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Baseball

A comparison of pitching biomechanics and sport specialization in high school pitchers. International Journal of Sports Physical Therapy, 17(5): 870-878, 2022.

Background: The prevalence of sport specialization in high school athletes continues to rise, particularly among baseball players. Previous research has focused on the incidence of injury among specialized and non-specialized athletes but has yet to examine the level of sport specialization and pitching biomechanics.

Hypotheses/Purpose: The purpose of this study was to investigate differences in pitching volume and biomechanics between low-, moderate-, and high-level specialized baseball pitchers. It was hypothesized that high-level specialized pitchers would have the most pitching volume within the current and previous years while low-level specialized pitchers would exhibit the least amount. The second hypothesis states that kinematics and kinetics commonly associated with performance and injury risk would differ between low-, moderate-, and high-level specialized pitchers.

Study Design: Case-Control Study

Methods: Thirty-six high school baseball pitchers completed a custom sport specialization questionnaire before participating in a three-dimensional pitching motion analysis. Sport specialization was based off current guidelines and categorized as low-, moderate-, and high-level specialized based upon self-reported outcomes. Pitchers then threw ≈10 fastballs from a mound engineered to professional specifications. Data averaged across fastballs was used for biomechanics variables. Key pitching biomechanical and pitching volume variables were compared between low-, moderate-, and high-level specialized pitchers.

Results: High-level specialized pitchers were older ($p = 0.003$), had larger body mass ($p = 0.05$) and BMI ($p = 0.045$), and threw faster ($p = 0.01$) compared to low-level specialized pitchers. Pitching volume and pitching biomechanics were similar across groups.

Conclusions: Pitching biomechanics were similar across groups, although high-level specialized pitchers threw with significantly higher throwing velocity compared to low-level pitchers. The low amount of pitching volume throughout the season may be responsible for the lack of additional observed differences. Further research should examine the relationship between pitching biomechanics, upper extremity strength and flexibility, and sport specialization.

Performance Research Reviews

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9340844/pdf/ijspt_2022_17_5_37259.pdf

Comparison of marker-less and marker-based motion capture for baseball pitching kinematics. Sports Biomechanics, Ahead of Print: 1-11, 2022.

Abstract - The purpose of this study was to compare baseball pitching kinematics measured with marker-less and marker-based motion capture. Two hundred and seventy-five fastball pitches were captured at 240 Hz simultaneously with a 9-camera marker-less system and a 12-camera marker system. The pitches were thrown by 30 baseball pitchers (age 17.1 ± 3.1 years). Data for each trial were time-synchronized between the two systems using the instant of ball release. Coefficients of Multiple Correlations (CMC) were computed to assess the similarity of waveforms between the two systems. Discrete measurements at foot contact, during arm cocking, and at ball release were compared between the systems using Bland-Altman plots and descriptive statistics. CMC values for the five-time series analyzed ranged from 0.88 to 0.97, indicating consistency in movement patterns between systems. Biases for discrete measurements ranged in magnitude from 0 to 16 degrees. Standard deviations of the differences between systems ranged from 0 to 14 degrees, while intraclass correlations ranged from 0.64 to 0.92. Thus, the marker-based and marker-less motion capture systems produced similar patterns for baseball pitching kinematics. However, based on the variations between the systems, it is recommended that a database of normative ranges be established for each system.

Kinetic and kinematic comparisons in high school pitchers with low and high pitch location consistency. Journal of Shoulder and Elbow Surgery, Ahead of Print: 1-28, 2022.

Purpose: While the performance metric ball velocity has often been associated with increased kinetics at the upper extremity and risk of injury in youth and adolescent pitchers, it is unclear if the performance metric pitch location consistency has any positive/negative associations with pitching kinetics.

Methods: High school pitchers(n=59) pitched 8-12 fastballs using 3D motion-capture (480 Hz). Pitchers were divided into high consistency (HiCon) and low consistency (LoCon) groups based on the absolute center deviation of each pitcher's pitch to the center of the pitchers mean pitch location. 95% confidence ellipses with major and minor radii were constructed, while kinematics and kinetics were compared.

Results: HiCon pitchers had decreased lead hip flexion at elbow extension (40±12° vs. 52±13° respectfully, p=0.008) while at foot contact, decreased back hip extension (1±10° vs. 10±13° respectfully, p=0.038) and increased back hip internal rotation (9±15° vs. -2±15° respectfully, p=0.043). LoCon pitchers achieved maximum lead hip flexion earlier (61.3±23.2% vs. 75.8±15.1% respectfully, p=0.039). A multi-regression model could predict 0.49 of variance in pitch location consistency using kinematic inputs.

Conclusion: Pitchers who differ in pitch location consistency outcomes do not appear to demonstrate physiologically unsafe kinematics. High school pitchers who strive for improved pitch consistency can consider adjusting parameters of hip kinematics during early portions of the pitch.

Using advanced data to analyze the impact of injury on performance of Major League Baseball pitchers – A narrative review. The Orthopaedic Journal of Sports Medicine, 10 (7): 1-9, 2022.

Abstract - Major league baseball (MLB) pitchers are at risk of numerous injuries during play, and there is an increasing focus on evaluating their performance in the context of injury. Historically, performance after return to play (RTP) from injury has focused on general descriptive statistics, such as innings or games played, or rate statistics with inherent variability (eg, earned run average, walks and hits per inning pitched, strikeouts per 9 innings, or walks per 9 innings). However, in recent years, MLB has incorporated advanced technology and tracking systems in every stadium, allowing for more in-depth analysis of pitcher-specific data that are captured with every pitch of every game. This technology allows for the ability to delve into the pitching performance on a basis that is more specific to each pitcher and allows for more in-depth analysis of different aspects of pitching performance. The purpose of this narrative review was to illustrate the current state of injury recording for professional baseball pitchers, highlight recent technological advances in MLB, and describe the advanced data available for analysis. We used advanced data in the literature to review the current state of performance analysis after RTP in MLB pitchers after injury. Finally, we strived to provide a framework for future studies to more meticulously assess RTP performance given the current available resources for analysis.

https://journals.sagepub.com/doi/pdf/10.1177/23259671221111169

Performance Research Reviews

Variability in pitch count limits and rest day requirements by state – Implications of season- long pitch counts in high school baseball pitchers. The American Journal of Sports Medicine, Ahead of Print: 1-8, 2022.

Background: It is unknown how different pitch count limits and rest day requirements affect cumulative pitch counts during a baseball season.

Purpose: To determine (1) the variability of pitch count rules in high school baseball and (2) the theoretical effect of different pitch count limits and rest day combinations on game, weekly, and seasonal pitch totals in high school baseball pitchers.

Study Design: Cross-sectional study.

Methods: Pitch count rules for the 2019-2020 academic year for 48 sanctioned states were recorded from each state's athletic association website. Maximum pitch count limits were recorded along with the number of pitches allowed before requiring 0 to 5 rest days before the next pitching outing. Rules were also analyzed for several distinctions, including the athlete's level of competition, age, and grade. To determine the effect of pitch count rules and rest days, a theoretical 3-month season was calculated in the following scenarios: (1) variable maximum pitch count limits with a universal 3-day rest requirement, (2) universal 110 pitch count limit with variable rest day requirements (3, 4, or 5 days), and (3) actual pitch count limits and required rest days for every state assuming pitchers throw as many pitches as allowed. Analysis of variance and Student t tests were used to compare between-group and intragroup seasonal pitch totals based on variations in required rest days.

Results: The most common maximum pitch count limit for a varsity high school athlete was 110 pitches (range, 100-125 pitches) with 4 rest days (range, 0-5 days). We found that 23 states (48%) did not make distinctions for pitch count rules based on the athlete's level of competition, age, or grade. We noted a 25% increase in total seasonal pitch counts between the smallest and largest pitch count limit when assuming constant 3-day rest. We found a 53% difference in total seasonal pitch count when rest days varied between 3 and 5 days with a constant 110-pitch limit. Allowing 140 pitches in a 4-day span without a specific rest day requirement resulted in the highest seasonal pitch count (Nevada). There was a 49% difference in maximum seasonal pitch counts between the most and least restrictive states ($P < .001$). Submaximum pitch limits resulted in higher seasonal pitch counts than maximum pitch limits in 56% of states.

Conclusion: Pitch count rules vary widely by state. Required rest days influenced total seasonal pitch counts more than maximum or submaximum pitch count limits.

Performance Research Reviews

Basketball

Knee movement characteristics of basketball players in landing tasks before onset of patellar tendinopathy: A prospective study. Frontiers in Sports and Active Living, Vol. 4 (Article 847945): 1-8, 2022.

Background: Patellar tendinopathy is one of the most common injuries for basketball players. Jumping and landing movement patterns are potential risk factors for patellar tendinopathy.

Hypothesis: Male college basketball players who developed patellar tendinopathy would demonstrate greater peak vertical ground reaction force and knee flexion angular velocity, and smaller knee flexion range of motion and knee flexion angles at initial contact compared to players who did not develop the injury when performing a stop-jump task within a year prior to the onset of the injury.

Study Design: Prospective study.

Methods: Freshmen college basketball male players (n = 181) were recruited for three consecutive years and followed to the end of the third year of the study. Three-dimensional kinematic and kinetic data during a stop-jump task were collected for all participants at the beginning of each school year. Peak vertical ground reaction force, knee flexion angle at initial foot contact with the ground, range of motion for knee flexion and maximal knee flexion angular velocity during the landing phases of the stop-jump task were collected and calculated. Development of patellar tendinopathy was monitored in follow-up. Independent t-tests and Cohen's d effect sizes (ES) were used to compare movement patterns between injury and no injury groups for each school year.

Results: A total of 60 knees developed patellar tendinopathy. The injury groups had a significantly greater peak vertical ground reaction force in freshmen and junior years (P = 0.020, ES = 0.13; P = 0.046, ES = 0.17), smaller knee flexion ROM in freshmen year (P = 0.002, ES = 0.10), and greater maximum knee flexion angular velocity in freshmen and junior year (P = 0.012, ES = 0.10; P = 0.001, ES = 0.35) during the horizontal landing phase before the takeoff of the jump compared to the no injury groups. The injury groups also had a significantly smaller knee flexion angle at initial contact during vertical landing phase after the takeoff of the jump in freshmen and junior years (P = 0.001, ES = 0.36; P = 0.001; ES = 0.37) during vertical landing phase.

Conclusion: Peak vertical ground reaction force, knee flexion angle at initial foot contact, knee flexion range of motion, and maximum knee flexion angular velocity are associated with patellar tendinopathy among male college basketball players in different school years.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9300994/pdf/fspor-04-847945.pdf

Machine learning for predicting lower extremity muscle strain in National Basketball Association athletes. The Orthopaedic Journal of Sports Medicine, 10(7): 1-11, 2022

Background: In professional sports, injuries resulting in loss of playing time have serious implications for both the athlete and the organization. Efforts to quantify injury probability utilizing machine learning have been met with renewed interest, and the development of effective models has the potential to supplement the decision-making process of team physicians.

Purpose/Hypothesis: The purpose of this study was to (1) characterize the epidemiology of time-loss lower extremity muscle strains (LEMSs) in the National Basketball Association (NBA) from 1999 to 2019 and (2) determine the validity of a machine-learning model in predicting injury risk. It was hypothesized that time-loss LEMSs would be infrequent in this cohort and that a machine-learning model would outperform conventional methods in the prediction of injury risk.

Study Design: Case-control study; Level of evidence, 3.

Methods: Performance data and rates of the 4 major muscle strain injury types (hamstring, quadriceps, calf, and groin) were compiled from the 1999 to 2019 NBA seasons. Injuries included all publicly reported injuries that resulted in lost playing time. Models to predict the occurrence of a LEMS were generated using random forest, extreme gradient boosting (XGBoost), neural network, support vector machines, elastic net penalized logistic regression, and generalized logistic regression. Performance was compared utilizing discrimination, calibration, decision curve analysis, and the Brier score.

Results: A total of 736 LEMSs resulting in lost playing time occurred among 2103 athletes. Important variables for predicting LEMS included previous number of lower extremity injuries; age; recent history of injuries to the ankle, hamstring, or groin; and recent history of concussion as well as 3-point attempt rate and free throw attempt rate. The XGBoost machine achieved the best performance based on discrimination assessed via internal validation (area under the receiver operating characteristic curve, 0.840), calibration, and decision curve analysis.

Performance Research Reviews

Conclusion: Machine learning algorithms such as XGBoost outperformed logistic regression in the prediction of a LEMS that will result in lost time. Several variables increased the risk of LEMS, including a history of various lower extremity injuries, recent concussion, and total number of previous injuries.

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Relationship between game load and player's performance in professional basketball. International Journal of Sports Physiology and Performance, Ahead of Print: 1-7, 2022.

Purpose: The purpose of the study was to examine the relationships between external and internal loads, and their ratio (efficiency index), with game performance between backcourt and frontcourt professional basketball players.

Methods: Game loads of 14 basketball players were monitored during 6 games. External load variables measured were total distance (TD); distance >18 km·h−1 , commonly known as high-speed running (HSR); and number of accelerations (ACC) and decelerations (DEC) >3 m·s−2 , whereas the internal load variable measured was average heart rate (HRmean). The ratio between external and internal load variables was calculated and defined through 4 efficiency indexes (TD:HRmean, HSR:HRmean, ACC:HRmean, and DEC:HRmean). Furthermore, basketball performance was quantified using game-related statistics.

Results: TD presented a small association with basketball performance, whereas the other external load variables and the 4 efficiency indexes calculated showed trivial relationships with game-related statistics. Furthermore, HRmean showed the greatest (small) associations with individual performance (P = .01–.02; r = .19 to .22). Regarding specific positions, the only 2 variables that presented significant differences were DEC (P = .01; d = 0.86) and DEC:HRmean (P = .01; d = 0.81), which showed higher values in backcourt players compared with frontcourt players.

Conclusions: The results suggest that the best performances of basketball players during official competition are not associated with higher game loads. This illustrates the necessity to assess basketball performance from a holistic approach and consider more than just external and internal variables to better understand the players' performance during basketball competition.

Segmental bioimpedance analysis as a predictor of injury and performance status in professional basketball players: A new application potential? Life, 12 (Article 1062): 1-10, 2022.

Performance Research Reviews

Abstract - Bioelectrical impedance vector analysis (BIVA) is a technique used for the assessment of body composition based on the electrical properties of biological tissues and for evaluating variations related to hydration and nutrition status changes. The present study aimed to investigate the possibility of predicting performance status and injuries using segmental BIVA analysis. Data were collected from 14 professional male athletes aged between 20 and 39 years of Caucasian and Afro-American ethnicity belonging to the US Victoria Libertas Pallacanestro Pesaro team in the Italian Serie A basketball championship. From an analysis of training injuries, the data highlight a possible positive link between the number of training injuries and upper hemisoma reactance (XCEmsSup) ($t = 2.881$, $p = 0.007$), an inverse relationship between training injury duration and higher right lower limb reactance (XCLegDx) ($t = -4.213$, $p < 0.001$), and an inverse relationship between injury duration and higher body mass index ($t = -4.213$, $p < 0.001$), highlighting how higher cellularity seems less prone to severe training injuries. Analyzing match-day injuries, right upper-limb higher reactance (XCArmdx) negatively correlates with match-day number of injuries ($t = -4.469$, $p < 0.001$), right upper limb resistance (RZArmDx) negatively correlates with lower match-day injury duration ($t = -4.202$, $p < 0.001$), and trunk resistance (RZTrunk) positive correlates with lower match-day injury duration ($t = 2.803$, $p = 0.008$), in contrast with the training data analysis. Analyzing the relationship between the BIVA parameters and performance indicators, right upper limb resistance (RzArmDx) has a positive link with plus–minus ($t = 2.889$, $p = 0.007$); however, RzArmDx negatively correlates with assist number ($t = -3.362$, $p = 0.002$), and BMI is directly proportional to assist number ($t = 2.254$, $p = 0.032$). These first data suggest a good correlation between the cellularity of different body districts and the risk of injuries in training but still leave several doubts surrounding the concrete predictive potential regarding performance and injuries during competitions while considering the numerous factors involved. Further studies on BIVA and similar applications could provide tools for managing athlete health and physical integrity preservation and potentially help us better understand the factors involved in improving performance.

The relationship between external and internal load parameters in 3 x 3 basketball tournaments. BMC Sports Science, Medicine and Rehabilitation, 14 (152): 1-11, 2022.

Purpose: 3×3 basketball games are characterized by high-intensity accelerations and decelerations, and a high number of changes of direction and jumps. It is played in tournament form with multiple games per day. Therefore, optimal

regeneration is crucial for maintaining a high-performance level over the course of the tournament. To elucidate how load of a match affects the athletes' bodies (i.e., internal load), muscular responses to the load of 3×3 games were analyzed. We aimed to investigate changes in contractility of the m. rectus femoris (RF) and m. gastrocnemius medialis (GC) in response to the load of single 3×3 games and a 3×3 tournament.

Methods: Inertial movement analysis was conducted to capture game load in 3×3. Changes in contractility were measured using tensiomyography (TMG). During a two-day tournament, TMG measurements were conducted in the morning and after each game. Additionally, of-game performance analysis consisting of jump and change-of-direction (COD) tests was conducted the day before the tournament.

Results: Significant changes of the muscle contractility were found for GC with TMG values being higher in the baseline than in the post-game measurements. In contrast to athletes of the GC group, athletes of the RF group responded with either decreased or increased muscle contractility after a single 3×3 game. A significant correlation between external and internal load parameters could not be shown. Concerning of-game performance, significant correlations can be reported for COD test duration, CMJ height and ΔVc as well as COD test duration and ΔDm. No systematic changes in muscle contractility were found over the course of the tournament in RF and GC.

Conclusion: The athletes' external 3×3 game load and their performance level did not seem to affect muscular contractility after a single 3×3 game or a complete 3×3 tournament within this investigation. This might indicate that elite athletes can resist external load without relevant local muscular fatigue. With respect to the course of the tournament, it can therefore be concluded that the breaks between games seem to be sufficient to return to the initial level of muscle contractility.

https://bmcsportsscimedrehabil.biomedcentral.com/articles/10.1186/s13102-022-00530-1

Football

Association between head impact biomechanics and physical load in college football. Annals of Biomedical Engineering, Ahead of Print: 1-7, 2022.

Performance Research Reviews

Abstract - Head impacts and physical exertion are ubiquitous in American football, but the relationship between these factors is poorly understood across a competitive season or even within an individual session. Gameplay characteristics, including player position and session type, may contribute to these relationships but have not been prospectively examined. The current study aimed to determine if an association exists between head impact biomechanics and physical load metrics. We prospectively studied college football players during the 2017–2021 football seasons across representative playing positions (15 offensive and defensive linemen, 11 linebackers and tight ends, and 15 defensive backs, running backs, and receivers). Participants wore halters embedded with Catapult Vector GPS monitoring systems to quantify player load and participant helmets were equipped with the Head Impact Telemetry System to quantify head impact biomechanics and repetitive head impact exposure (RHIE). Generalized linear models and linear regression models were employed to analyze in-session and season-long outcomes, while addressing factors such as player position and session type on our data. Player load was associated with RHIE ($p < 0.001$). Season-long player load predicted season-long RHIE ($R2 = 0.31$; $p < 0.001$). Position group affected insession player load ($p = 0.025$). Both player load and RHIE were greater in games than in practices ($p < 0.001$), and position group did not affect RHIE ($p = 0.343$). Physical load burden was associated with RHIE within sessions and across an entire season. Session type affected both RHIE and player load, while position group only affected player load. Our data point to tracking physical load burden as a potential proxy for monitoring anticipated RHIE during the season.

Bad altitude: Categorizing elevation produces spurious association with concussions in the National Football League. Journal of Orthopaedic & Sports Physical Therapy, Ahead of Print: 1-16, 2022.

Objective: To assess whether prior analyses, where there was a relationship between altitude and concussion rates in American football, would replicate using a larger data set and altitude as a continuous variable.

Design: Cohort study replication

Methods: We analyzed data from all NFL regular season games from 2012-19. Concussions were identified from public databases and NFL injury reports. The altitude of each stadium was identified using mapping software. Concussion rates were calculated for each stadium and plotted against continuous altitude. We calculated crude rate ratios for several categorical cutpoints and used logistic and Poisson regression models to assess associations with continuous altitudes.

Performance Research Reviews

Results: We identified 867 players (1,103 player-seasons) who sustained 1,159 concussions during the time period 2012 to 2019. All continuous plots and models showed no evidence of any association between concussions and altitude. A Poisson model found an IRR of 1.00 (95% CI 0.99-1.01) for every 100 ft increase in altitude. A 644 ft cutpoint (used in previous studies) produced a significant difference (incidence rate ratio (IRR) 0.71, 95% CI: 0.54-0.94) in 2012-13, but this did not replicate in 2014-19 (0.99, 95% CI: 0.84-1.14).

Conclusions: We found no association between altitude and concussion rates in the NFL when altitude was analyzed continuously rather than inappropriately categorized. Our findings should increase skepticism of any effect of altitude on concussions at the elevations at which most American football is played as well as clinical interventions based on that theory. It also underscores the importance of keeping continuous variables continuous wherever possible.

Concussions increase the odds of lower-extremity injuries in National Football League players: Four-year review of publicly available data. Arthroscopy, Sports Medicine, and Rehabilitation, Vol. 4 (4): e1489-e1495, 2022.

Objective: To investigate the effect of multiple concussions on the risk of lower-extremity injuries in National Football League (NFL) players.

Methods: All active NFL players from September 2016 to January 2017 through September 2019 to January 2020 regular seasons were eligible for inclusion. All players who sustained multiple concussions during the study period were identified using publicly available data and included in the multiple concussion (MC) cohort. Players who sustained a single concussion (SC) as well as controls were age and position matched to the MC cohort using MEDCALC case-control. Lower-extremity injuries were then documented for the players included in all 3 cohorts.

Results: The odds of sustaining a lower-extremity injury were significantly greater in the MC as well as the SC cohort when compared with the no concussion (NC)-matched cohort (odds ratio 2.92, standard deviation [SD] 1.7-4.9) and 2.28 (SD 1.5-3.6), respectively. However, we found no significant difference in the odds of sustaining a lower-extremity injury when comparing the SC with the MC cohort (odds ratio 1.00, SD 0.7-1.3). The time to lower-extremity injury after return to play from a concussion was significantly shorter in the SC group when compared with the MC group, within 1 year following a concussion injury (P = .01).

Conclusions: There was a significant increase in the odds of suffering a lowerextremity injury after return to play in NFL players exposed to SC or MC when compared with age- and position-matched controls who did not sustain a concussion

within the study period. There was no significant difference in the odds of suffering a lower-extremity injury after return to play for NFL players exposed to MC when compared with players exposed to a SC during our study period. Our findings suggest a potential need for injury-prevention protocols following concussion injuries.

Consensus Head Acceleration Measurement Practices (CHAMP): Origins, methods, transparency and disclose. Annals of Biomedical Engineering, Ahead of Print: 1-29, 2022.

Abstract - The use of head kinematic measurement devices has recently proliferated owing to technology advances that make such measurement more feasible. In parallel, demand to understand the biomechanics of head impacts and injury in sports and the military has increased as the burden of such loading on the brain has received focused attention. As a result, the field has matured to the point of needing methodological guidelines to improve the rigor and consistency of research and reduce the risk of scientific bias. To this end, a diverse group of scientists undertook a comprehensive effort to define current best practices in head kinematic measurement, culminating in a series of manuscripts outlining consensus methodologies and companion summary statements. Summary statements were discussed, revised, and voted upon at the Consensus Head Acceleration Measurement Practices (CHAMP) Conference in March 2022. This manuscript summarizes the motivation and methods of the consensus process and introduces recommended reporting checklists to be used to increase transparency and rigor of future experimental design and publication of work in this field. The checklists provide an accessible means for researchers to apply the best practices summarized in the companion manuscripts when reporting studies utilizing head kinematic measurement in sport and military settings.

Investigating circadian advantages in the National Football League: A case study of West coast teams. International Journal of Sport and Society, Vol. 13(1): 1-12, 2022.

Abstract - Previous research in the National Football League (NFL) has shown that teams traveling eastward may gain circadian advantages during competition. The current study examines thirty years of performance using all West Coast teams subject to frequent travel in the NFL. We hypothesized that the West Coast teams would gain circadian

advantages during eastward travel compared to travel within the same time zone, and when playing at their circadian peaks during the afternoon. Data for all away games played from the 1990 to 2019 seasons were collected from Pro Football-Reference and FiveThirtyEight (n = 1,018). We investigated the impact of time of game, time zone, and their interaction on game outcomes, points scored and allowed, interceptions, sacks, punts, and completion, field-goal, and extra-point percentages. A series of generalized regressions with Bonferroni-corrected post-hoc tests were performed, controlling for day of the game and each team's strength using Elo rating. We found that teams experienced greater competitive advantages the further eastward they traveled, winning more games, and scoring the most points in the Eastern time zone. Our results also illustrated that teams scored more, allowed fewer points, and had higher completion percentages during afternoon games. Our study provides further evidence for the circadian rhythm advantage for West Coast teams. Limitations, implications, and future directions in the context of the NFL are also discussed.

Longitudinal assessment of NCAA Division I football body composition by season and player age. Journal of Strength and Conditioning Research, Vol. 36(6): 1682-1690, 2022.

Abstract - The purpose of this study was to examine longitudinal body composition changes by position, categorized by season and age, using dual X-ray absorptiometry in NCAA Division I football players. Seven hundred nineteen collegiate male football players aged 18–22 years (Xage ± SE 5 19.4 ± 0.05 years) were examined. Percent body fat (%BF), fat mass (FM), lean mass (LM), total body mass (TM), bone mineral density (BMD), and visceral adipose tissue (VAT) were measured. Players were categorized into position groups of Linemen, Big Skill, Skill, or Special Team. One player scan was used per season (preseason, postseason, and spring season). Analysis of variance and Tukey HSD assessed total and regional differences across age, position groups, and seasons (significance of $p < 0.05$). Linemen had the greatest FM and LM measures compared with other groups for season and age. From preseason to postseason, %BF, FM, LM, and BMD significantly decreased for each position group. From post-season to spring season, %BF, FM, and VAT decreased, whereas LM increased within each position group. FM, VAT, LM, and TM increased with age in all position groups. The findings of this study indicate that body composition significantly worsened from preseason to postseason and improved from the preseason and postseason to the spring season.

Soccer

Performance Research Reviews

Reliability and validity of the 30-15 intermittent field test with and without a soccer ball. Research Quarterly for Exercise and Sport, Ahead of Print: 1-11, 2022.

Objective: The purpose of this study was to examine the reliability and validity of the 30–15 Intermittent Field Test (30– 15IFT) with and without a ball.

Methods: Twenty-four collegiate female soccer players (19.46 ± 1.22 years; 167.01 ± 7.23 cm; 60.95 ± 7.84 kg) performed 1 trial of the Yo-Yo Intermittent Recovery (YYIR) test, 3 trials of the 30–15IFT, and 3 trials of the 30–15IFT with a ball (30–15IFT-B), separated by a minimum 48 hours. Maximal intermittent running velocity (VIFT), heart rate at exhaustion (HRpeak), and rating of perceived exertion (RPE) were collected.

Results: Intraclass correlation coefficients (ICCs) between trials demonstrated good reliability during the 30–15IFT in VIFT (ICC = 0.88) and HRpeak (ICC = 0.89), in addition to the 30–15IFT-B VIFT (ICC = 0.83) and HRpeak (ICC = 0.87). VIFT was significantly reduced in 30–15IFT-B (15.82 km h−1) compared to 30–15IFT (17.52 km h−1; $p < .001$), regardless of trial. HR and RPE were significantly greater in 30–15IFT compared to 30–15IFT-B ($p < .05$). Estimated maximal oxygen consumption (VO2max) YYIR and estimated VO2max of 30–15IFT and 30–15IFT-B was very strongly ($r = 0.82$) and strongly ($r = 0.68$) correlated.

Conclusion: The 30–15IFT is considered valid and reliable and the 30–15IFT-B was reliable in female soccer players.

High metabolic load distance in professional soccer according to competitive level and playing positions, PeerJ, 10: e13318: 1-14, 2022.

Background: High metabolic load distance provides global information about the soccer players' total high-intensity activities. Thus, this study aimed to examine the Spanish professional soccer players' high metabolic load distance profile, comparing competitive level and playing positions.

Methods: A total of 18,131 individual match observations were collected from outfield players competing during the 2018/2019 and 2019/20 seasons in the First and Second Spanish Professional Soccer Leagues (LaLigaTM). High Metabolic Load Distance (HMLD; distance covered with a power consumption above 25.5 W·kg−1 and accelerations or decelerations (e.g., accelerating from 2 to 4 m·s−2 for 1 s) were included), and HMLD per minute (HMLDmin) were analyzed by the ChryonHego video-tracking system. Players were classified according to their playing position as follows: Central Backs (CB), Full Backs (FB), Center Midfields (CM), Wide Midfields (WM), and Forwards (FW).

Performance Research Reviews

Results: No differences between competitive levels were found in any variable when all players were analyzed conjointly except for HMLDmin overall and during the second half. However, when playing positions were considered, differences between competitive levels were observed in all positions, mainly in HMLD and HMLD during the first-half variables. In addition, several differences between playing positions were observed, with CB presenting the lowest values in all variables compared to their counterparts in both competitive levels, whereas CM in First Division and WM in Second Division showed the highest values in the HMLD variables.

Discussion: The findings are of interest to analyze the HMLD in professional soccer players, enabling the adaptation and individualization of training in this population according to the competitive level and specific playing position of each player.

https://peerj.com/articles/13318/

The effects of injury, contextual match factors and training load upon psychological well-being in English Premier League soccer players via season-long tracking. European Journal of Sports Science, Ahead of Print: 1-23, 2022.

Abstract - The study aimed to track psychological wellbeing (PWB) across two consecutive soccer seasons examining the effects of injury, illness, training load (TL) and contextual match factors (playing status, match selection and individual win-rate). Furthermore, examine PWB prior to injury or illness event. Thirty-two English Premier League (EPL) soccer players completed the 'Warwick-Edinburgh Mental Wellbeing Scale' every two weeks. No differences were found for group averaged PWB across the seasons (52.2 ± 0.3 vs. 51.8 ± 1.1) ($p > 0.05$). Previous 7-day TL measured using GPS (session duration, total distance, explosive distance, low-intensity distance, high speed distance (HSD) and sprint distance (SD)) were not related to current PWB ($p > 0.05$). Yet, previous 14-day HSD ($r (385) = - 0.095$) and 21-day SD ($r (385) = 0.100$) were related to current PWB ($p < 0.05$). Only 100% (vs. 0%) win-rate in the previous 14-days to the questionnaire revealed a higher current PWB score (52.7 ± 4.7 vs. 50.9 ± 5.6 ($p < 0.05$)). PWB did not differ prior to an injury or illness event, when players were injured or had low contextual match factors at time of questionnaire or previous match, and the previous 7-days ($p > 0.05$). In conclusion, PWB fluctuations across the season are associated with prior TL and multiple negative results. But prior PWB was not linked to injury or illness events. Implications for prioritizing interventions to improve PWB during periods of chronic high intensity TLs and losing streaks, monitoring PWB, and use in injury and illness prediction are discussed.

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Highlights:

• Psychological wellbeing responses, as measured by the 'Warwick-Edinburgh Mental Wellbeing Scale' did not change significantly at a group level between the phases of the two seasons.
• Prior training load was associated with wellbeing scores, specifically previous 14-day high speed distance and 21-day sprint distance.
• Psychological wellbeing scores were only affected by win/loss rate in the previous 14-days. • These findings highlight the importance of timely interventions to improve wellbeing in periods of negative results, and the recommendation of longitudinally monitoring wellbeing.

Swimming

Swimming warm-up and beyond: Dryland protocols and their related mechanisms – A scoping review. Sports Medicine – Open, 8 (120): 1-44, 2022.

Abstract - In swimming, the beneficial effects of the in-water warm-up are often undermined by the long transition periods before competition (≥20 min). For that reason, studies comparing the effects of in-water warm-ups followed by dryland activities have been conducted in the swimming literature. This has brought conflicting evidence due to large combinations of supervised and unsupervised warm-up procedures used. Therefore, a scoping review was performed to discuss (1) why warm-up strategies are important for competitive swimming; to identify (2) what are the different warm-up approaches available in the literature, and; to establish (3) what are the main conclusions, considerations and gaps that should be addressed in further research to provide clearer guidance for interventions. The search was conducted on PubMed, Web of Science, Scopus, and SPORTDiscus databases. To be considered eligible, studies must have assessed acute short-term responses of warm-up procedures in swimmers by using randomized controlled trials or pre-post study designs. A total of 42 articles were included in this review. The effectiveness of warm-up responses was evaluated based on the inclusion or not of warm-up, the type of conditioning activity (in-water exercise, inwater exercise combined with dryland or dryland exercise only), its duration, and intensity. (1) Warm-up mechanisms have been mainly related to temperature changes associated to cardiovascular adaptations and short-term specific neuromuscular adaptations. Thus, maintaining muscle activity and body temperature during the transition phase immediately prior to competition could help swimmers' performance; (2) the most common approach before a race

usually included a moderate mileage of in-water warm-up (~1000 m) performed at an intensity of≤60% of the maxi- mal oxygen consumption, followed by dryland protocols to keep the muscle activity and body temperature raised during the transition phase. Dryland activities could only optimize performance in sprint swimming if performed after the in-water warm-up, especially if heated clothing elements are worn. Using tethered swimming and hand-paddles during warm-ups does not provide superior muscular responses to those achieved by traditional in-water warm-ups, possibly because of acute alterations in swimming technique. In contrast, semi-tethered resisted swimming may be considered as an appropriate stimulus to generate post-activation performance enhancements; (3) nothing has yet been investigated in backstroke, butterfly or individual medley, and there is a paucity of research on the effects of experimental warm-ups over distances greater than 100 m. Women are very under-represented in warm-up research, which prevents conclusions about possible sex-regulated effects on specific responses to the warm-up procedures.

https://link.springer.com/article/10.1186/s40798-022-00514-y

Longitudinal tracking of body composition, lower limb force-time characteristics and swimming start performance in high performance swimmers. International Journal of Sports Science & Coaching, 17(1): 83-94, 2022.

Abstract - This study aimed to (1) track changes in body composition, lower body force-time characteristics, and swim start performance over a competitive season, and (2) investigate the intra-individual associations between changes in body composition and lower body force-time characteristics to swim start performance in five high performance swimmers (three males, two females). Over a 12-month period, body composition, lower body force-time characteristics and swim start performance were assessed at three time points via DXA scan, squat jump and swim start performance test (start times to 5 and 15 m and several kinematic and kinetic outputs). Throughout a competitive season of concurrent swimming and dry-land resistance training, improvements in lower body lean mass and squat jump force-time characteristics were observed. However, changes in start times varied between athletes. Total body and lower body lean mass both displayed large negative correlations with the time spent in the entry and propulsive underwater phases (r = –0.57 to –0.66), along with a large positive correlation with glide time (r = 0.56–0.53). Additionally, lower body lean mass exhibited large to very large positive correlations with the flight phase (r = 0.70–0.73). Overall, these findings provide some insight into the potential magnitude of change in body composition, lower body force-time characteristics and swim start performance in high performance swimmers within a season. The large to very large

correlations between increased lower body lean mass and SJ force-time metrics to improvements in aspects of start performance may provide useful information to coaches and sports scientists.

Biophysical impact of 5-week training cessation on sprint swimming performance. International Journal of Sports Physiology and Performance, 17: 1463-1472, 2022.

Purpose: To assess changes in swimming performance, anthropometrics, kinematics, energetics, and strength after 5-week training cessation.

Methods: Twenty-one trained and highly trained swimmers (13 males: 17.4 [3.1] y; 50-m front crawl 463 [77] FINA points; 8 females: 16.7 [1.7] y; 50-m front crawl 535 [48] FINA points) performed a 50-m front-crawl all-out swim test, dryland and pool-based strength tests, and 10-, 15-, 20-, and 25-m front-crawl all-out efforts for anaerobic critical velocity assessment before and after a 5-week training cessation. Heart rate and oxygen uptake (VO ˙ 2) were continuously measured before and after the 50-m swim test (off-kinetics).

Results: Performance was impaired 1.9% (0.54 s) for males (P = .007, d = 0.91) and 2.9% (0.89 s) for females (P = .033, d = 0.93). Neither the anthropometrical changes (males: r 2 = .516, P = .077; females: r 2 = .096, P = .930) nor the physical activities that each participant performed during the off-season (males: r 2 = .060, P = .900; females: r 2 = .250, P = .734) attenuated performance impairments. Stroke rate and clean swimming speed decreased (P < .05), despite similar stroke length and stroke index (P > .05). Blood lactate concentrations remained similar (P > .05), but VO ˙ 2 peak decreased in females (P = .04, d = 0.85). Both sexes showed higher heart rate before and after the 50-m swim test after 5 weeks (P < .05). Anaerobic metabolic power deterioration was only observed in males (P = .035, d = 0.65). Lower in-water force during tethered swimming at zero speed was observed in males (P = .033, d = 0.69). Regarding dryland strength, lower-body impairments were observed for males, while females showed upper-body impairments (P < .05).

Conclusions: A 5-week training cessation yielded higher heart rate in the 50-m front crawl, anaerobic pathways, and dryland strength impairments. Coaches should find alternatives to minimize detraining effects during the off-season.

Tennis

Performance Research Reviews

Determinant physical factors of tennis serve velocity: A brief review. International Journal of Sports Physiology and Performance, 17: 1159-1169, 2022.

Purpose: To review the main physical aspects that could positively or negatively influence serve velocity (SV).

Methods: An examination of existing literature including studies analyzing positive (biomechanical aspects, anthropometrics, range of motion, strength, and power) and negative (competition-induced fatigue) associations to SV are summarized in this review.

Results: Aspects such as lower-leg drive, hip and trunk rotations, upper-arm extension, and internal rotation seem to be the major contributors to racquet and ball speed. Favorable anthropometric characteristics, such as body height, arm length, and a greater lean body mass, seem to positively influence SV. Also, strength indicators such as maximal isometric strength and rate of force development in specific joint positions involved in the kinetic chain alongside upper-body power seem to be related to faster serves. On the other hand, the effects of prolonged or repetitive match play may impair the aforementioned factors and negatively influence SV.

Conclusions: Following specific serving models that seem to enhance velocity production and efficient motion is highly recommended. Moreover, achieving a higher impact point, alongside shifting body composition toward a greater lean body mass, will most likely aid toward faster serves. Programs aiming at improving maximal isometric strength and rate of force development in specific positions involved in the kinetic chain including stretchshortening cycle predominance and the mimicking of the serve motion seem of great interest to potentially increase SV. Effective recovery and monitoring of these variables appear to be essential to avoid impairments produced by continued or repetitive competition loads.

Recovery during and after a simulated multi-day tennis tournament: Combining active recovery, stretching, cold-water immersion, and massage interventions. European Journal of Sport Science, 22(7): 973-984, 2022.

Abstract - The aim of this study was to investigate the effects of a mixed-method recovery intervention (MMR) consisting of active recovery, stretching, cold-water immersion, and massage on physical, technical, physiological, and

perceptual recovery during and after a five-day simulated tennis tournament. Nine competitive male tennis players (age, 24.6±4.2 years) with national ranking positions (German Tennis Federation) and Universal Tennis Ratings between approximately 11– 13 participated in two singles tennis tournaments, which were separated by a three-month washout period. During the tournaments, participants played five two-and-a-half-hour competitive singles tennis match on five consecutive days. For the assignment to one of two groups, athletes were matched into homogeneous pairs according to their ranking. Then, within each pair, the players were randomly assigned to one of two groups. The first group performed MMR during the first tournament, whereas the other group used passive recovery (PAS). During the second tournament, recovery conditions were interchanged. Measures of physical and technical performance as well as physiological and perceptual responses (heart rate, blood lactate concentration, perceived exertion) were recorded during match-play sessions. Furthermore, muscle soreness, perceived recovery state, blood markers, countermovement jump height (CMJ), and repeated sprint ability (RSA) were determined before, during, and after the five-day tournament periods. Results showed significant changes over time ($P < 0.05$) in muscle soreness, perceived recovery state, creatine kinase, c-reactive protein, insulin-like growth factor 1, and countermovement jump height. However, no significant differences or recovery strategy x time interactions were noted either for tennis-specific performance (e.g. number of total points won) or any other of the measured parameters between MMR and PAS ($P > 0.05$). In conclusion, the repeated use of MMR during and after a five-day tennis tournament did not affect match performance, match load, or recovery from repeated days of tennis match play.

Associations between lower limb eccentric muscle capability and change of direction speed in basketball and tennis players. PeerJ, 10: e13439: 1-15, 2022

Background: The ability to perform a quick and rapid change of direction (CoD) is an important determinant of success in a variety of sports. Previous studies have already highlighted that eccentric strength is a dominant predictor of CoD. However, these studies evaluated eccentric strength through a limited number of outcome measures and used small sample sizes.

Methods: A total of 196 athletes participated in the study. The aim of our study was to investigate: (1) the correlation between eccentric outcome measures derived from different tests (Nordic hamstring exercise (NHE), countermovement jump (CMJ) and flywheel (FW) squats), (2) the association between eccentric outcome measures and CoD 90 ◦ , CoD 180 ◦ ; and (3) proportion of explained variance in CoD performance.

Results: Very large associations (r = 0.783, p < 0.001) were observed between peak torque during NHE (NHEPT) and force impulse during the eccentric phase of CMJ (CMJFI). Small to moderate correlations were calculated between peak eccentric force in flywheel squats and peak eccentric force in CMJ (r = 0.220–035, p < 0002). All eccentric CMJ outcome measures and NHEPT were reported as moderate negative associations with both CoD tests. Eccentric measures explained 25.1% of the variance in CoD 90 ◦ (CMJPF, NHEPT, F0.125 –peak eccentric force during FW squats with 0.125 kg m2 load), while the same outcome measures explained 37.4% of the variance for CoD 180 ◦ .

Conclusion: Our results suggest that different measures of eccentric strength specifically contribute to CoD performance. Therefore, for successful CoD performance, different aspects of eccentric strength training should be considered in testing and training (maximal eccentric strength, eccentric-concentric actions with fast execution).

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Volleyball

Spike arm swing techniques of Olympics male and female elite volleyball players (1984- 2021). Journal of Sports Science and Medicine, 21: 465-472, 2022.

Abstract - In the last decades, indoor volleyball has experienced significant rule changes and a high player specialization in both sexes. Different spike attack arm swing techniques have developed which might affect performance and risk of injury. While a variety of arm swing techniques was already shown in world class beach volleyball players, it is unclear if this is also true for world class indoor volleyball. Therefore, the purpose of this study was to assess the spike attack arm swing techniques of Olympic volleyball winners and finalists (1984-2021) and to investigate possible differences between sex, playing position, scoring system, and compared to beach volleyball. Eighty-two male (M) and 85 female (F) players were assessed from video recordings from ten competitions. Five different arm swing techniques in the cocking phase (Straight, Bow-and-arrow high, Bow-and-arrow low, Snap, Circular) were classified by two experts. The most frequent technique for both sexes was the Circular (M = 40.2%; F = 38.8%), followed by Snap (M = 28.0%; F = 23.5%), Bow-and-arrow low (M = 20.7%; F = 21.2%), Bow-and-arrow high (M = 7.3% F = 11.8%), and Straight (M = 3.7%; F = 4.7%). Bow-and-arrow high and Straight techniques were significantly less used than other techniques in both sexes. There were no significant differences (p > 0.05) in arm swing techniques between sexes, playing positions, and scoring system but significant differences (p < 0.001) to beach volleyball. Although most volleyball textbooks only describe the Bow-and-arrow techniques, most of the world class indoor volleyball players used Circular and Snap arm swing techniques. Reasons for that could be the implicit knowledge of players (and coaches) regarding increased performance

(ball speed) and injury prevention. Based on these results we suggest to critically revise arm swing technique training especially for young players and players with shoulder problems.

Validation of internal and external load metrics in NCAA D1 women's beach volleyball. Journal of Strength and Conditioning Research, 36(8): 2223-2229, 2022.

Abstract - The purpose of this study was to determine the validity of internal and external load metrics in NCAA D1 women's beach volleyball. Subjects included 13 NCAA D1 women's beach volleyball players (age: 20.3 6 1.4 years). A total of 578 data points were analyzed from 51 team training sessions, including practice, games, and sport-specific conditioning during the pre-season semester (15 weeks). Data points included Edward's training impulse (TRIMP) (228.0 6 80.7 arbitrary units [AU]), session rating of perceived exertion (sRPE) Load (532.5 ± 232.8 [AU]), distance covered (DC) in meters (2,635.4 ± 884.3 [m]), and daily environmental condition variables {(temperature (76.5 ± 13.7 [˚F]), relative humidity (72.5 ± 13.2 [%]), and wet-bulb globe temperature (52.9 ± 19.9 [˚F])}. The subjects wore Polar Team Pro heart rate monitors with global positioning system during each session. Subjects completed an sRPE questionnaire after every session. Pearson product moment correlations yielded statistically significant relationships (p , 0.01) between TRIMP and sRPE Load (r = 0.81), TRIMP and DC (r = 0.78), and sRPE Load and DC (r = 0.82). A forward selection multiple regression yielded that sRPE Load could predict TRIMP with the equation: TRIMPTometz 5 78.735 + (sRPE Load * 0.28) (p < 0.001). These findings support sRPE Load as a valid alternative to TRIMP when monitoring internal loads in NCAA D1 women's beach volleyball. Session rating of perceived exertion Load may be more practical and accessible for teams. Distance covered should be considered when periodizing and monitoring training loads because of its relationship with internal loads.

Volleyball competition on consecutive days modifies jump kinetics but not height. International Journal of Sports Physiology and Performance, Ahead of Print: 1-9, 2022.

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Purpose: In volleyball, jump execution is critical for the match outcome. Game-play-related neuromuscular impairments may manifest as decreased jump height (JH) or increased jump total duration, both of which are pivotal for performance. To investigate changes in JH and kinetics with game play, the authors conducted a prospective exploratory analysis using minimal-effect testing (MET) and equivalence testing with the 2 one-sided tests procedure, univariate, and bivariate functional principal component analysis, respectively.

Methods: Twelve male varsity athletes completed 3-set matches on 2 consecutive days. Countermovement jumps were performed on a force platform immediately prematch and postmatch on days 1 and 2 and once on days 3 and 4.

Results: Across sessions, JH was equivalent ($P < .022$, equivalence test), while total duration reported inconclusive changes ($P > .227$). After match 2, MET indicated that relative force at zero velocity ($P = .036$) decreased, while braking duration ($P = .040$) and time to peak force ($P = .048$) increased compared with baseline. With the first and second functional principal components, these alterations, together with decreased relative braking rate of force development ($P = .092$), were already evident after match 1. On day 4, MET indicated that relative peak force ($P = .049$), relative force at zero velocity ($P = .023$), and relative braking rate of force development ($P = .021$) decreased, whereas braking duration ($P = .025$) increased from baseline.

Conclusions: Impairments in jump kinetics were evident from variables related to the countermovement-jump braking phase, while JH was equivalent. In addition to these experimental findings, the present research provides information for the choice of sample size and smallest effect size of interest when using MET and 1- and 2-dimensional analyses for countermovement-jump height and kinetics.

Meet Ted Lambrinides

Ted Lambrinides serves as a NFL-PFATS Sport Science Consultant, providing monthly research updates for all NFL teams. In addition, he provides the Professional Baseball Strength and Conditioning Coaches Society (PBSCCS) and the National Basketball Strength Coaches Association (NBSCA) with sports research updates