery, sleep, and wellness during the off-season in collegiate women's lacrosse athletes. Data from 20 athletes were evaluated throughout 2 weeks of off-season. Workload was determined by Edwards Training Impulse (eTRIMP), total distance (TD), high-speed running distance (HSR), and session rating of perceived exertion-derived internal training load (sRPE-TL). Resting heart rate and heart rate variability were measured during a 10-minute period upon waking each morning. A Consensus Sleep Diary and Modified Hooper wellness questionnaires were completed within 60 minutes of waking to determine sleep efficiency (SE), sleep onset latency, wake after sleep onset (WASO), total sleep time, and wellness scores. Repeated-measures correlations determined the bidirectional relationships between workload and measures of sleep and wellness ( $\alpha = 0.05$ ). Total



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distance, eTRIMP, and sRPE-TL inversely correlated with the following night's SE ( $r = -0.204$ ,  $-0.218$ , and  $-0.172$ , respectively) and SE positively correlated with same-day TD ( $r = 0.222$ ) and eTRIMP ( $r = 0.199$ ). This relationship was attributable to WASO, with both TD ( $r = 0.187$ ) and eTRIMP ( $r = 0.179$ ) having positive correlations with WASO. A positive correlation with session duration was observed for TD ( $r = 0.811$ ), eTRIMP ( $r = 0.914$ ), HSR ( $r = 0.417$ ), and sRPE-TL ( $r = 0.168$ ). Significant associations between workload, sleep, and wellness outcomes were found, with WASO and session duration emerging as key factors. Although we observed associations between workload, subjective wellness, sleep outcomes, the small-to-moderate relationship strengths suggest other contributing factors. Practitioners should prioritize sleep hygiene education to help athletes mitigate potential sleep disruptions caused by training.

### ***What biomechanical parameters are related to drag-flick performance in field hockey? A systematic review. Sports Biomechanics, 24(4): 2025.***

**Abstract** - The drag-flick is a highly relevant skill to enlarge scoring opportunities during penalty corners in field hockey. Understanding drag-flick biomechanics will likely assist in optimizing training and performance of drag-flickers. The purpose of this study was to identify the biomechanical parameters related to drag-flicking performance. Five electronic databases were systematically searched from inception to 10 February 2022. Studies were included if quantified biomechanical parameters of the drag-flick were assessed and related to performance outcomes. Quality assessment of the studies was performed according to the Joanna Briggs Institute critical appraisal checklist. Study type, study design, participants' characteristics, biomechanical parameters, measurement instrumentation and results were extracted from all included studies. The search yielded 16 eligible studies (142 drag-flickers). Many different single kinematic parameters were associated with drag-flick performance and related to biomechanical aspects described in this study. Nonetheless, this review identified a lack of a solid body of knowledge on this topic due to a low number of studies as well as low study quality and strength of evidence. Future high-quality research is needed to develop a clear biomechanical blueprint of the drag-flick to better understand this complex motor skill.



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### Soccer

***Examining agreement between coach prescribed and observed training loads with those that are reported by professional female soccer players. Journal of Strength and Conditioning Research, Ahead of Print: 1-7, 2025.***

**Abstract** - There is no research exploring agreement of training load (TL) between players and coaches in female soccer, therefore, we examined agreement of perceived TL between professional female soccer players and their coaches. An observational research design was used with a professional women soccer team (3 coaches and 23 players), with data collected for an 8-week training period from a total of 20 training sessions. Internal TL was measured using differential ratings of perceived exertion (dRPE) on the original Borg CR-100 scale, with exertional scores taken for the overall ratings of perceived exertion, ratings of perceived exertion of breathlessness, ratings of perceived exertion on the legs, and technical ratings of perceived exertion. External TL was measured with PlayerData global positioning system units, worn during every training session, with total distance and high-intensity distance data selected for the study. Players and coaches were familiarized with dRPE and the CR-100 scale. Before training, coaches provided a training plan alongside prescribed dRPE and external load. After training, coach-observed dRPE and external load measures were collected alongside player-perceived dRPE. Two 1-sided tests assessed equivalence between coach (prescribed and observed) and player-perceived dRPE. Statistically significant equivalence was reported for agreement between coach (prescribed and observed) and player-perceived dRPE ( $p < 0.05$ ). However, for both external TL measures, no statistical significance in agreement was reported between coaches and players. This study provides preliminary evidence of agreement between coach and player perceptions of TL in professional woman's soccer. This study provides a key finding in professional woman's soccer, potentially allowing greater precision in TL prescription and achieving desired training outcomes.



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### ***Normative single joint isometric hamstring strength scores from professional soccer players during preseason. Journal of Strength and Conditioning Research, Ahead of Print: 1-8, 2025.***

**Abstract** - Monitoring changes in isometric force production from the hamstrings has become increasingly common in team sports. With an increase in force plate availability in soccer, isometric hamstring assessments have become popular, yet normative benchmarks do not currently exist. The purpose of this study was to provide normative force production benchmarks for professional soccer players obtained during isometric hamstring assessments. One hundred forty-two senior professional men's soccer players (age, 24.56  $\pm$  5.09 years; height, 183.63  $\pm$  5.84 cm; mass, 82.12  $\pm$  8.35 kg) performed 2 isometric assessments with 30° and 90° of hip flexion and similar knee joint angles. Mean and standard deviation were determined across 3 trials, differences between soccer positions (goalkeeper, defender, midfielder, and strikers) and differences between limbs were determined through one-way ANOVA. p value was set at .05, and effect size was calculated using Cohens d. Benchmarks were developed using T-scores. Trivial-moderate positional differences (d 5 0.09–0.95) were observed for absolute peak force, whereas only trivial positional differences (d 5 0.00–0.01) were observed for relative peak force (i.e., peak force/body mass). Trivial between limb differences (d 5 0.12–0.13) were observed for assessment performed at 90°; however, small differences were observed in the 30° test (d 5 0.27–0.29). Benchmark values are provided for relative peak force due to no meaningful difference between positions. Practitioners could use the normative benchmarks provided to determine training needs and establish specific goals. The isometric hamstring assessment positioned at 30° of knee and hip flexion may be more sensitive to determine interlimb differences.

### ***Physiological, physical and technical demands during sided soccer game formats: A review. International Journal of Sports Medicine, Ahead of Print: 1-32, 2025.***

**Abstract** - This meta-analysis aimed to compare the acute physiological, physical, and technical demands in soccer players during different sided game formats (1v1 to 10v10). This review included studies on soccer players with a competitive or developmental level, focusing on games with at least one comparison of sided formats. Outcomes assessed included physiological parameters (e.g., heart rate and blood lactate levels), physical demands (e.g., distance and accelerations), and technical actions (e.g., passes). The risk of bias assessment tool for nonrandomized studies of interventions (RoBANS 2) and (Grading of Recommendations, Assessment, Development and Evaluation) were used to evaluate the risk of bias and the certainty of evidence. The search across PubMed, Scopus, and Web of Science identified 2,545 records, of which 72 studies were included. Meta-analyses found that 2v2 and 3v3 formats were more



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physiologically intense, showing higher perceived exertion and blood lactate levels, with 3v3 also having higher heart rates. The 4v4 and 3v3 formats resulted in greater physical demands compared to the 2v2 format, with increased distances covered at various speeds, although differences were minimal beyond the 4v4 format. Smaller formats promoted ball possession, while the 3v3 format resulted in more successful shots, dribbles, and passes. In conclusion, small-sided games (< 3v3) were more physiologically demanding, mid-sized formats (> 4v4) increased locomotor demands, and smaller formats improved technical skills, although the findings should be interpreted cautiously due to study limitations.

***Should GPS data be normalized for performance and fatigue monitoring in soccer? A theoretical-practical discussion on high-speed running. *Frontiers in Sports and Active Living*, 7: 1603767, 2025.***

**Abstract** - High-speed running (HSR) is one of the performance metrics of interest, as the volume of HSR during matches has been increasing over the last decade, which suggests that weekly training loads should be adjusted to align with this trend, enabling players to cope with match demands. However, the use of HSR thresholds lacks a solid rationale for their application and fails to account for individual player capacities, likely not reflecting their actual HSR efforts. As such, this theoretical-discussion provides important implications for training prescription, aiming to optimize performance and minimize fatigue. It emphasizes the significant differences in the conceptualization of HSR and highlights the advantages of adopting a normalized approach that reflects the physiological, mechanical and neuromuscular aspects related to HSR, as well as the intermittent profile of football matches. Practical HSR threshold definitions tailored to the capacities of each athlete are proposed, enabling a more evidence-based approach for the interpretation of training loads and game/player profiling. More specifically, within our proposal, HSR can be subdivided into two types: (1) HSR-1, characterized by an entry threshold based on a normalized critical speed, and (2) HSR-2, defined by an entry threshold corresponding to 75% of the athlete's maximum speed.



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### Softball

#### ***Epidemiological trends of elbow and forearm injuries in high school baseball and softball players. JSES Reviews, Reports, and Techniques, Ahead of Print: 1-25, 2025.***

**Background:** Elbow and forearm injuries are common in high school baseball and softball players. Given the trends in overuse and early sport specialization it may be prudent to provide an updated review of the epidemiological data to aid injury prevention efforts.

**Methods:** Data regarding elbow and forearm injuries in high school baseball and softball players from the 2005-2006 through 2018-2019 seasons was extracted from the National High School Sports-Related Injury Surveillance Study.

**Results:** There were 518 total elbow and forearm injuries reported for 5,738,470 AEs yielding an overall injury rate of 0.90/10000 AEs. Baseball had an increase of 0.044 elbow/forearm injury increase per 10000 AEs per year ( $p=0.04$ , 95%CI: 0.03, 0.085) while softball did not have a significant change. Baseball had a significantly higher injury rate in competition than practice (IRR=2.29, 95%CI: 1.86, 2.83). While there was no significant difference in overall injury rate for baseball pitchers than non-pitchers, softball non-pitchers had a significantly greater injury rate than pitchers (IRR=0.25, 95%CI: 0.15, 0.42).

**Conclusion:** This study found that overall forearm and elbow rate of injury has increased for baseball since the 2005-2006 season. There was no significant trend in softball. Softball nonpitchers had a higher rate of injury than pitchers while there was no difference between positions in baseball. This trend and difference between sports and positions imply the importance of injury prevention efforts tailored to each athlete.

#### ***The incidence of shoulder and elbow injuries in high school and collegiate softball athletes: A systematic review. Sports Health, Ahead of Print: 1-10, 2025.***

**Context:** Despite increased youth and adolescent participation in fast-pitch softball and the reporting of upper extremity injuries, there remains a relative paucity of research examining shoulder and elbow injuries in high school and collegiate softball athletes.



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**Objective:** To evaluate the reported incidence, setting, and positional factors associated with shoulder and elbow injuries in high school and collegiate fast-pitch softball players.

**Data Sources:** PubMed, Ovid, Medline, EMBASE, Scopus, Cochrane Central, and Clinicaltrials.gov.

**Study Selection:** English-language articles reporting the incidence of shoulder and/or elbow injuries occurring in high school or collegiate fast-pitch softball players were included. Biomechanical studies, review articles, abstract only texts, previous systematic reviews, and meta-analyses were excluded.

**Study Design:** Systematic review.

**Level of Evidence:** Level 4.

**Data Extraction:** Two reviewers independently evaluated studies. Data related to the reported incidence of shoulder and elbow injuries, injury setting, position, and rate of return to play after injury were recorded.

**Results:** A total of 22 studies were identified. In high school athletes, shoulder injury rates ranged from 0.88 to 1.14 per 10,000 athletic exposures (AE), with elbow injury rates ranging from 0.41 to 0.71 per 10,000 AE. In collegiate athletes, reported injury rates ranged from 3.76 to 5.93 per 10,000 AE for shoulder and 1.5 to 3.39 per 10,000 AE for elbow injuries. Shoulder and elbow injuries were reported more commonly during competition in high school athletes, and with greater frequency in the practice setting in collegiate athletes. No association between injury incidence and position was appreciated at either the high school or collegiate level. Most (81%-96%) athletes were able to return to sport within 3 weeks of injury.

**Conclusion:** The incidence of shoulder and elbow injuries was greater in collegiate softball athletes than in high school athletes.

### Swimming

***The Associations Between the Swimming Speed, Anthropometrics, Kinematics, and Kinetics in the Butterfly Stroke. Bioengineering, 12: 797, 2025.***

**Abstract** - There is scarce information about what characterizes the swimming speed in the butterfly stroke and the role of thrust in its characterization and prediction. The aim of this study was to compare the fastest and poorest butterfly swimmers based on a set of anthropometric, kinematic, and kinetic variables and to identify the swimming speed predictors. Eight young male swimmers were divided into two equal groups (each group comprising four swimmers). The



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swimming speed, as well as a set of anthropometric, kinematic, and kinetic variables, were measured. The swimming speed presented significant differences between the groups ( $p = 0.011$ ,  $d = 2.18$ ). The stroke frequency (kinematics,  $p = 0.027$ ,  $d = 1.69$ ) and thrust (kinetics,  $p = 0.034$ ,  $d = 1.57$ ) also presented significant differences between the groups. The swimming speed presented significant correlations with the stroke index ( $r_s = 0.83$ ,  $p = 0.011$ ) and thrust ( $r_s = 0.83$ ,  $p = 0.011$ ). The swimming speed was predicted by a combination of the stroke frequency and thrust ( $R^2 = 0.84$ ,  $p = 0.010$ ). Coaches and athletes must be aware that combining fast stroke frequencies and the generation of greater thrust leads to the fastest swimming speeds.

### ***Effects of different warm-up methods on 50-meter breaststroke swimming performance. *Frontiers in Bioengineering and Biotechnology*, 12: 1505648, 2025.***

**Purpose:** To examine the effects of different warm-up methods on 50 m breaststroke performance in both breaststroke specialists and individual medley swimmers.

**Methods:** 18 swimmers (breaststroke group: 9, individual medley group: 9) who met the qualification standards for the National Intercollegiate Athletic Games participated in this study. Each participant completed four different warm-up protocols (a conventional 1,400 m warm-up and a 700 m conventional warm-up that integrated tubing-assisted (TA), paddle (PD), or squat (SQ) warm-ups) over four separate days. Following each warm-up protocol, a 50 m breaststroke performance test was conducted with inertial measurement unit (IMU) sensors attached to specific body segments to evaluate and compare stroke performance, stroke length, stroke frequency, and the acceleration of the hands, sacrum, and feet across different warm-up methods.

**Results:** The breaststroke specialists who performed the TA warm-ups recorded significantly less time than those who performed the conventional 1,400 m warm-ups ( $35.31 \pm 1.66$  s vs.  $35.67 \pm 1.83$  s,  $p = 0.006$ ). There was a trend that individual medley specialists who performed the SQ warm-ups recorded less time than those who performed the PD warm-ups ( $34.52 \pm 1.45$  s vs.  $34.92 \pm 1.46$  s,  $p = 0.043$ ). The stroke length of breaststroke specialists following the TA warm-ups was shorter than that following the PD warm-ups, the SQ warm-ups, and the conventional 1,400 m warm-ups. Breaststroke specialists who engaged in the TA warm-ups had higher stroke frequency than those who engaged in the conventional 1,400 m warm-ups, the SQ warm-ups, and the PD warm-ups. During the TA warm-ups, breaststroke specialists exhibited a shorter stroke length and a higher stroke frequency than individual medley specialists. Acceleration data from the center of mass and limb segments, recorded by IMUs, were insufficient to fully explain the variations in stroke frequency, stroke length, and overall performance caused by the different warm-up protocols.



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**Conclusion:** Breaststroke specialists exhibited significant improvement in their 50 m breaststroke performance after the TA warm-up. By contrast, individual medley specialists benefited more from the SQ warm-up.

### Tennis

***Exploring Difference in Hand-Foot Coordination Ability Among Tennis Players of Different Sport Levels Based on the Correlation Between Lower-Limb Acceleration and Hand Grip Force. Sensors, 16: 5152, 2025.***

**Purpose:** To quantify real-time hand-foot coupling in tennis and test whether the coupling pattern differs by playing standard.

**Methods:** Fifteen nationally certified second-level male athletes and fifteen recreational beginners performed multi-directional swings, alternating forehand-backhand groundstrokes and serve-and-volley sequences while tri-axial ankle acceleration and racket-grip force were synchronously recorded in wearable inertial measurement units (IMUs). Grip metrics (mean force, peak force, force duration) and acceleration magnitudes were analysed with MANOVA and Hedges'  $g$  effect sizes, followed by the Benjamini-Hochberg correction ( $\alpha = 0.025$ ).

**Results:** Across tasks, athletes showed higher mean ankle acceleration (standardised mean difference, Hedges'  $g$ ) but 45% lower mean grip force (Hedges'  $g = -1.28$ ; both  $p < 0.01$ ). The association between acceleration and grip metrics was moderate-to-strong and negative in athletes ( $r = -0.62$  with mean grip force;  $r = -0.69$  with force duration), whereas beginners exhibited moderate-to-strong positive correlations ( $r = 0.48-0.73$ ).

**Conclusion:** We quantified hand-foot coordination in tennis by synchronising tri-axial ankle acceleration with calibrated racket-grip force across three match-realistic tasks. Relative to beginners, athletes demonstrated an inverse coupling between ankle acceleration and grip-force metrics, whereas beginners showed a direct coupling, consistent with our purpose of quantifying coordination via synchronised wearable sensors.



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***International Tennis Federation (ITF), Women's Tennis Association (WTA), and Association of Tennis Professionals (ATP) Expert Group Statement on Nutrition in High-Performance Tennis. Current Evidence to Inform Practical Recommendations and Guide Future Research. International Journal of Sports Nutrition and Exercise Metabolism, Ahead of Print: 1-38, 2025.***

**Abstract** - The sport of tennis involves unique nutritional demands for the physical and technical aspects of match play and training, as well as the nutritional challenges associated with extensive travel and a lengthy competition calendar. An expert group assembled by The International Tennis Federation, the Women's Tennis Association, and the Association of Tennis Professionals has produced a scientific review of current evidence to inform practical recommendations for high-performance tennis. The narrative summary considers the diversity within the tennis community, including male and female players, youth players, and wheelchair players. The Expert Group Statement addresses nine specific topics: (a) introduction to tennis; (b) physiological characteristics of tennis training and match play; (c) training nutrition; (d) body composition, low energy availability, and relative energy deficiency in sport; (e) match-day nutrition; (f) dietary supplements for tennis performance; (g) environmental and travel issues; (h) nutrition guidelines during periods of illness and injury rehabilitation; and (i) special population groups. The statement advocates for an evidence-based approach to nutrition in high-performance tennis and emphasizes a "food first" philosophy, prioritizing food over supplements to meet nutrient requirements effectively. In recognition of the benefits of sound nutrition, strategies in supporting health and performance over a player's career, academies, national federations, and international organizations are encouraged to engage professionals with appropriate nutrition-related qualifications and professional registrations to support players effectively.

### **Volleyball**

***Patellofemoral pain elite female volleyball players: Correlation with trunk muscle strength. Cureus, 17(7): e88729, 2025.***

**Abstract** - Background Patellofemoral pain (PFP) is a prevalent musculoskeletal condition, particularly among adolescent and young adult females, often associated with sports involving high knee loads, such as volleyball. While previous studies have examined local and distal factors contributing to PFP, the role of trunk muscle strength remains underexplored, particularly in elite athletes. Objective The objective of this study is to investigate the correlation between PFP and trunk muscle strength in elite adolescent female volleyball players. Methods A retrospective analysis



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was conducted on 23 elite adolescent female volleyball players (mean age: 15.59 years) from the Hellenic National Team. Trunk muscle strength was measured using isokinetic dynamometry (Biodex System 4 Pro, Biodex Medical Systems, Inc., Shirley, NY, USA) during maximum flexion and extension at 90° of trunk inclination. Participants were categorized into PFP (n = 11) and non-PFP groups (n = 12) based on clinical evaluation. Statistical analysis included comparison of peak torque (Nm/kg), mean power, and agonist-antagonist ratios between groups. Results No significant differences were found in trunk flexion strength ( $p = 0.449$ ), trunk extension strength ( $p = 0.423$ ), or agonist-antagonist ratios ( $p = 0.601$ ) between PFP and non-PFP groups. Trunk extension strength was consistently greater than flexion strength across all participants. Most athletes with PFP reported pain onset linked to increased training loads. Conclusions Despite the hypothesized correlation, this study did not identify significant differences in trunk muscle strength between volleyball players with and without PFP. These findings contrast with prior research on non-athletic populations, suggesting that elite athletes may possess compensatory mechanisms. Further studies are warranted to clarify the role of trunk strength in PFP pathophysiology and inform targeted prevention and rehabilitation strategies in elite sports.

***Accuracy of three-field-based devices for measuring counter movement jump performance in elite female volleyball players. Journal of Strength and Conditioning Research, Ahead of Print: 1-6, 2025.***

**Abstract** - Accuracy of three field-based devices for measuring counter movement jump performance in elite female volleyball players. J Strength Cond Res XX(X): 000-000, 2025-The purpose of this study was to determine the accuracy of 3 field-based methods for assessing countermovement jump (CMJ) performance in elite female volleyball players, using force plate (FP) data as the criterion standard. Sixteen collegiate female volleyball players (age =  $19.4 \pm 1.5$  years, height =  $176.2 \pm 10.6$  cm, body mass =  $71.5 \pm 11.1$  kg) performed the CMJ while being simultaneously measured by a jump-and-reach device (JR), linear position transducer (LPT), mobile phone application (APP), and a criterion FP system. CMJ height from the FP ( $36.16 \pm 3.88$  cm) was significantly lower than the JR ( $39.53 \pm 5.18$  cm,  $p < 0.01$ ) and LPT ( $48.23 \pm 4.44$  cm,  $p < 0.01$ ) but slightly higher than the APP ( $35.32 \pm 3.75$  cm,  $p < 0.01$ ). In addition, the APP displayed the strongest correlation ( $r = 0.99$ ,  $p < 0.01$ ) and smallest standard error of estimate (SEE  $\pm 0.27$  cm) and 95% limits of agreement ( $\pm 0.57$  cm) compared with the other 2 devices. For CMJ, the mean power from the FP ( $2,243.00 \pm 458.03$  W) was significantly different from JR ( $2,615.69 \pm 798.03$  W,  $p = 0.02$ ) and APP ( $1,354.31 \pm 241.98$  W,  $p < 0.01$ ), but not the LPT ( $2,447.08 \pm 559.32$  W,  $p = 0.40$ ). Although the correlations for mean power ( $r = 0.61-0.76$ ) between the field devices and criterion were significant ( $p < 0.05$ ), the SEE's (range  $\pm 310.90$  to  $\pm 377.09$  W) and limits of agreement (range  $\pm 655.28$  to

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$\pm 1,064.08$  W) were considerably large. Based on the results, the APP seems to provide the most valid CMJ height measures. However, the caution should be used for assessing CMJ mean power with the field tools.

### Wrestling/Combat Sports

***Genetic factors of elite wrestling status: A multi-ethnic comparative study. Genes, 16: 906, 2025.***

**Background:** In recent years, comprehensive analyses using a genome-wide association study (GWAS) have been conducted to identify genetic factors related to athletic performance. In this study, we investigated the association between genetic variants and elite wrestling status across multiple ethnic groups using a genome-wide genotyping approach.

**Methods:** This study included 168 elite wrestlers (64 Japanese, 67 Turkish, and 36 Russian), all of whom had competed in international tournaments, including the Olympic Games. Control groups consisted of 306 Japanese, 137 Turkish, and 173 Russian individuals without elite athletic backgrounds. We performed a GWAS comparing allele frequencies of single-nucleotide polymorphisms (SNPs) between elite wrestlers and controls in each ethnic cohort. Cross-population analysis comprised (1) identifying SNPs with nominal significance ( $p < 0.05$ ) in all three groups, then (2) meta-analyzing overlapped SNPs to assess effect consistency and combined significance. Finally, we investigated whether the most significant SNPs were associated with gene expression in skeletal muscle in 23 physically active men.

**Results:** The GWAS identified 328,388 (Japanese), 23,932 (Turkish), and 30,385 (Russian) SNPs reaching nominal significance. Meta-analysis revealed that the *ATP2A3* rs6502758 and *UNC5C* rs265061 polymorphisms were associated ( $p < 0.0001$ ) with elite wrestling status across all three populations. Both variants are located in intronic regions and influence the expression of their respective genes in skeletal muscle.

**Conclusions:** This is the first study to investigate gene polymorphisms associated with elite wrestling status in a multi-ethnic cohort. *ATP2A3* rs6502758 and *UNC5C* rs265061 polymorphisms may represent important genetic factors associated with achieving an elite status in wrestling, irrespective of ethnicity.



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### ***Effects of Weight-Cutting Practices on Sleep, Recovery, and Injury in Combat Sports: A Scoping Review. Journal of Functional Morphology and Kinesiology, 10: 319, 2025.***

**Objectives:** This scoping review aims to synthesize the methodological characteristics of weight-cutting strategies, summarize their effects on sleep, recovery, and injury outcomes, and identify research gaps.

**Methods:** Following the PRISMA guidelines, searches were conducted on 20 May 2025, across PubMed, Scopus, and Web of Science, with snowball citation tracking and expert consultation to enhance retrieval. Inclusion criteria targeted peer-reviewed studies involving competitive or recreational combat sport athletes (all ages and sexes) undergoing weight-cutting practices, reporting outcomes on sleep (e.g., quality and duration), recovery (e.g., perceived fatigue and biomarkers), or injury incidence (e.g., reported injuries and odds ratios). Studies included randomized controlled trials, non-randomized trials, or cohort studies with or without comparator groups. The risk of bias was assessed using the RoB 2 tool for randomized trials and the ROBINS-I tool for non-randomized studies.

**Results:** From 2784 records, 17 studies met the inclusion criteria. Participant ages ranged from  $17.79 \pm 0.75$  to  $30.1 \pm 7.5$  years, predominantly national-level combat sport athletes (wrestling, judo, taekwondo, and MMA). Rapid weight loss (RWL, 2-10% body mass loss over 1-7 days) via food/fluid restriction, sauna use, and caloric deficits consistently increased creatine kinase (peaking at  $713.4 \pm 194.6$  U/L), perceived fatigue ( $41.8 \pm 0.9$  to  $51.3 \pm 2.0$  A.U.), and injury rates (45.62 injuries/1000 athletic exposures in females). Cortisol responses showed increases in some studies (from  $499.9 \pm 107.8$  to  $731.6 \pm 80.2$  nmol/L) and decreases in others (from  $603.2 \pm 146.8$  to  $505.8 \pm 118.4$  nmol/L). Sleep quality showed mild worsening ( $5.15 \pm 1.83$  to  $5.52 \pm 1.71$  A.U.), and perceived recovery declined post-RWL ( $101.40 \pm 2.52$  to  $87.63 \pm 2.47$  A.U.).

**Conclusions:** RWL in combat sports consistently impairs recovery, increases muscle damage and fatigue, and increases injury risk, though sleep quality effects are less pronounced. Variability in weight-cutting protocols, outcome measures, and study designs shows the need for standardized methodologies, broader inclusion of female athletes, and longitudinal studies to assess long-term impacts.

#### **Link to Full-Text Articles:**

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