



Performance Research Reviews

February 2026

Baseball

Angular momentum of the overhand, three-quarter, sidearm, and underhand delivery styles in the fastball pitch. Journal of Sports Engineering and Technology, Ahead of Print: 1-11, 2025.

Abstract - The aim of the study was to investigate differences in angular momentum values in the global coordinate system and the trunk coordinate system—the latter rotated about the throwing direction by the trunk lateral tilt angle at release for each style—throughout the entire baseball pitching between overhand, three-quarter, sidearm, and underhand styles, using waveform analyses. A total of 91 male Japanese amateur pitchers for the four deliveries of the pitches were videotaped and analyzed. Ball velocity was faster in overhand and three-quarter throws than underhand, and trunk lateral tilt angle at release was greatest for overhand, followed by three-quarter, sidearm, and underhand. System and trunk-and-head angular momentum values around the axis along the throwing direction in the global coordinate system were largely different among the four styles, distinguishing the styles from each other. Although the upper body angular momentum values around the axis perpendicular to the throwing direction in the global coordinate system substantially differ among delivery styles, differences in the area around the corresponding axis in the trunk coordinate system were minimal, and the differences in angular momentum values (overhand, three-quarter > three-quarter > underhand) mainly found around the trunk longitudinal axis, suggesting that the angular momentum around the trunk longitudinal axis is essential for achieving a fast ball.

Effectiveness of single leg isometric bridge and Nordic hamstring exercise testing for prediction of hamstring injury risk in professional baseball players. The American Journal of Sports Medicine, Ahead of Print: 1-9, 2025.

Background: Several investigations have examined various methods of measuring hamstring strength to determine the effectiveness of these tests in predicting hamstring injury (HSI) risk in athletes. However, no previous studies have examined the effectiveness of hamstring strength and interlimb asymmetry utilizing a newly developed modified single leg isometric bridge test (SLIBT) versus a standard Nordic hamstring exercise (NHE) to predict HSI in professional baseball players.



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Purpose: To determine whether preseason hamstring strength and interlimb asymmetry measured using a modified SLBIT versus an NHE are associated with future HSI in professional baseball players, as well as if measures of hamstring strength and interlimb asymmetry using the SLBIT are correlated to values from the NHE.

Study design: Cohort study; Level of evidence, 3.

Methods: Professional baseball players ($n = 465$) from 8 teams affiliated with a single Major League Baseball organization completed a preseason hamstring strength assessment as part of routine athlete monitoring before the 2019, 2021, and 2022 seasons. A total of 38 new HSI events were recorded among 36 players over 751 player-seasons included in the analysis.

Results: Lower hamstring strength levels in subsequent HSI limbs were observed compared with the 2-limb mean hamstring strength of healthy players for the SLBIT (365.1 ± 58.4 vs 390.9 ± 59.6 N; $P = .014$) and NHE (403.5 ± 90.4 vs 440.5 ± 76.0 N; $P = .017$). Players with NHE hamstring strength <377 N exhibited a significantly higher risk of HSI (RR, 2.49; 95% CI, 1.18-5.27; $P = .027$). Logistic regression indicated an inverse relationship between hamstring strength and HSI risk, with each 10-N increase in the SLBIT and NHE corresponding to a 7.4% and 6.2% risk reduction, respectively (with no interaction effects between tests). Interlimb asymmetry measures from both the SBILT and NHE were not indicative of subsequent HSI. Moderate significant correlations ($r = 0.33$ - 0.39) were observed for absolute and relative hamstring strength measured utilizing the SLBIT versus the NHE. No significant correlations were found between measures of interlimb asymmetry when assessed by the SBILT versus the NHE.

Conclusion: The current investigation indicates that low levels of hamstring strength measured in both the SLBIT and NHE are associated with an increased risk of future HSI. Thus, these measures could be utilized to identify at-risk players and to develop mitigation strategies to limit the rate of HSI and maximize time at play.

Grip strength, muscle soreness and pain threshold perception evolution in baseball pitchers in a simulated 75-pitch game: A repeated measures study. BMJ Open Sport & Exercise Medicine, 11: e0021, 2025.

Background/aim: In baseball pitching, neuromuscular fatigue and its manifestations on muscle strength, muscle soreness and pain perception affect pitching performance. The purpose of this study was to quantify the evolution of



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grip strength, muscle soreness and pain threshold perception and pitching velocity in baseball pitchers throughout a simulated 75-pitch game.

Methods: 30 high-level amateur male baseball pitchers were recruited. Repeated measure analysis of covariance with age as a covariate ($p < 0.05$) was used to identify significant differences across blocks of pitches for grip strength, muscle soreness, pain threshold perception and pitching velocity.

Results: Dominant arm grip strength (55.67 ± 12.32 kg to 48.62 ± 12.25 kg ; -12.66%) and pitching velocity (119.87 ± 8.00 km/hour to 118.75 ± 6.90 km/hour ; -0.93%) declined while muscle soreness perception increased in dominant arm forearm flexors (1.65 ± 1.16 to 4.19 ± 2.02 ; 25.38%), biceps (1.81 ± 1.39 to 4.31 ± 1.85 ; 25%) and non-dominant arm forearm flexors (1.38 ± 1.10 to 2.12 ± 1.63 ; 7.31%) across the pitching blocks ($p < 0.05$).

Conclusion: In summary, a pitch count of 75 fastball pitches triggered an acute decline in grip strength combined with an increase in muscle soreness perception of the throwing arm in baseball pitchers.

Normative hip range of motion and strength profiles of uninjured baseball athletes: A systematic review. Journal of Sport Rehabilitation, 34: 691-703, 2025.

Context: The baseball athlete incorporates the use of the entire kinetic chain while throwing. Hip range of motion (ROM) and strength have been previously studied in its relation to injury development. It is a clinical necessity to understand the normative profiles of hip musculoskeletal function across the playing career.

Objectives: To identify the normative hip ROM and strength profiles of baseball players across level of play.

Evidence acquisition: The researchers searched the electronic databases MEDLINE, SPORTDiscus, CINAHL, and Embase using a custom search strategy. After applying inclusion and exclusion criteria, 31 articles were reviewed. Of these 31 articles, 22 examined hip ROM and/or strength in uninjured baseball athletes. A manual search of the references of those 22 articles revealed 4 additional articles that met the inclusion criteria. In total, 26 articles were included in data collection.

Evidence synthesis: Articles were assessed for quality using the appraisal tool for cross-sectional studies. The appropriate hip ROM and strength data, along with player demographics, were extracted and reviewed to ensure accuracy. Articles were also categorized based on level of play and player position.



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Conclusions: Hip ROM and strength profiles of baseball athletes across all levels of play were identified and presented to comprehensively summarize the available data on normative musculoskeletal hip profiles. Observed differences between positions and across levels of play were documented. In general, hip external rotation ROM was greater than internal rotation across all levels and between the stance and lead limbs. As age and level of play increased, the difference between hip external rotation and internal rotation ROM also increased. Hip strength increased as level of play (and subsequently age) increased. These summarized data can be used as benchmarks to compare clinical populations.

Basketball

Incidence of knee cartilage pathology on magnetic resonance imaging and correlation to clinical symptoms and orthopaedic history among players at the National Basketball Association Draft Combine. American Journal of Sports Medicine, Ahead of Print: 1-8, 2025.

Background: High-level basketball athletes at the collegiate level and in the National Basketball Association (NBA) have a greater proportion of knee cartilage pathology than the nonathlete population. However, little is known as to whether identified pathology on knee magnetic resonance imaging (MRI) correlates with clinical symptoms or orthopaedic history in these players.

Purposes: (1) To evaluate knee MRI scans in a cross-sectional population of NBA Draft Combine players to establish prevalence of knee pathology, including that of articular cartilage and meniscus in professional basketball players. (2) To identify independent variables including demographic characteristics, playing history, previous knee injury, and symptoms that correlate to these MRI findings.

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

Methods: Players from the NBA Draft Combine over a 2-year period voluntarily participated by undergoing bilateral knee MRI scanning and completing clinical questionnaires. MRI scans were independently and blindly evaluated by 2 radiologists for cartilage assessment (using modified Noyes score) and meniscal pathology. Associations between imaging findings and pain/function scores and orthopaedic history were evaluated.

Results: A total of 43 players (80 knees) were included. Intraclass correlation coefficients were a mean of 0.827 for agreement and 0.831 for consistency for the modified Noyes score. Cartilage pathology was identified in 48.3% of knees, with the most common locations being the patella and trochlea. Previous knee surgery was associated with lateral tibial



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plateau chondral pathology (odds ratio [OR], 6.58; $P = .04$). Reduced function scores were predictive of cartilage pathology on the lateral femoral condyle (OR, 0.55; $P = .03$). Increased pain scores were associated with a nonzero modified Noyes score (OR, 6.11; $P < .01$).

Conclusion: The incidence of pathology identified on knee MRI scans in players at the NBA Draft Combine without clinical symptoms was high, in line with the hypothesis. Little correlation was found between the objective imaging findings and subjective pain, function, and orthopaedic injury history. Clinicians treating high-level athletes should focus on treating clinically significant findings and be cautious about treating pathology found on imaging that may not explain or correlate with symptoms. It remains critical to study the natural history of imaging findings in these athletes to better ascertain the ultimate effect of sport and physiologic load on disease progression.

Investigation of force plate jump testing metrics relevant to return to play decision making in basketball athletes after anterior cruciate ligament reconstruction. International Journal of Sports Physical Therapy, 20(7): 985-994, 2025.

Background: Force plate vertical jump testing can identify persistent lower limb asymmetries after anterior cruciate ligament reconstruction (ACLR). Unfortunately, there is no consensus on which vertical jump task, nor the hundreds of available metric assessment combinations that are relevant to basketball athletes after ACLR.

Purpose: The purpose of this study was to examine the jump performances of high school and collegiate male basketball athletes in the final stages of ACLR rehabilitation to 1) establish referenceable between-limb symmetry scores, and 2) identify metrics that best detect between-limb asymmetry during common vertical jump tasks.

Study Design: Retrospective cohort examination

Methods: Forty-nine male high school and collegiate basketball athletes who underwent primary ACLR were examined using a dual force plate system in the final stages rehabilitation. Participants were subdivided into two groups: athletes who exhibited above or below 90% isokinetic quadriceps peak torque limb symmetry index (LSI). Select jump metrics were collected from three jumping tasks: double-leg countermovement jump (DL-CMJ), single-leg countermovement jump (SL-CMJ), and single-leg repeat hop (SL-RH). Referenceable LSI jump scores were reported using descriptive analysis and compared between the two groups using independent samples t-tests.



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Results: Significant differences in LSI between the two groups were identified ($p < 0.05$) during the DL-CMJ: eccentric rate of force development (MD= -22.6), concentric impulse (MD= -22.4), concentric impulse 100ms (MD= -24.0), contact time (MD= -.43), and peak take-off force (MD= -12.7), and during the SL-RH: jump height (MD= -12.4) and flight time:contact time (MD= 13.3). No significant differences were found during SL-CMJ testing.

Conclusions: In the final phases of ACLR rehabilitation, basketball athletes who exhibit quadriceps strength asymmetry also demonstrated greater asymmetry during double-leg and single-leg reactive jumping tasks but not during single-leg countermovement jumps suggesting the importance of a battery of jump tests to ensure adequate restoration of physical qualities required for the sport.

Level of Evidence: Level 3

Optimizing offensive gameplan in the National Basketball Association with machine learning. arXiv.2308.06851: 1-6, 2025.

Abstract - Throughout the analytical revolution that has occurred in the NBA, the development of specific metrics and formulas has given teams, coaches, and players a new way to see the game. However - the question arises - how can we verify any metrics? One method would simply be eyeball approximation (trying out many different gameplans) and/or trial and error - an estimation-based and costly approach. Another approach is to try to model already existing metrics with a unique set of features using machine learning techniques. The key to this approach is that with these features that are selected, we can try to gauge the effectiveness of these features combined, rather than using individual analysis in simple metric evaluation. If we have an accurate model, it can particularly help us determine the specifics of gameplan execution. In this paper, the statistic ORTG (Offensive Rating, developed by Dean Oliver) was found to have a correlation with different NBA playtypes using both a linear regression model and a neural network regression model, although ultimately, a neural network worked slightly better than linear regression. Using the accuracy of the models as a justification, the next step was to optimize the output of the model with test examples, which would demonstrate the combination of features to best achieve a highly functioning offense.



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Return to basketball for college and professional athletes after surgical repair of Achilles tendon. *Annals of Biomedical Research*, 5(2): 1-4, 2025.

Background: Basketball places extreme mechanical stress on an athlete's body, leading to a variety of injuries within the sport. Achilles tendon (AT) ruptures have started to garner attention as the incidence of this season ending injury continues to increase [1]. AT ruptures have also been shown to have a higher prevalence in basketball compared to other sport populations. [2]. With the recovery time of AT ruptures being a minimum of 6 months, and data supporting a decrease in player performance and career longevity, it is important to understand the indicated pathophysiology behind the injury along with the surgical management options [2].

Objective: This article aims to investigate the return to basketball for collegiate and professional athletes after an Achilles tendon rupture.

Methods: A systematic literature search was conducted using the University of Texas Rio Grande Valley (UTRGV) online database. The search included the terms "Achilles" and "return to play" to identify relevant studies assessing average time of return to play and the factors that can influence said time.

Results: A total of 19 studies were reviewed, showing that 9-10 months was the average duration of return to play for professional basketball players following an Achilles injury. Multiple publications show a player's performance decrease following injury while one manuscript showed an improvement in performance for players, which could be attributed to the latter investigating collegiate players that are younger than professional basketball players.

Conclusion: There is evidence that supports a reasonable expectation for athletes to return to play 10 months after an AT surgery. However, a variety of factors contribute to the ability of the individual athlete to return to play.

Football

Calf muscle injury in elite athletics: An 8-season prospective cohort study. *Journal of Science and Medicine in Sport*, Ahead of Print: 1-23, 2025.

Objectives: To describe epidemiological data of indirect calf muscle injury (CMI) in elite track and field athletes. To investigate relationships between CMI and athlete characteristics to inform future injury prevention strategies.

Design: Descriptive epidemiology study.



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Methods: A total of 201 track and field athletes, mean age 25.9 ± 4.4 , were prospectively observed over 8 seasons (616 athlete seasons). The main outcome measures were injury location, injury number, incidence, incidence proportion, severity, burden and recurrence. Poisson generalised that linear regression models were used to explore relationships between potential risk factors.

Results: There were 85 CMIs during the study period. Thirty three percent of CMIs were classified as severe. Soleus injuries had the highest incidence, burden and recurrence and were present across all event groups. Incidence proportion of all CMIs was 11.1 %, with the highest incidence of injuries occurring in April. Acute CMI was the most common mechanism, with the right lower limb (58 %) being more affected than the left (42 %). There was no association between CMI occurrence and sex, though there was a significant positive effect between both age and previous lower limb injury.

Conclusions: Calf muscle injury is prevalent in elite track and field athletes. CMI has a peak incidence in April which can have a detrimental effect on an athlete's performance goals for the impending summer competition season. The soleus muscle is the most injured muscle with the biggest burden and recurrence making it a muscle of focus when developing rehabilitation and prevention programs. Older athletes, and athletes with a previous lower limb injury, are more at risk of CMI in elite athletics. Due to the burden and potential performance impact of CMI, further injury prevention efforts are required to reduce the impact of this injury type.

Periodization for Success – In-season external training loads relative to competition load in American football. *Frontiers in Sports and Active Living*, 7: 1662240, 2025.

Introduction: Despite an exponential development in performance monitoring technologies, the physical performance demands of sport remain an understudied topic in scientific literature. Thus, the primary purpose of this study was to quantify and compare the training loads (TL) of a collegiate American football team between in-season practices and official games by general position group, event type, and to assess the interaction between the two.

Methods: Twenty-seven NCAA Division-II athletes volunteered to participate in this investigation. In-season TL during 32 practices (categorized as days before game day; GD minus) and 11 conference games were recorded using global positioning system technology. Collected data included total duration, total distance, yards traveled per minute, hard running distance, hard running efforts, 2-dimensional (2D) load, and 3-dimensional (3D) load.



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Results: A factorial analysis of variance revealed significant main effects in TL for event type ($p < 0.001$) and position groups ($p < 0.001$), and an interaction effect between the two ($p < 0.001$). Unique microcyclic characteristics were observed for each measure of interest. Relative to game values (100%), values for training duration (+25% to -12%; GD-4 to GD-1), yards per minute (+15% to -11%), total distance (+37% to -3%), hard running distance (+33% to -7%), hard running efforts (+33% to -12%), 2D-load (+40% to -7%), and 3D-load (+44% to -3%) were significantly greater than game values on distinct days during the week.

Discussion: These findings can improve the current understanding of practice demands relative to games, which may support more optimal sport-specific periodization approaches within American football.

Resident Case Series: The utility of the Athletic Shoulder Test using wireless portable force plates for measuring peak force in NCAA Division 1 collegiate quarterbacks. International Journal of Sports Physical Therapy, 20(7): 1039-1049, 2025.

Background: Given the high incidence of shoulder injuries among quarterbacks due to the repetitive stress of the overhead throwing motion, there is a need for targeted, sport-specific assessments that reflect the functional demands of throwing. The Athletic Shoulder (ASH) test, previously validated in rugby and baseball populations, offers a potential solution for upper extremity strength assessment in football quarterbacks. The primary purpose of this case series was to explore the feasibility of conducting the ASH test as a method for evaluating upper extremity strength in overhead athletes, specifically collegiate quarterbacks.

Study design: Case series.

Methods: Three NCAA Division I quarterbacks participated in weekly ASH testing over a nine-week period. Peak isometric force, peak force normalized to body weight, and limb symmetry indices were measured in the shoulder "Y" and "T" positions using portable force plates. Testing was completed pre-practice on non-game days to minimize fatigue effects and maintain consistency.

Results: The dominant shoulder consistently produced greater peak force than the non-dominant side in both Y and T positions. The mean dominant-to-non-dominant limb symmetry index was 1.13 in the Y position and 1.14 in the T position. Within limbs, peak force was greater in the Y position than in the T position. In both positions and in both arms, athletes generated at least 14% of their body weight in force on average.



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Conclusion: These findings can provide insight into strength asymmetries and functional performance benchmarks, enabling strength coaches, athletic trainers, and rehabilitation professionals to fine-tune training and rehabilitation programs. Incorporating the ASH test into a standardized assessment battery may enhance the ability to evaluate an athlete's readiness to train or compete, promoting a proactive approach to performance optimization and injury prevention. Its utility and actionable metrics make the ASH test a practical tool for in-season monitoring, allowing practitioners to make informed, data-driven adjustments throughout the season.

Level of evidence: Level 4.

Using a Bayesian network to classify time to return to sport based on football injury epidemiological data. PLOS ONE, 20(3): e0314184, 2025.

Abstract - The return-to-sport (RTS) process is multifaceted and complex, as multiple variables may interact and influence the time to RTS. These variables include intrinsic factors related the player, such as anthropometrics and playing position, or extrinsic factors, such as competitive pressure. Providing an individualized estimation of time to return to play is often challenging, and clinical decision support tools are not common in sports medicine. This study uses epidemiological data to demonstrate a Bayesian Network (BN). We applied a BN that integrated clinical, non-clinical factors, and expert knowledge to classify time day to RTS and injury severity (minimal, mild, moderate and severe) for individual players. Retrospective injury data of 3374 player seasons and 6143 time-loss injuries from seven seasons of the professional German football league (Bundesliga, 2014/2015 through 2020/2021) were collected from public databases and media resources. A total of twelve variables from three categories (player's characteristics and anthropometrics, match information and injury information) were included. The response variables were 1) days to RTS (1-3, 4-7, 8-14, 15-28, 29-60, > 60, and 2) injury severity (minimal, mild, moderate, and severe). The sensitivity of the model for days to RTS was 0.24-0.97, while for severity categories it was 0.73-1.00. The user's accuracy of the model for days to RTS was 0.52-0.83, while for severity categories, it was 0.67-1.00. The BN can help to integrate different data types to model the probability of an outcome, such as days to return to sport. In our study, the BN may support coaches and players in 1) predicting days to RTS given an injury, 2) team planning via assessment of scenarios based on players' characteristics and injury risk, and 3) understanding the relationships between injury risk factors and RTS. This study demonstrates the how a Bayesian network may aid clinical decision making for RTS.



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Gymnastics

Integration of coordination and kinetic analysis reveals mechanisms of upper limb joint loading and technique-specific strategies in female gymnastics. Sports Biomechanics, Ahead of Print: 1-18, 2026.

Abstract - This study aimed to identify differences in upper-limb coordination by integrating vector coding with joint kinetics across three round-off (RO) techniques to better explain potential injury mechanisms. Twelve female gymnasts performed six trials of each RO technique (Parallel, Reverse, T-shape). The kinematic and kinetic data were collected. All analyses focused on the contact phase of the second hand. Elbow and Wrist joint flexion/extension ($E_{F/E}$ - $W_{F/E}$) and rotation (E_{ROT} - W_{ROT}) couplings were assessed using modified vector coding to determine coupling angle (CA) and variability (CAV). Elbow joint adduction/abduction moments (M_{elbow}) and joint power (JP_{elbow}) were calculated using inverse dynamics. Joint kinetics and CA were overlaid on the same plots to visualise how kinetic patterns corresponded with coordination dynamics. Results showed decreased M_{elbow} using the T-shape technique ($p < 0.001$) with E_{ROT} - W_{ROT} in-phase, while Reverse and Parallel techniques exhibited anti-phase with increased M_{elbow} ($p < 0.001$) and lower CAV using Reverse technique. Furthermore, $E_{F/E}$ - $W_{F/E}$ coupling revealed technique-specific control strategies; notably, the T-shape technique exhibited a different transition from anti-phase to in-phase motion, indicating a potentially more effective transfer from JP_{elbow} absorption to generation. The result provides new insights into the underlying mechanism of these differences through integration of coordination analysis with traditional biomechanics.

Epidemiology and Risk Factors of Wrist Pain and Injury in Adolescent Artistic Gymnasts: A Systematic Review and Meta-analysis. Orthopaedic Journal of Sports Medicine, 14(1): 1-17, 2026.

Background: Adolescent gymnasts are at increased risk for wrist pathology due to repetitive high-impact wrist loading during the midgrowth spurt.

Purpose: To conduct a comprehensive systematic review on the epidemiology and risk factors for wrist pain and injury in adolescent artistic gymnasts.

Study design: Systematic review; Level of evidence, 4.



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Methods: Under PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, we searched MEDLINE, EMBASE, CINAHL, Cochrane, and SPORTDiscus from inception to January 2025. We included observational studies of adolescent artistic gymnasts that reported prevalence, incidence, and/or risk factors for wrist pain, acute injuries, chronic injuries (causing physal stress or not attributable to a specific acute event), or positive ulnar variance (PUV). Where applicable, meta-analyses were conducted to estimate the pooled prevalence and proportion of new cases for each outcome using common- or random-effect models. Results from studies that were not possible to pool were also reported.

Results: Of the 3650 records identified, 25 studies (185,107 gymnasts) were included for analysis. All evidence was deemed low to very low certainty. Nine studies suggested a pooled wrist pain prevalence of 53% (95% CI, 39%-66%), with 1 study reporting the proportion of new wrist pain cases to be 2% over 1 year. The prevalence of acute wrist injuries reported in 1 study was 34%, and the pooled proportion of new cases was 4% (n = 2 studies; 95% CI, 2%-7%) over a 2-year period. The pooled prevalence of chronic wrist injury was 36% (n = 6 studies; 95% CI, 12%-71%), and the pooled proportion of new chronic wrist injury cases was 5% (n = 2 studies; 95% CI, 3%-10%) over a 2-year period. Two studies suggested a pooled PUV prevalence of 4% (95% CI, 1%-14%), with 1 study reporting the proportion of new PUV cases to be 16% over an 18-month period in preteen gymnasts (mean $\pm$ SD age, 10 $\pm$ 2 years). Wrist pain was significantly associated with age between 10 and 14 years, increased age at training onset, training intensity, body mass index, years training, and weekly training hours.

Conclusion: Our review demonstrated that adolescent artistic gymnasts demonstrate an alarmingly high prevalence of acute and chronic wrist pain and wrist injury. Further research on training intensity thresholds and risk reduction strategies is imperative for informing and implementing guidelines that protect the health of this vulnerable population.

Golf

Assessment of golf-specific skill performance: A systematic review, 3D visualization, and standardized testing framework. European Journal of Applied Physiology, Ahead of Print: 1-15, 2026.

Purpose: Skill testing is a key component of sports science, yet research on golf performance assessment remains limited. This study aims to systematically review existing methods for evaluating golf performance and to visually present their design principles and indicator systems using a 3D bubble chart, ultimately proposing an optimized and standardized testing framework for golf skills.



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Methods: Following the PRISMA guidelines, this study conducted a systematic search of Web of Science, PubMed, SPORTDiscus, Scopus, and Google Scholar, ultimately including 13 studies for analysis.

Results: Combined with 3D visualization indicate that existing research is overly concentrated on driving and putting, while iron and chipping tests are markedly underrepresented, limiting the comprehensive understanding of the four core golf skills. The number of shots and selection of measurement variables lack standardization. Although complex biomechanical and club-ball dynamics indicators can help explain performance mechanisms, overemphasis on these measures often overlooks the core objective of golf-getting the ball into the hole.

Conclusion: This study proposes a standardized modular testing framework centered on "target-hitting." Consists of four modules: ball-striking zone (e.g., grass, bunkers, slopes), target zone (e.g., fairway, green, and varying sizes), shot distance, and club selection. By adjusting the combination of modules, it can simulate complex scenarios and accommodate athletes of different skill levels, providing a scientific reference for research, training, and performance evaluation. This study also provides guidance on the test modules and test site setup.

An examination of the correlation between antagonist coactivation of the abdomen and rotational kinematics in skilled golfers. Sports Biomechanics, Ahead of Print: 1-16, 2026.

Abstract - The objective was to examine how phase-specific abdominal antagonist co-activation (CoA) influences trunk rotational kinematics in skilled golfers. Thirty male amateurs (19.7 ± 0.7 years; handicap 9.6 ± 2.4) performed 6 iron swings with synchronised motion capture and surface electromyography of the external obliques (EO). Pearson correlations and linear regression were applied. CoA showed distinct phase-dependent effects. During take-away, higher CoA correlated with greater peak pelvic velocity ($r = 0.460$; $r^2 = 0.21$), indicating stabilising function. Early downswing CoA was negatively associated with X-factor at impact ($r = -0.516$; $r^2 = 0.26$) and peak pelvic velocity ($r = -0.540$; $r^2 = 0.29$), suggesting that reduced CoA facilitates proximal acceleration and elastic energy transfer. During downswing acceleration, CoA positively predicted peak thoracic velocity ($r = 0.397$; $r^2 = 0.15$) and thoracic deceleration ($r = 0.450$; $r^2 = 0.20$), reflecting a dual role in energy transfer and active braking. Early follow-through CoA was positively associated with thoracic deceleration ($r = 0.440$; $r^2 = 0.19$), supporting post-impact trunk control. These findings suggest that skilled golfers modulate EO CoA across swing phases to balance stability, energy transfer and controlled segmental deceleration, highlighting the functional significance of abdominal CoA for swing performance and injury prevention.



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Hockey

Training Load Distribution Across Weekly Microcycles According to the Match Schedule During the Regular Season in a Professional Rink Hockey Team. Journal of Functional Morphology and Kinesiology, 11: 16, 2026.

Background. This study aimed to quantify differences in the internal training load (ITL) of an elite rink hockey (RH) team across days within and between three types of microcycles: pre-season, in-season regular, and in-season congested, to provide insights to optimise microcycle scheduling.

Methods. One international-level male RH team comprising seven outfielders (29.6 ± 4.7 years; height, 178.9 ± 2.3 cm; body mass, 77.8 ± 5.7 kg) and one goalkeeper (32 years; height, 180.4 cm; body mass, 83.6 kg) was monitored for 21 microcycles. The ITL was assessed using the session rate of perceived exertion (sRPE) and quantified as time based on a triphasic classification commonly utilised in team sports: low-intensity training (LIT, <80% heart rate maximum (HRmax)), medium-intensity training (MIT, 80-90% HRmax), and high-intensity training (HIT, >90% HRmax). Generalized estimating equations were used to examine differences across within-microcycle training days and between seasonal phases, with linear mixed models applied as sensitivity analyses.

Results. Across all phases, significant day-to-day variations in ITL were observed within microcycles (all $p < 0.001$), with both subjective (sRPE) and objective (LIT-HIT) ITLs progressively decreasing as match days (MDs) approached, showing moderate-to-large population-averaged effects with 95% confidence intervals consistently not crossing zero. The pre-season exhibited the highest overall ITL ($p < 0.001$), characterised by a substantially greater sRPE and increased time spent across all intensity zones, with the largest magnitudes observed for LIT and MIT compared with the in-season phases.

Conclusions. Findings suggest that an international-level RH team progressively reduced the ITL as MDs approached with the highest loads scheduled earlier within microcycles. Moreover, the pre-season had the highest ITLs. This ITL distribution may provide useful guidance for RH coaches and support staff in optimising microcycle planning.



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Data-Driven Player Performance Metrics in Ice Hockey. Sports Data Analytics: Techniques, Applications, and Innovations, 211-229, 2026.

Key Limitations of Traditional Metrics

Traditional stats like **goals (G)**, **assists (A)**, **points (P = G + A)**, and **+/-** treat every event equally, without considering context. For example:

- A goal scored when trailing by 1 late in the game is far more valuable than one when leading by 5.
- They emphasize offense over defense.
- They ignore factors like opponent quality, game state (score differential, time remaining, manpower advantages), player roles (e.g., defensive forwards vs. scorers), or contribution to team success in high-stakes situations (e.g., playoffs or close games).

These gaps make traditional metrics less useful for roster building, scouting, contract decisions, or strategy under salary caps.

Evolution and Data Sources

- Early efforts added defensive elements (e.g., adjusted +/- via regression).
- Modern analytics use **event data** (~3000 events per game: shots, passes, hits, puck recoveries, with details on players involved, location, success, on-ice personnel).
- Emerging (but not public) **puck/player tracking** enables even finer metrics (e.g., space creation, passing quality).

Advanced Data-Driven Approaches

The chapter overviews state-of-the-art metrics:

- **Context-aware** ones, like event impact (probability of leading to a goal in the next 20 seconds) or Markov models that assign values to game states and actions (e.g., shots, passes) based on how they shift expected outcomes (goals, wins).
- Metrics for player pairs or lines (team chemistry).



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- Clustering players by style/roles (k-means or soft clustering) for better comparisons across multiple stats.
- Applications to drafting, scouting, undervalued/overvalued players, and how new metrics (e.g., Corsi → expected goals/xG) have shifted play styles (more high-quality shots vs. volume).

A key critique: Many advanced metrics are complex and hard to explain to coaches, players, or GMs without stats/ML backgrounds, reducing adoption.

Two Detailed Examples

1. **Explainable, goal-importance-based variants** (Lambrix et al., 2025): Builds on traditional G/A/P but weights them by a **Game Points Importance Value (GPIV)** for each goal.
 - GPIV calculates how much a goal changes expected team points (0–2 in regulation, extra point in OT) based on context (time, goal differential, manpower differential).
 - Highest GPIV for tying/leading goals late when close (GD near 0), or OT winners.
 - New metrics: GPIV-G, GPIV-A, GPIV-P (sum weighted by GPIV instead of +1 per goal/assist).
 - These correlate highly (>0.9) with originals but highlight players involved in high-leverage goals (e.g., 2013–14 top GPIV-P rankings shift players like Ovechkin/Bäckström up vs. pure points).
 - Useful complement for identifying clutch performers or those excelling in tough situations, even on weaker teams.
2. **Markov-based models** (various works): Model game as states with values (e.g., expected goals/win probability), crediting players for actions that improve state value. These capture both offense/defense and context but are more complex.

Relevance for Strength & Conditioning Professionals

While this chapter focuses on analytics for scouting, roster decisions, and strategy (not directly training), it underscores:

- Player roles matter—defensive/offensive contributions aren't captured equally by basic stats.
- Context (game state, special teams, high-pressure moments) influences true impact.



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- Data-driven insights can reveal physical/mental attributes (e.g., clutch performance, defensive reliability) worth targeting in training, recovery, or conditioning programs.
- Newer metrics may guide individualized programming (e.g., building resilience for high-stakes scenarios) or evaluating how well a player's development translates to on-ice results in different contexts.

Overall, the chapter advocates moving beyond raw totals toward contextual, explainable metrics to build better teams and inform holistic player development. For S&C pros working with hockey programs, it highlights the growing role of analytics in understanding what truly drives performance beyond gym numbers.

Lacrosse/Field Hockey

Directional and Skill-Level Differences in the Speed-Accuracy Trade-Off During Lacrosse Passing. Journal of Functional Morphology and Kinesiology, 11: 8, 2026.

Background: Passing in lacrosse is a fundamental skill essential for both offense and defense, directly influencing game flow. Although the speed-accuracy trade-off is well recognized in motor control, its features in lacrosse passing—particularly regarding directional aspects and skill differences—remain unclear. This study quantified the relationship between pass speed, accuracy, bias, and consistency and examined directional effects and skill-level differences.

Methods: Twenty-two female university players (skilled: $n = 9$; unskilled: $n = 13$) executed overhand passes to a 5 cm × 5 cm target from 11 m under three effort conditions: warm-up, game intensity, and full effort. Ball speed was derived from lateral video, and landing coordinates from posterior footage. Accuracy, bias, and consistency were assessed using radial error (RE), centroid error (CE), absolute CE ($|CE|$), and bivariate variable error (BVE). Directional patterns were analyzed through lateral and vertical components and the 95% confidence intervals of the major and minor axes of an error ellipse. A two-way analysis of variance was performed with condition as the within-subject factor and skill level as the between-subject factor.

Results: Ball speed increased significantly across conditions. RE, $|CE|$, and BVE increased with speed, showing directional dependence: variability expanded mainly along the major axis, while the minor axis remained stable. Skilled players showed smaller RE and BVE, with differences most evident vertically and along the major axis. CE direction stayed consistent, indicating that reduced accuracy stemmed from greater bias magnitude and lower consistency rather than shifts in the mean landing point.



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Conclusions: Findings confirm a speed-accuracy trade-off in lacrosse passing, characterized by directional specificity and skill-related effects. Combining RE, CE, BVE, and ellipse-axis analyses clarified error structure, showing variability concentrated along the movement axis. These results support training focused on vertical control and timing and highlight the value of directional metrics for assessing lacrosse performance. Future research should include male athletes, advanced levels, and in-game scenarios to extend generalizability.

Longitudinal development of match performance in elite field hockey players training within a high-performance environment. Journal of Sports Sciences, Ahead of Print: 1-13, 2026.

Abstract - This study examined whether the performance characteristics of male university field hockey players were associated with undergraduate degree year of study. Fifty-two male university field hockey players (age 20.8 ± 2.4 years, stature 1.79 ± 0.06 m, body mass 75.8 ± 8.3 kg) were monitored over 85 matches played across four national league seasons in the UK (2018-2022) using 15 Hz Global Positioning System units and heart rate monitors. Total distance, high-speed running distance (≥ 15.5 km.h⁻¹), accelerations (≥ 2 m.s⁻¹), decelerations (≤ -2 m.s⁻¹), average heart rate and percentage of time spent at $>85\%$ of maximum heart rate were compared between 1st year, 2nd year and final year players across 1090 player-match files. Hierarchical linear modelling of performance characteristics (Match - level 1, Player - level 2), normalised to 70 min match time, found that the total and high-speed running distance covered by final year players was lower compared to 2nd year players (by 163 m and 127 m, respectively, both $p < 0.05$). With increased training experience in a high-performance program, running performance required to perform optimally could be reduced in university players due to the high level of match performance achieved, development of game understanding and improved technical ability.

Soccer

Are countermovement jump variables indicators of injury risk in professional soccer players? A machine learning approach. Applied Sciences, 15: 12721, 2025.

Background: Muscle injuries are among the main problems in professional soccer, affecting player availability and team performance. Countermovement jump (CMJ) variables have been proposed as indicators of injury risk and for detecting strength imbalances, although their use is less explored than isokinetic assessments. Unlike previous studies based



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solely on linear statistics, this research integrates biomechanical data with machine learning approaches, providing a novel perspective for injury prediction in elite soccer.

Objective: To examine the association between CMJ variables and muscle injury risk during a competitive season, considering injury incidence and effective playing minutes. It was hypothesized that specific CMJ asymmetries would be associated with a higher injury risk, and that machine learning algorithms could accurately classify players according to their injury status.

Methods: Forty-one professional soccer players (18 women, 23 men) from national league teams (Chile) were assessed during preseason using force platforms. Non-contact muscle injuries and playing minutes were recorded over 10 months after the CMJ evaluations. Analyses included two-way ANOVA (sex $\times$ injury status) and machine learning algorithms (Logistic Regression, Decision Tree, K-Nearest Neighbors [KNN], Random Forest, Gradient Boosting [GB]).

Results: Significant sex differences were observed in most variables ($p < 0.05$ and $\eta^2 > 0.11$), except peak force and peak power asymmetry. For injury status, only peak force asymmetry differed, while sex $\times$ injury interactions were found in peak power and left peak power. KNN (Accuracy = 87% and CI 95% = 71% to 96%) and GB (Accuracy = 84% and CI 95% = 68% to 94%) achieved the best classification performance between injured and non-injured players.

Conclusions: CMJ did not show consistent statistical differences between injured and non-injured groups. However, machine learning models, particularly KNN and GB, demonstrated high predictive accuracy, suggesting that injuries are a complex phenomenon characterized by non-linear patterns. These findings highlight the potential of combining CMJ with machine learning approaches for functional monitoring and early detection of injury risk, though validation in larger cohorts is required before establishing clinical thresholds and preventive applications.

Match peak speed across a soccer season: The influence of playing position, competition, match outcome, and match location. Kinesiology, 57: 83-91, 2025.

Abstract - This study compared match peak speeds (MPS) across a full season considering different playing positions, competitions, match outcomes, and match locations. Thirty-one elite male soccer players were monitored during matches using global navigation satellite system devices. Independent mean differences [95% confidence intervals] were calculated for the investigated variable (MPS). Fullbacks reached higher MPS than central defenders (CD) ($d=0.78$ [0.56, 1.00]), central midfielders (CM) ($d=-0.75$ [-0.93, -0.57]) and forwards ($d=-0.32$ [-0.55, -0.08]); wide midfielders reached higher MPS than CD ($d=0.66$ [0.43, 0.90]) and CM ($d=0.64$ [0.45, 0.84]); and forwards reached higher MPS than CD

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($d=0.46$ [0.22, 0.71]) and CM ($d=0.41$ [0.21, 0.62]). Higher MPS were reached during the National League than the National Cup ($d=-0.38$ [-0.58, -0.19]) and the Supercup ($d=-0.57$ [-1.09, -0.06]); higher MPS were reached during the State Cup than the National Cup ($d=-0.32$ [-0.55, -0.09]) and the Supercup ($d=-0.57$ [-1.12, -0.05]); and higher MPS were reached during the International Cup than the National Cup ($d=0.26$ [0.04, 0.48]). Higher MPS were reached during matches lost than won ($d=0.19$ [0.03, 0.35]). Playing position was the highest differentiator of MPS across a soccer season, underlining the importance of players' individualization when assessing MPS or when calculating normalized speed thresholds. MPS can also vary between competitions, especially if teams face lower division teams.

The impact of cold-water immersion on post-match recovery in trained soccer players: A systematic review and meta-analysis. Scandinavian Journal of Medicine & Science in Sports, 36: e70202, 2026.

Abstract - Cold-water immersion (CWI) is widely used by elite soccer players to enhance recovery after match play, yet systematic evidence supporting the effectiveness of this intervention is lacking. This systematic review with meta-analysis aimed to evaluate the effects of CWI on the recovery of physical performance, muscle damage, and delayed muscle soreness in trained soccer players after match play. A systematic database search was conducted and inclusion criteria were: (1) peer-reviewed, controlled trials; (2) competitive soccer players; (3) comparison of CWI with control/placebo after match/simulated match-play; (4) at least one of the following outcomes: 20 m sprint, countermovement jump (CMJ), leg strength via maximal voluntary contraction (MVC), creatine kinase (CK) for muscle damage, or delayed onset of muscle soreness (DOMS); and (5) outcome measurements taken 24, 48 or 72 h post-match. Random-effects meta-analyses were performed to calculate standardized mean differences (SMD) with 95% confidence intervals (CI) and prediction intervals (PI). Ten studies met the inclusion criteria. CWI significantly improved recovery of MVC (SMD = 1.02 [95% CI: 0.55 to 1.50; 95% PI: -0.48 to 2.53]) and CMJ (SMD = 0.38 [95% CI: 0.12 to 0.64; 95% PI: -0.39 to 1.15]), while sprint performance remained unaffected (SMD = -0.59 [95% CI: -1.41 to 0.23; 95% PI: -4.14 to 2.95]). CWI reduced CK levels (SMD = -0.77 [95% CI: -1.17 to -0.37; 95% PI: -2.23 to 0.69]) and alleviated DOMS (SMD = -1.04 [95% CI: -1.91 to -0.17; 95% PI: -4.12 to 2.03]). MVC and CK recovery improved consistently across all time points, while DOMS relief was observed at 24 and 72 h post-match. CMJ benefits were only evident at 48 h post-match. However, as the 95% PIs for all outcomes included the null effect, the observed benefits should be interpreted cautiously, as future studies may yield smaller or null effects. Overall, CWI may enhance recovery of muscle strength, reduce muscle damage, and alleviate soreness in trained male and female soccer players, but does not seem to impact sprint performance, and its effect on CMJ is time-dependent.



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Effects of a 90-min nap on time-motion metrics and psychophysiological responses during small-sided games in professional soccer players. Scandinavian Journal of Medicine & Science in Sports, 36: e70193, 2026.

Abstract - This study investigated the impact of a 90-min nap (N90) on time-motion metrics and psychophysiological responses during small-sided games (SSGs) in soccer players. In a within-subjects counterbalanced design, 15 professional male soccer players (mean $\pm$ SD; age: 22.4 ± 1.2 years; stature: 178 ± 9 cm; body mass: 70.1 ± 4.0 kg; estimated $\text{VO}_{2\text{max}}$: $55.9 \pm 2.8 \text{ mL}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$) completed two SSGs sessions under N90 and no-nap (N0) conditions. N90 was monitored using a Fitbit Charge 6 wristband. Daytime sleepiness was assessed pre- and post-nap. Mood states, the wellness status (Hooper index), and cognitive performance (Go/NoGo task) were evaluated before each SSGs session. Time-motion metrics, obtained via the FieldWiz GPS system, along with exercise heart rate (HR), were continuously monitored throughout the SSGs. Blood lactate concentration ([La]) and ratings of perceived exertion (RPE) were assessed post-SSGs. Compared to N0, the N90 condition resulted in a significantly greater total distance covered during SSGs ($p = 0.002$, Cohen's $|d| = 0.96$), lower pre-session resting HR ($p < 0.001$, $|d| = 1.33$), and reduced relative exercise HR ($p = 0.03$, $|d| = 0.33$). Additionally, post-SSGs [La] and RPE were lower following N90 ($p = 0.015$, $|d| = 0.71$ and $p = 0.001$, $|d| = 1.03$ respectively). The N90 also led to higher vigor scores ($p = 0.003$, $|d| = 1.01$), lower Hooper index values ($p = 0.02$, $|d| = 0.59$), and faster reaction time ($p = 0.02$, $|r| = 0.60$) than N0. A 90-min nap before SSGs training increased total distance covered, reduced perceived fatigue, and enhanced mood, wellness, and cognitive alertness. These findings support implementing a 90-min nap as a practical ergogenic aid to optimize recovery status, performance, cognitive alertness and overall well-being in professional soccer players.

Softball

The Softball Pitching Plane (SPP): A Reliable Geometric Descriptor of Arm Trajectory and Its Relationship to Ball Velocity in Adolescent Pitchers. Applied Sciences, 16: 574, 2026.

Abstract - This study introduced Softball Pitching Plane (SPP), a best-fit geometric plane designed to characterize the throwing arm spatial trajectory during the windmill softball pitch. The purpose was to evaluate the reliability of this planar representation and determine whether deviations from the SPP were associated with ball velocity. Forty-nine adolescent softball pitchers each performed 15 drop-ball pitches (735 total pitches). Kinematics were recorded using a 15-sensor electromagnetic tracking system. A weighted orthogonal least squares algorithm was applied to compute the best-fit plane across three intervals (WU-BR, TOP-BR, and DS-BR). Reliability was assessed using within-subject



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variability, leave-one trial-out error, and ICCs. Linear mixed-effects models were used to examine associations between SPP parameters and ball velocity. The downswing–ball release interval of the wrist trajectory showed the most stable planar pattern (RMS = 0.053 m). SPP parameters demonstrated high reliability ($CV \leq 4.2\%$; $ICC = 0.81\text{--}0.90$). RMS deviation negatively predicted ball velocity at both within-pitcher ($-0.11 \text{ km}\cdot\text{h}^{-1}$ per cm, $p = 0.003$) and between pitcher levels ($-0.40 \text{ km}\cdot\text{h}^{-1}$ per cm, $p = 0.03$). These findings indicate that, in adolescent softball pitchers, the SPP provides a reliable geometric description of throwing-arm motion during the downswing–ball release phase, with reduced deviation associated with higher pitch velocity.

Adaptations of the posterior rotator cuff muscles and ulnar collateral ligament in collegiate female softball players: A cross-sectional study. Journal of Sports and Rehabilitation Sciences, Ahead of Print: 1-8, 2026.

Abstract - Overhead throwing sports, such as softball, impose significant biomechanical demands on the shoulder and elbow, yet chronic musculoskeletal adaptations in female softball players remain underexplored. This study aimed to investigate whether repetitive overhead throwing in collegiate female softball players leads to increased thickness of the supraspinatus, infraspinatus, and ulnar collateral ligament (UCL) in the throwing arm compared to the non-throwing arm. A cross-sectional study was conducted with 19 female collegiate softball players from an NCAA Division I team, excluding pitchers. Ultrasound imaging was used to measure the thickness of the supraspinatus, infraspinatus, and UCL with participants seated with arms relaxed for supraspinatus and infraspinatus imaging, and with the elbow flexed at 90° for UCL imaging. Paired t-tests were used to compare tissue thickness between arms. Mean thicknesses were similar across arms (supraspinatus: 1.93 (standard deviation [SD]=0.31) cm vs. 1.95 (SD=0.29) cm; infraspinatus: 2.26 (SD=0.35) cm vs. 2.18 (SD=0.34) cm; UCL: 0.58 (SD=0.05) cm vs. 0.56 (SD=0.06) cm). Paired t-tests revealed no significant differences between the throwing and non-throwing arms for supraspinatus thickness ($P=0.401$), infraspinatus thickness ($P=0.236$), or UCL thickness ($P=0.171$). We observed no between-arm differences in resting thickness of the supraspinatus, infraspinatus, or UCL; these data do not provide evidence for hypertrophic adaptation in these tissues among collegiate female softball players. This suggests that throwing may not provide sufficient stimulus to drive significant structural adaptation in these tissues. These findings highlight the need to explore additional adaptive mechanisms and position-specific demands to inform injury prevention strategies better.



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Swimming

Influence of Lower-Extremity Joint Torque and Power During Vertical and Horizontal Jumps on Swimming Start Performance in Competitive Swimming. Journal of Strength and Conditioning Research, 40(1): e50-e61, 2026.

Abstract - Jumping ability plays a crucial role in optimizing kick start performance in swimming. However, effective training methods for transferring the enhanced jumping ability to the kick start movement remain unclear owing to insufficient understanding of the relationship between kick start and jump movements. This study explores the relationship between kinematic parameters during the kick start and leg muscular power output in horizontal and vertical jumps. Fourteen male competitive swimmers (20.2 ± 2.3 years) participated in the swim start and jump tests. Jump performance was evaluated using vertical jumps (VJ), squat jumps (SJ), and standing long jumps (SLJ). Key metrics included the jump height (VJ, SJ), horizontal distance (SLJ), take-off velocity, joint torques, and power output. The results showed that flight distance, influenced by the vertical velocity of the center of mass (CM) at take-off, was significantly correlated with 5-m and 10-m performance ($P < 0.05$). Jump performance metrics were notably associated with swim start parameters, highlighting the importance of jump direction. However, these metrics did not correspond to the vertical velocity of the CM at take-off during the kick start ($r = -0.059-0.473$, n.s). Swimmers with greater flight distances exhibited higher joint torques and power in the knee and ankle joints during jumps, as along with greater deviation of the CM take-off angle during the kick start. These findings suggest distinct technical requirements for enhancing both flight distance and CM horizontal velocity. Targeted resistance and plyometric training, combined with technical adjustments in CM positioning, may improve swimming start performance.

One Sprinter, Two Olympic Preparations: A Single-Athlete Longitudinal Observational Study of Training-Intensity Distribution and Implications for Future 50 m Events. Sports, 14: 23, 2026.

Purpose: This single-athlete, longitudinal observational study describes training intensity distribution (TID) across two Olympic preparation cycles (Rio 2016 vs. Tokyo 2021) and explores whether differences in high-intensity exposure coincided with performance outcomes.



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Methods: An elite male 50 m freestyle specialist (personal best 21.27 s; height: 187 cm, weight: 80 kg, body mass index: 22.9 kg·m⁻², fat-free mass: 75.2 kg, and fat mass: 4.8 kg) was monitored across four mesocycle periods. TID is expressed as % of total swim volume in three zones: Z1 (low intensity), Z2 (threshold), Z3 [high intensity/race-pace, including High Intensity Interval Training (HIIT) and Sprint Interval Training (SIT)]. Both the coach and swimmer signed a written informed consent for the use of their data.

Results: For Rio 2016, TID (Z1/Z2/Z3) was as follows: General 80/0/20, Specific 60/0/40, Precompetition 40/30/30, and Taper 50/20/30, indicating a polarized approach. For Tokyo 2021, TID shifted to: General 85/0/15, Specific 60/0/40, Pre-competition 30/30/40, and Taper 40/20/40. Discussion: In this single athlete, a greater proportion of work in Z3 during the Tokyo cycle, particularly in the Pre-competition and Taper phases, probably coincided with improved performance (21.57 vs. 21.79 s).

Conclusions: Although clear causal inference is not possible, these observations depict the probability that sprint-swim preparation for 50 m events needs a training volume oriented to Z3 and relatively less in Z1. However, the study's design, the methods by which the TID was recorded, etc., limit any generalization about the interpretation of the findings. Therefore, future studies should address these limitations, providing more insights into improving the training on that kind of events.

Tennis

The impact of cognitive load on lower limb biomechanics during the take-off phase before service in tennis players of different levels. Journal of Sports Sciences, Ahead of Print: 1-12, 2026.

Abstract - This study examines the impact of cognitive load (CL) on lower limb biomechanics during the take-off preparation phase of the platform serve in tennis players of varying skill levels. Fifteen elite and fifteen amateur tennis players performed platform serves before and after completing a 30-minute Stroop task designed to induce CL. Key biomechanical parameters, including joint range of motion (ROM), joint moments, centre of mass (COM) displacement, and ground reaction force (GRF), were assessed using both kinematic and kinetic analysis. After CL, the biomechanical performance of amateur athletes significantly decreased compared to elite athletes. Specifically, amateur athletes showed a 14.19° lower ankle joint range of motion in the sagittal plane ($p < 0.001$), a 0.04-meter lower COM displacement in the frontal plane ($p = 0.017$), and a 0.15 Nm/BW lower knee extension moment ($p < 0.001$). CL adversely affects the lower limb biomechanics of amateur players more than elite players, with elite players demonstrating greater



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stability. These findings suggest that elite players have developed more efficient motor control mechanisms through extensive training. Tailored training interventions that account for different skill levels could enhance performance stability and mitigate the risk of injury.

The Effects of a Strategic Instructional Self-Talk Intervention on Performance in a Complex Tennis Rally. Behavioral Sciences, 16: 87, 2026.

Abstract - The purpose of the present study was to examine the effects of a strategic self-talk intervention on a complex tennis performance test through the use of a narrow internal instructional self-talk plan. Fifty young beginner tennis players from two tennis academies were assigned into intervention and control groups. A pre/post quasi-experimental design was implemented, including baseline assessment, training intervention, and final assessment. The intervention lasted five weeks, during which all participants underwent the same training, with the experimental group using strategic self-talk. Repeated measures MANOVA revealed a significant time by group interaction for all tennis strokes; pairwise comparisons showed that the all strokes performance of the self-talk group improved from initial to final assessment and was better than the performance of the control group at final assessment. In addition, repeated measures ANOVA examining the overall performance of the rally showed that the intervention group achieved higher total rally scores than the control group. The effectiveness of the intervention in this multi-stroke task suggests that strategic self-talk facilitated movement sequences, possibly through an efficient shifting of attention. Accordingly, practitioners are encouraged to explore the potential of strategic self-talk for tasks requiring such attentional demands.

Volleyball

The relationship between hand dominance and ACL tears in competitive volleyball athletes. The Orthopaedic Journal of Sports Medicine, 14(1): 1-5, 2026.

Background: Knee injuries are common in volleyball athletes, often resulting from the sport's unique movement requirements. Among these, anterior cruciate ligament (ACL) tears are particularly prevalent, and while the existing literature has examined risk factors such as biomechanical asymmetries and landing mechanics, there is limited research on the relationship between hand dominance and the side of injury.

Purpose: To examine the relationship between hand dominance and ACL tear laterality in competitive volleyball players diagnosed with first-time unilateral ACL tears.



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

Methods: After a medical record review of 1529 consecutive patients, 149 met the inclusion criteria, resulting in a study population of 124 females and 25 males. Data on sex, age, body mass index, handedness, and ACL tear laterality were collected from the medical records. A Fisher exact test was used to assess the association between handedness and ACL tear laterality, while binomial tests evaluated differences in ACL tear laterality within each handedness group.

Results: Among the 136 right-handed players, 81.62% tore their left ACL, while 18.38% tore their right ACL. Among the 13 left-handed players, 84.62% tore their right ACL, while 15.38% tore their left ACL. A statistically significant association was found between hand dominance and ACL tear laterality ($P < .001$). Additionally, statistical significance was found between right-handed players tearing their left ACL ($P < .001$) and left-handed players tearing their right ACL ($P < .05$).

Conclusion: This study suggests a significant relationship between hand dominance and ACL tear laterality in competitive volleyball players. Right-handed volleyball players were significantly more likely to tear their left ACL, whereas left-handed players predominantly tore their right ACL. These findings suggest a biomechanical or sports-specific risk factor contributing to ACL injury patterns in volleyball players.

Functional movement screen asymmetries in female volleyball players across playing positions. Scientific Reports, Ahead of Print: 1-23, 2026.

Abstract - This study aimed to identify positional differences and asymmetries in functional movement patterns among female volleyball players. A total of 107 professional female athletes from the provinces of Çanakkale and Istanbul participated in the study. Height and body weight measurements were taken to calculate body mass index (BMI), and the Functional Movement Screen (FMS) was administered. Data were analyzed using the SPSS statistical software package. The Wilcoxon Signed Ranks Test was employed for asymmetry analyses, while the Kruskal-Wallis test was used to evaluate differences across playing positions.

The findings revealed no statistically significant differences in FMS test scores among players in different positions for deep squat, hurdle step, inline lunge, shoulder mobility, active straight-leg raise, trunk stability push-up, and rotary stability. Regarding injury risk, no significant associations were observed between FMS scores and injury risk for deep squat, inline lunge, active straight-leg raise, and rotary stability; however, statistically significant associations were found for hurdle step, shoulder mobility, and trunk stability push-up. In terms of right-left asymmetries, no significant



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differences were identified in hurdle step, inline lunge, active straight-leg raise, and rotary stability, while shoulder mobility showed a statistically significant asymmetry between the right and left sides.

In conclusion, FMS performance was found to be similar across playing positions among female volleyball players. Additionally, FMS testing appears to be a valuable tool for identifying movement-related indicators and detecting asymmetries in this population. FMS results may be practically applied to support individualized training design and preseason screening in volleyball players.

Wrestling/Combat Sports

Correlation between core stability parameters and injury rate in elite-level wrestling sport: Results of 6-month follow-up. The Orthopaedic Journal of Sports Medicine, 14(1): 1-8, 2026.

Background: Elite wrestling is a contact sport characterized by high levels of physical fitness and a high level of injury. Studies have shown that poor "core stability" is associated with increased risk of injury in other sports. This study examines the correlation between the different parameters of "core stability" and the injury rate in elite wrestling.

Hypothesis: It was hypothesized that poor results on core stability tests would be associated with an increased risk of injury.

Study design: Cohort study; Level of evidence, 2.

Methods: We involved 60 members of the Azerbaijan National Wrestling Team (mean age 25.5 ± 4.6 years) who met the predefined inclusion and exclusion criteria. Baseline assessment of core stability was performed using the Limits of Stability Test on the Biodex Balance System, McGill's Endurance Test Battery, and complex core stability tests. Injuries were defined as tissue damage resulting from sports participation that led to at least 1 day of time loss from training or competition. Data were collected over a 6-month period. Descriptive statistics, including interquartile ranges, were recorded, and Pearson correlation coefficients were calculated to assess relationships between variables.

Results: A total of 997 injuries were recorded over 6 months (median injury burden: 54.6 days/1000 training hours; median days lost per injury: 16.5 [IQR, 14.0-19.8]). Core stability measures demonstrated significant negative correlations with multiple injury parameters, indicating that better stability performance was associated with reduced injury risk and severity. The McGill Side Bridge (right) test showed the strongest association with injury burden ($r = -0.596$, $P < .001$) and days out of training ($r = -0.597$, $P < .001$). The dynamic overall score was also highly correlated with



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injury burden ($r = -0.530$, $P < .001$) and injury incidence ($r = -0.472$, $P < .001$). Across all injury outcomes, days out of training demonstrated the greatest number of significant correlations, ranging from $r = -0.412$ to $r = -0.597$ (all $P < .05$).

Conclusion: Our study demonstrates that there is a significant relationship between poor core stability parameters and injury burden. These results could suggest that a specially designed core-specific training program could help reduce injury rates in wrestling, provided that a controlled study-featuring core exercises administered to an experimental group-confirms the link between weak core stability and an increased risk of injury.

Unconventional alternatives for weight loss for wrestling athletes. Remunom, 1(2): 1-8, 2026.

Abstract - A widely discussed and very common subject in the life of the Wrestling athlete as well as in that of combat sports athletes, in the search for a better performance in fights, is weight loss. Therefore, this literature review aims to show weight loss alternatives with a focus on wrestling athletes who are high school students and also college students. In addition to bringing isolated alternatives, this study seeks to show the combination of some of these alternatives for a better result at the time of weight loss, such as the combination of high-intensity training with dehydration and diet. Rapid weight loss (PRP) usually lasts three weeks or less, and is based on severe restriction in food intake, fluid intake, strenuous exercise, training in rubberized clothing, use of saunas, induction of vomiting, and often the use of pharmacological agents such as laxatives, stimulants, and diuretics. To be a curiosity, in a study with 45 fighters from all combat sports, some PRP methods stood out for their frequency of use, such as: running (91.1%), saunas (55.6%), rubberized clothing (48.8%), cycling (33.3%), swimming (24.4%) and diuretics (11.1%).

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