



Performance Research Reviews

October 2024

Baseball

A review of the effects of early sport specialization on the health of adolescent baseball players. Bone Bulletin, Vol. 2(1): Article 11: 1-4, 2024.

Overview - Participation in sports during adolescence is beneficial for participants as it improves fitness, enhances psychosocial development, increases academic performance, and boosts self-esteem. One of the most popular sports among adolescent athletes is baseball, with nearly 500,000 high school players in the United States in 2020. While participation in sports has been shown to have clear benefits and has been steadily increasing, recent decades have also seen a dramatic rise in the level of competition. As a direct result, there has been an increase in the prevalence of early sports specialization (ESS) with an estimated 14-47% of adolescent athletes focusing on one sport.³ ESS refers to a prepubertal athlete who engages in rigorous training for a single sport for over 8 months annually, while refraining from participation in other sports to concentrate on their primary athletic pursuit. Although ESS is becoming increasingly prevalent across various sports, baseball stands out with the highest prevalence of ESS (12.1%). This practice has become more popular due to parents, coaches, and athletes' understanding of the common adage of the "10,000-hour rule", where 10,000 hours of dedicated practice on one skill is required to achieve mastery or expertise in that skill.⁶ Assuming this rule holds true in sports, it is logical to think more time spent training on one sport at a younger age will translate into more success in the form of better performance. Parents also assume that greater success enables increased opportunities to receive collegiate scholarships and a better likelihood of recruitment to play in Major League Baseball (MLB). However, recent research has shown that the "10,000-hour rule" has not been shown to translate to sports and ESS may be far more detrimental for adolescent baseball players than it is beneficial.



Performance Research Reviews

Effects of shoulder corrective training program on pitching loads and sonographic morphology in elbow joint in youth baseball players. Journal of Strength and Conditioning Research, 38(8): e440-e447, 2024.

Abstract - We assessed the effects of a 12-week shoulder corrective training program for shoulder flexibility and strengthening on pitching loads and sonographic morphology of the elbow joints in youth baseball players. Seventeen subjects were recruited and underwent evaluations before and after the training program. We found that following training, subjects demonstrated significantly increased ranges of shoulder internal rotation ($38.9 \pm 12.9^\circ$ vs. $69.2 \pm 10.8^\circ$, $p < 0.001$), external rotation ($91.2 \pm 14.6^\circ$ vs. $107.3 \pm 9.5^\circ$, $p = 0.004$), and horizontal adduction ($21.5 \pm 8.0^\circ$ vs. $32.7 \pm 7.3^\circ$, $p = 0.002$); improved strength in the shoulder internal rotators (8.7 ± 1.6 kg vs. 9.8 ± 2.1 kg, $p = 0.04$), external rotators (6.5 ± 1.9 kg vs. 7.5 ± 2.8 kg, $p = 0.04$), middle trapezius (12.7 ± 2.1 kg vs. 14.3 ± 2.4 kg, $p = 0.04$), and middle deltoid muscles (10.8 ± 3.3 kg vs. 14.8 ± 3.2 kg, $p = 0.001$); and decreased thickness of the ulnar collateral ligament (6.1 ± 0.6 mm vs. 4.8 ± 0.7 mm, $p = 0.002$). Although there was no substantial change in elbow torque and arm speed, significantly increased ball speed (51.2 ± 4.6 mph vs. 54.1 ± 4.5 mph, $p < 0.001$) and decreased arm slot ($63.8 \pm 11.9^\circ$ vs. $53.0 \pm 12.7^\circ$, $p = 0.02$) were observed. We suggest that adequate corrective training should be performed regularly to minimize or mitigate adverse soft tissue changes at the elbow in youth baseball players. Balanced shoulder strength and flexibility may decrease medial elbow stress during pitching. Future studies should consider the kinetic and kinematic effects of other corrective training programs on the shoulder or elbow joint during pitching.

Practical Applications - The youth baseball players demonstrated increased shoulder rotational ranges and strength, increased scapular muscle strength, and decreased UCL thickness associated with increased ball speed and preserved elbow valgus torque after performing corrective training for shoulder flexibility and strength. Corrective training may need to integrate sports technique training to transfer physical improvements into sports performance and avoid altered pitching movements. Pitching loads and sonographic morphology of medial elbow and shoulder flexibility and strength should be regularly monitored for the protocol design and implementation of corrective training program.



Performance Research Reviews

Fastball quality after ulnar collateral ligament reconstruction in Major League Baseball pitchers. The American Journal of Sports Medicine, Ahead of Print: 1-9, 2024.

Background: The ulnar collateral ligament (UCL) is essential for elbow stability during pitching. In professional baseball, the fastball (FB) is the most commonly used pitch, making postrecovery FB performance after UCL reconstruction (UCLR) a crucial aspect to consider.

Hypotheses: (1) Pitchers undergoing UCLR would show no significant changes in performance metrics compared with nonoperated pitchers with similar FB velocity and spin rate, and (2) no significant variance would be found in these metrics within the operated pitchers concerning their preinjury anthropometric characteristics and pitching performance metrics.

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

Methods: The study included 91 Major League Baseball (MLB) pitchers who underwent primary UCLR between January 1, 2015, and December 31, 2021. A matched 1:1 control group of MLB pitchers without UCLR injuries was established. Publicly available pitch metrics and anthropometric data were compared between the study and control groups.

Results: Disparities in several performance metrics emerged during the first postreturn year (PRY1), including FB use percentage ($P = .029$), fielder independent pitching (FIP) ($P = .021$), and standardized FB runs above average per 100 pitches (wFB/C) ($P < .001$). Subgroup analysis within the UCLR group revealed a negative correlation between presurgery mean FB velocity and its subsequent change ($P < .001$) and a positive correlation with changes in FIP ($P = .025$) from the index year to PRY1. A negative correlation was observed between FB use percentage in the index year and its change by PRY1 ($P = .002$). By the second postreturn year, no significant differences were found in these performance metrics. No factors were significantly related to prolonged recovery time.

Conclusion: Although FB velocity and spin rate remained consistent, significant differences were observed in FB use percentage, FIP, and wFB/C in PRY1. However, by second postreturn year, these differences were no longer significant. No specific risk factors were identified concerning prolonged recovery time between pre-UCLR FB pitching metrics and the physical anthropometric data. These results suggest that although the short-term postsurgery period may affect more specialized pitching metrics, the basic pitching performance metrics, as hypothesized, remain largely unaffected by UCLR.



Performance Research Reviews

Major League Baseball pitchers' arm angles measured on game videos were not associated with an increased risk of UCL injury. Arthroscopy, Sports Medicine, and Rehabilitation, Ahead of Print: 1-16, 2024.

Purpose - The purpose of this study is to use publicly available Major League Baseball (MLB) game video to investigate whether pitch type and pitching elbow angle at peak valgus stress and at release point are associated with the odds of undergoing Tommy John surgery.

Methods - This case-control study compared pitchers who had undergone UCL reconstruction to a matched control group of pitchers who had not undergone the surgery. Pitchers were selected based on inclusion in online baseball player and injury databases including the MLB Health and Injury Tracking System (MLB HITS), with those pitching less than 10 innings in Major League Baseball excluded. The experimental group included measurements from all pitchers before their UCL injury who eventually underwent Tommy John surgery since 2010. Greedy matching algorithm was used to select a matched cohort of pitchers based on age, height, weight, years in the MLB, hand dominance, pitching role (starter versus reliever), and average pitching velocity. Conditional logistic regression models were used to measure the association between pitch angle and log odds of receiving a Tommy John surgery.

Results - There were 249 paired cases and controls (N = 498) included in the conditional logistic regression analysis. There was no statistically significant association between average elbow angle at peak valgus stress and the odds of undergoing Tommy John surgery (OR = 1.02, 95% CI: 0.99 – 1.03; p = .14).

Conclusion - Peak valgus elbow angle, release point angles, and combinations of angles and specific pitches were not associated with an increased risk of undergoing Tommy John surgery.

Level of Evidence - Level III - Observational study, case-control design



Performance Research Reviews

Basketball

Comparative analysis of key performance indicators in Euroleague and national basketball leagues. Journal of Physical Education and Sport, Vol. 24(6): 1360-1372, 2024.

Background: Understanding the performance metrics that underpin team success in the dynamic professional basketball world is crucial. This study originated in the context of increasing academic and professional interest in performance analytics, focusing on how teams in elite leagues, such as the Euroleague and their respective national leagues, adapt and perform based on specific key performance indicators (KPIs).

Purpose: The primary objective of this research is to bridge the existing bibliographic gap by comparing the effectiveness of various KPIs in predicting match outcomes in both the Euroleague and National Basketball Leagues. This comparison aims to identify how strategic adaptations and performance measures differ according to the unique demands and styles of the respective competitions.

Methodology: The study utilized two main datasets: one encompassing all Euroleague 2022–23 matches and the other compiling cumulative statistics from Euroleague teams over three seasons. Machine learning techniques, including Random Forest, Logistic Regression, and Support Vector Machines, were employed along with the Boruta algorithm for feature selection to enhance predictive accuracy and SHapley Additive exPlanations (SHAP) for the interpretability of the model output.

Results: The analysis identified that certain KPIs, such as the effective field goal percentage, defensive ratings, and assists-to-turnover ratio, vary significantly in their impact on game outcomes between Euroleague and National League games. These variations imply that teams may need to tailor their strategies depending on the league in which they play.

Conclusions: This study significantly advances the field of sports analytics by providing a detailed comparative analysis of basketball performance metrics across two competitive settings. It offers practical insights that can help coaches and analysts optimize team performance and strategic planning. Moreover, sophisticated data analysis techniques have allowed for a deeper understanding of the complex dynamics that influence basketball game outcomes, thereby making a significant contribution to the literature and practice of sports performance analysis.



Performance Research Reviews

Considerations for vertical jump testing in collegiate basketball players: The impact of immediate individual versus social comparison feedback and team leaderboard engagement. International Journal of Sports Science & Coaching, Ahead of Print: 1-8, 2024.

Abstract - Recent literature has shown that the provision of feedback can enhance vertical jump performance acutely, as well as chronically when implemented during phases of training. The aim of our study was to investigate the influence of two types of visual feedback on performance and variability of countermovement jump-derived force-time characteristics in a cohort of male and female National Collegiate Athletic Association Division 1 basketball players. Specifically, individual visual feedback (IVF) was compared to a form of social comparison feedback (SCF), and authors hypothesized there to be performance increases and more stable measures in the SCF condition. In line with this hypothesis, findings suggested significantly enhanced performance in the SCF condition for seven out of eight force-time metrics (e.g. jump height and reactive strength index modified). However, given the small between-condition effect sizes, differences between conditions may lack practical significance. Furthermore, findings suggested less between-jump variability in the SCF condition, compared to the IVF condition, making for a more stable assessment. This in particular makes for more reliable measures, for which when studied over time, more subtle changes in performance may be observed. In summary, our findings highlight acutely enhanced vertical jump performance, and more stable measures, when athletes are exposed to an SCF condition, compared to a normal IVF condition. Practitioners are encouraged to consider these findings when planning vertical jump assessments and are discouraged from implementing different types of feedback at random, especially when measuring performance over time.

Dismissing the idea that basketball is a “contactless” sport: Quantifying contacts during professional gameplay. Frontiers in Sports and Active Living, 6: 1419088, 2024.

Introduction: Basketball, introduced by Naismith as a contactless and indoor alternative to sports such as American football, now frequently involves physical contact among players, challenging the traditional notion. Up to date, a thorough understanding of these contacts and their implications remains limited. This study aims to analyze player contacts, embedding it within overall load monitoring to optimize performance and reduce injury risk.

Methods: Using a mixed-method design, video-based observations and quantitative analysis were employed to study contact characteristics during ten professional male basketball matches. Fisher exact tests and chi-squared tests ($p < .05$) were conducted to examine positional variations across different contact variables.



Performance Research Reviews

Results: A total of 2,069 player contacts were examined, showing centers had the most contacts at 40.5%, followed by power forwards (19.6%), point guards (17.7%), shooting guards (12.9%), and small forwards (9.3%). Notably, half-court defense (46.1%) and set offense (48.9%) emerged as the primary game phases associated with the majority of contacts across all playing positions. Key play actions leading to physical contact included screening/picking (25.7%), box outs (22.9%), and fights for position (FFP) (18%). Post hoc analyses identified significant associations between centers (32.6%, 5.93) and point guards (21.5%, -1.98) during screening/picking maneuvers. Moreover, the torso/upper body (48.1%) and upper extremities (38.2%) were identified as the most affected contact points, while lower extremities and the head/neck exhibited minimal impact. Additionally, 81.4% (n = 1,684) of contacts resulted in kinematic displacement, whereas 18.6% (n = 385) exhibited no change. Post hoc analyses indicated significant associations of physical contacts against opposing counterparts for each playing position.

Discussion: Basketball entails frequent physical contacts across all playing positions, with distinct patterns observed for each playing position. Integrating contact monitoring alongside traditional load metrics offers a more comprehensive understanding of physical demands in professional basketball. Practical implications include the developing of tailored training strategies based on playing position-specific contact profiles and recognizing the physiological and biomechanical impacts of contacts. Future research should consider whether the number of contacts between players has increased over the years, and it should acknowledge the impact of player contacts on performance in basketball in order to refine training strategies and enhance player well-being.

Male NBA G-League and collegiate basketball athletes have a high prevalence of radiographic ankle abnormalities. Arthroscopy, Sports Medicine, and Rehabilitation, Ahead of Print: 1-26, 2024.

Purpose: The purposes of this study were to characterize radiographic foot/ankle bony abnormalities in elite-level, asymptomatic male basketball athletes, and to investigate the association between anthropometric (age, height, weight) or sport-specific characteristics (total exposures, player position, pregame ankle taping) and the prevalence of abnormal radiographic findings in asymptomatic basketball athletes

Methods: Elite-level basketball players who underwent routine, pre-season static radiographic imaging, including antero-posterior, lateral, and mortise views of the ankle were included. Radiographs were collected from asymptomatic athletes participating in pre-season history and physical with negative anterior drawer/talar tilt test. Radiographs were



Performance Research Reviews

evaluated by a musculoskeletal radiologist and board-certified orthopedic surgeon; kappa statistics were used to evaluate agreement.

Results: Fifty-four basketball players (34 collegiate, 20 professional; mean age 21.5 years) were included, totaling 5,148 player exposures from 2017-2019. 106 ankles presented with radiographic findings (98.15%). The most prevalent radiographic finding was pes planus (47.22%), followed by degenerative joint disease (DJD) (33.33%), talonavicular sclerosis (28.70%), prominent stieda process (25.93%), os trigonum (20.93%), os subfibulare (11.11%), pes cavus (5.56%), subtalar coalition (2.78%), and cavovarus (0.93%). Height ≥ 80 " was significantly associated with talonavicular sclerosis and Kellgren-Lawrence 1 changes.

Conclusions: This study demonstrated a strong association between height and talonavicular sclerosis and DJD, as well as a relatively high prevalence of pes planus and DJD in asymptomatic collegiate and professional basketball players.

Football

Age of first exposure does not relate to post-career health in former American-style football players. Sports Medicine, Ahead of Print: 1-10, 2024.

Objective: Prior studies examining small samples of symptomatic former professional football players suggest that earlier age of first exposure (AFE) to American football is associated with adverse later life health outcomes. This study examined a larger, more representative sample of former professional American football players to assess associations between AFE before age 12 (AFE < 12) and clinical outcomes compared with those who started at age 12 or older (AFE 12+).

Methods: Former professional American football players who completed a questionnaire were dichotomized into AFE < 12 and AFE 12+. AFE groups were compared on outcomes including symptoms of depression and anxiety, perceived cognitive difficulties, neurobehavioral dysregulation, and self-reported health conditions (e.g., headaches, sleep apnea, hypertension, chronic pain, memory loss, dementia/Alzheimer's disease, and others).

Results: Among 4189 former professional football players (aged 52 ± 14 years, 39% self-reported as Black), univariable associations with negligible effect sizes were seen with AFE < 12, depressive symptoms ($p = 0.03$; $\eta^2 = 0.001$), and anxiety-related symptoms ($p = 0.02$; $\eta^2 = 0.001$) only. Multivariable models adjusting for age, race, body mass index, playing position, number of professional seasons, and past concussion burden revealed no significant relationships



Performance Research Reviews

between AFE < 12 and any outcome. Linear and non-linear models examining AFE as a continuous variable showed similar null results.

Conclusions: In a large cohort of former professional American-style football players, AFE was not independently associated with adverse later life outcomes. These findings are inconsistent with smaller studies of former professional football players. Studies examining AFE in professional football players may have limited utility and generalizability regarding policy implications for youth sports.

Key Points

- Prior studies suggested that starting to play football at younger ages (i.e., before 12 years old) may be associated with worse later-life outcomes (e.g., cognitive functioning, depression symptoms), but these studies had small sample sizes and all participants had self-reported cognitive, behavioral, and/or mood symptoms. Larger studies have not found this association.
- Questionnaire data provided by 4189 former American-style professional football players did not indicate that younger age of first exposure to football was significantly associated with any self-reported negative health outcomes when adjusting statistical models for other important variables.
- Future longitudinal cohort studies of youth football that further clarify the potentially harmful elements of youth football will assist parents and healthcare professionals in balancing the positive effects of football participation (e.g., cardiovascular conditioning, mentoring and community support, teamwork, self-esteem) and with the potential risks associated with play.

An examination of competitive rule evolution in the National Football League. Managing Sport and Leisure, Ahead of Print: 1-18, 2024.

Purpose/rationale: Competitive rules, which have implications for player safety, fairness, and entertainment, change over time, yet institutional accounts offer only a high-level view of rule change. This study centers, and looks within, competitive rules to examine how they evolve in professional sport.

Design/methodology/approach: Using an inductive approach, we conducted a qualitative document analysis of NFL rule books published between 1980 and 2020. We developed and examined longitudinal trajectories of player conduct rules.



Performance Research Reviews

Findings: The analysis reveals rule components (i.e. actions, actors, times, spaces, sanctions) and patterns of change. Rules generally expanded in scope and length. We draw on communications from NFL leaders to connect the findings to institutional factors.

Practical implications: The findings offer a framework for rule managers as they iterate rules to make sport safer, fairer, and more entertaining.

Research contribution: This study sheds light on how competitive rules evolve at the level of component parts, providing a foundation for future institutional scholarship on the causes and consequences of rule change.

Originality/value: This research offers a microfoundations and longitudinal understanding of rule change in sport, with insights for academics and rule managers.

Association between total genotype score and muscle injuries in top-level football players: A pilot study. Sports Medicine – Open, 10:22, 2024.

Background: Recently, genetic predisposition to injury has become a popular area of research and the association between a few single nucleotide polymorphisms (SNPs) and the susceptibility to develop musculoskeletal injuries has been shown. This pilot study aimed to investigate the combined effect of common gene polymorphisms previously associated with muscle injuries in Italian soccer players.

Results: A total of 64 Italian male top football players (age 23.1 ± 5.5 years; stature 180.2 ± 7.4 cm; weight 73.0 ± 7.9 kg) were genotyped for four gene polymorphisms [ACE I/D (rs4341), ACTN3 c.1729C > T (rs1815739), COL5A1 C > T (rs2722) and MCT1 c.1470A > T (rs1049434)]. Muscle injuries were gathered for 10 years (2009-2019). Buccal swabs were used to obtain genomic DNA, and the PCR method was used to genotype the samples. The combined influence of the four polymorphisms studied was calculated using a total genotype score (TGS: from 0 to 100 arbitrary units; a.u.). A genotype score (GS) of 2 was assigned to the "protective" genotype for injuries, a GS of 1 was assigned to the heterozygous genotype while a GS of 0 was assigned to the "worst" genotype. The distribution of genotype frequencies in the ACE I/D (rs4341), ACTN3 c.1729C > T (rs1815739) and MCT1 c.1470A > T (rs1049434) polymorphisms was different between non-injured and injured football players ($p = 0.001$; $p = 0.016$ and $p = 0.005$, respectively). The incidence of muscle injuries was significantly different among the ACE I/D (rs4341), ACTN3 c.1729C > T (rs1815739) and COL5A1 C > T (rs2722) genotype groups, showing a lower incidence of injuries in the "protective" genotype than "worse" genotype (ACE, $p < 0.001$; ACTN3, $p = 0.005$) or intermediate genotype (COL5A1, $p = 0.029$). The mean TGS in non-injured football players



Performance Research Reviews

(63.7 ± 13.0 a.u.) was different from that of injured football players (42.5 ± 12.5 a.u., $p < 0.001$). There was a TGS cut-off point (56.2 a.u.) to discriminate non-injured from injured football players. Players with a TGS beyond this cut-off had an odds ratio of 3.5 (95%CI 1.8-6.8; $p < 0.001$) to suffer an injury when compared with players with lower TGS.

Conclusions: These preliminary data suggest that carrying a high number of "protective" gene variants could influence an individual's susceptibility to developing muscle injuries in football. Adapting the training load parameters to the athletes' genetic profile represents today the new frontier of the methodology of training.

Muscle-to-bone ratio in NCAA Division 1 collegiate football players by position. Journal of Strength and Conditioning Research, Ahead of Print: 1-6, 2024.

Abstract - The purpose of this study was to compare the muscle-to-bone ratio (MBR) in National Collegiate Athletic Association Division I football players (collegiate football players [CFP]) to healthy, age-matched controls. In addition, we examined MBR in CFP by position. A total of 553 CFP and 261 controls had their total and regional lean mass (LM), fat mass (FM), and bone mineral content (BMC) determined by dual x-ray absorptiometry (DXA). College football players were categorized by positions defined as offensive linemen (OL), defensive linemen (DL), tight end, linebacker (LB), running back (RB), punter or kicker, quarterback (QB), defensive back (DB), and wide receiver (WR). There were significant differences between CFP and controls for total LM (80.1 ± 10.0 vs. 56.9 ± 7.8 kg), FM (22.2 ± 12.5 vs. 15.2 ± 7.1 kg), and BMC (4.3 ± 0.5 vs. 3.1 ± 0.5 kg). Although there were significant differences in body composition between CFP and controls, there was no significant differences in total MBR between CFP and controls (18.6 ± 1.4 vs. 18.8 ± 1.7). Regionally, CFP had significantly lower trunk MBR than controls (26.7 ± 2.7 vs. 28.7 ± 4.2), but no difference was seen in leg or arm MBR. Positional differences in CFP were noted as total MBR being significantly higher in DL (19.0 ± 1.4) than in DB (18.1 ± 1.3), WR (18.1 ± 1.3), and LB (18.2 ± 1.3). OL had a significantly higher total MBR (19.2 ± 1.3) than DB (18.1 ± 1.3), LB (18.2 ± 1.3), QB (18.1 ± 1.0), and WR (18.1 ± 1.3). In addition, RB had significantly higher total MBR (18.8 ± 1.3) than DB (18.1 ± 1.3) and WR (18.1 ± 1.3). This study may provide athletes and training staff with normative values when evaluating total and regional MBR with DXA.

Practical Applications - This study explored the use of DXA to determine total and regional MBR in CFP. Although an MBR range suggesting optimal muscular loading of the skeleton may exist, there is currently no normative data to identify such a range in CFP specifically. Thus, this article provides insight into the MBR across positions in CFP, as well as in comparison to a control population. Moreover, these data provide information regarding total and regional MBR for different positions. These data can be used by athletes and coaches as reference data when using DXA to measure total



Performance Research Reviews

and regional MBR because these numbers will likely differ from others such as skinfold, girth, and circumference measures. Moreover, these data provide information regarding the total and regional MBR for each position. The similarity between mirrored positions observed in this study and our previous report on NFL athletes suggests that MBR may play a role in on-field positional requirements. The data presented in this report can be used to identify ideal ranges for each position in collegiate football players. However, it is important to clarify that the data presented here are averages and SD for each position. In practice, performance metrics must be considered because each individual will have their own optimal body type to maximize performance. In collegiate football players total and regional MBR provides an objective measure to monitor changes in muscle and bone masses. As athletes are encouraged to alter their body composition, the MBR can provide a matrix to monitor these alterations. This article provides normative data to compare players against the normal population and positional differences that may prove to be useful in evaluating players.

Reliability of three landmine-punch-throw variations and their load-velocity relationships performed with the dominant and nondominant hands. International Journal of Sports Physiology and Performance, Ahead of Print: 1-8, 2024.

Purpose: This study assessed the reliability and load–velocity profiles of 3 different landmine-punch-throw variations (seated without trunk rotation, seated with trunk rotation, and standing whole body) with different loads (20, 22.5, and 25.0 kg), all with the dominant hand and nondominant hand.

Methods: In a quasi-randomized order, 14 boxers (24.1 [4.3] y, 72.6 [10.1] kg) performed 3 repetitions of each variation with their dominant hand and their nondominant hand, with maximal effort and 3 minutes of interset rest. Peak velocity was measured via the GymAware Power Tool (Kinetic Performance Technologies). The interclass correlation coefficients and their 95% CIs were used to determine the intrasession reliability of each variation × load × hand combination. Additionally, a 2 (hand) × 3 (variation) repeated-measures analysis of variance assessed the load–velocity profile slope, and a 3 (variation) × 2 (hand) × 3 (load) repeated-measures analysis of variance assessed the peak velocity of each variation.

Results: Most variations were highly reliable (intraclass correlation coefficient > .91), with the nondominant hand being as reliable or more reliable than the dominant hand. Very strong linear relationships were observed for the group average for each variation ($R^2 \geq .96$). However, there was no variation × hand interaction for the slope, and there was no



Performance Research Reviews

main effect for variation or hand. Additionally, there was no interaction for the peak velocity, but there were main effects for variation, hand, and load ($P < .01$).

Conclusion: Each variation was reliable and can be used to create upper-body ballistic unilateral load–velocity profiles. However, as with other research on load–velocity profile, individual data allowed for more accurate profiling than group average data.

Gymnastics

Predictors of anterior cruciate ligament tears in adolescent and young adults. Orthopaedic Journal of Sports Medicine, 12(9): 1-8, 2024.

Background: Anterior cruciate ligament (ACL) injury in youth can lead to expensive treatment, lengthy rehabilitation, and long-term impairment. Injuries to the ACL are more common in adolescents who participate in organized sports.

Purpose: To examine whether there is an association between age, physical activity patterns, pubertal timing (Tanner stage), or body mass index (obesity/overweight status) and the risk of developing an ACL injury in youth.

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

Methods: Data from the Growing Up Today Study (GUTS), a prospective cohort study of youth throughout the United States, were used in this study. From 1996 to 2003, questionnaires were sent to GUTS participants every 12 to 18 months to assess a variety of self-reported factors; in a related 2004 questionnaire, ACL tears and other diagnoses among the participants were reported. Cox proportional hazard models were run to determine the sex-specific association of activity patterns and pubertal timing with risk of developing an ACL tear.

Results: A total of 4519 boys and 5622 girls (age: 9-15 years) were included, with 2.4% and 2.0% sustaining an ACL injury, respectively. Age was found to be a significant risk factor for ACL injury in both sexes (male: hazard ratio [HR] = 1.30 [95% CI, 1.14-1.48]; female: HR = 1.23 [95% CI, 1.10-1.38]). Mean hours per week engaged in vigorous activity was also predictive of a higher risk of ACL injury (male: HR = 1.04 [95% CI, 1.01-1.08]; female: HR = 1.10 [95% CI, 1.07-1.14]). The sports that were the most predictive of injury were running, basketball, soccer, and cheerleading/gymnastics in girls and running, football, and karate/martial arts in boys. Additionally, in boys, overweight/obese status was found to be a significant predictor of ACL injury (HR = 2.61 [95% CI, 1.60-4.26]). Furthermore, among 9- to 13-year-old girls, advanced Tanner stage was a strong predictor of injury risk (HR = 2.43 [95% CI, 1.10-5.36]).



Performance Research Reviews

Conclusion: Age, time engaged in vigorous activity, overweight/obese status, and advanced Tanner stage were associated with an increased risk of ACL injury in young adults and adolescents. Further research with follow-up data will help complement this study and continue to highlight the risk factors associated with ACL reconstruction in adolescents and young adults.

The effect of safety modifications on head kinematics experienced during common skills in women's artistic gymnastics. Journal of Sports Sciences, Ahead of Print: 1-15, 2024.

Abstract - The objective of this study was to evaluate the effect of skill modifications on head motion experienced during women's artistic gymnastics skills. Nine gymnasts (four beginner and five advanced) completed three trials of up to 24 skill progressions, each consisting of a skill and two progressive safety modifications. Gymnasts were instrumented with mouthpiece sensors embedded with an accelerometer and gyroscope collecting motion data at 200, 300, and 500 Hz during each skill performance. Peak-to-peak linear and rotational kinematics during contact phases and peak rotational kinematics during non-contact phases were computed. A mixed-effects model was used to compare differences in modification status nested within skill categories. Timer skills (i.e. drills that simulate performance of a gymnastics skill) resulted in the highest median Δ LA and Δ RA of all skill categories, and 132 skill performances exceeded 10 g Δ LA during a contact phase. Modifications were associated with significant reductions in head kinematics during contact phases of timers, floor skills, bar releases, and vault skills. Gymnasts can be exposed to direct and indirect head accelerations at magnitudes consistent with other youth contact sports, and common safety modifications may be effective at reducing head motion during contact and non-contact phases of gymnastics skills.

Golf

Using a golf specific functional movement screen to predict golf performance in collegiate golfers. PeerJ, 12:e17411, 2024.

Background: This study aims to examine the relationship between functional movements and golf performance using the Golf Specific Functional Movement Screen (GSFMS).

Methods: This cross-sectional study included a total of 56 collegiate golfers (aged 20.89 ± 0.99 years, height of 174.55 ± 7.76 cm, and weight 68.48 ± 9.30 kg) who met the criteria, and were recruited from Hainan Normal University in June



Performance Research Reviews

2022. The participants' golf motor skills (1-yard putt, 10-yard putt, 25-yard chip, 130/100-yard set shot, driver, and 9-hole stroke play) were tested and the GSFMS (e.g., pelvic tilt, pelvic rotation, and torso rotation) was used.

Results: There were significant weak or moderate correlations between the variables. Furthermore, a multiple linear regression analysis found that pelvic rotation and lower-body rotation abilities can significantly predict golf skill levels, which collectively explain 31.2% of the variance in golf skill levels among collegiate golfers (Adjusted R² = 0.312, F = 2.663, p < 0.05). Standardized β values indicate that pelvic rotation ($\beta = 0.398$) has a more substantial impact on golf skill levels than lower-body rotation ($\beta = 0.315$).

Conclusions: This study found the weak to moderate correlations between the GSFMS and golf performance, and pelvic rotation and lower-body rotation abilities, thus predicting golf skills. Our findings provide novel insights into the relationship between functional abilities and comprehensive skill performance within the context of the Gray Cook's Movement Pyramid model, and provide theoretical support and practical reference for collegiate golf motor-skill learning and sports injury prevention.

Associations between physical characteristics and golf clubhead speed: A systematic review with meta-analysis. Sports Medicine, 54(6): 1553-1577, 2024.

Background: Historically, golf does not have a strong tradition of fitness testing and physical training. However, in recent years, both players and practitioners have started to recognize the value of a fitter and healthier body, owing to its potential positive impacts on performance, namely clubhead speed (CHS).

Objective: The aim of this meta-analysis was to examine the associations between CHS (as measured using a driver) and a variety of physical characteristics.

Methods: A systematic literature search with meta-analysis was conducted using Medline, SPORTDiscus, CINAHL and PubMed databases. Inclusion criteria required studies to have (1) determined the association between physical characteristics assessed in at least one physical test and CHS, (2) included golfers of any skill level but they had to be free from injury and (3) been peer-reviewed and published in the English language. Methodological quality was assessed using a modified version of the Downs and Black Quality Index tool and heterogeneity assessed via the Q statistic and I². To provide summary effects for each of the physical characteristics and their associations with CHS, a random effects model was used where z-transformed r values (i.e. zr) were computed to enable effect size pooling within the meta-analysis.



Performance Research Reviews

Results: Of the 3039 studies initially identified, 20 were included in the final analysis. CHS was significantly associated with lower body strength ($zr = 0.47$ [95% confidence intervals {CI} 0.24-0.69]), upper body strength ($zr = 0.48$ [95% CI 0.28-0.68]), jump displacement ($zr = 0.53$ [95% CI 0.28-0.78]), jump impulse ($zr = 0.82$ [95% CI 0.63-1.02]), jumping peak power ($zr = 0.66$ [95% CI 0.53-0.79]), upper body explosive strength ($zr = 0.67$ [95% CI 0.53-0.80]), anthropometry ($zr = 0.43$ [95% CI 0.29-0.58]) and muscle capacity ($zr = 0.17$ [95% CI 0.04-0.31]), but not flexibility ($zr = -0.04$ [95% CI -0.33 to 0.26]) or balance ($zr = -0.06$ [95% CI -0.46 to 0.34]).

Conclusions: The findings from this meta-analysis highlight a range of physical characteristics are associated with CHS. Whilst significant associations ranged from trivial to large, noteworthy information is that jump impulse produced the strongest association, upper body explosive strength showed noticeably larger associations than upper body strength, and flexibility was not significant. These findings can be used to ensure practitioners prioritize appropriate fitness testing protocols for golfers.

Key Points

- Clubhead speed (CHS) is one of the most important factors for golfers when aiming to optimize distance from tee shots, as it helps to offer an advantage over their competitors.
- From empirical investigations, numerous physical characteristics have been shown to be associated with CHS.
- Specifically, explosive force production in the lower body (as measured by jumping) elicits stronger associations than maximal lower body strength.
- Similarly, upper body explosive strength appears to be of greater importance than upper body strength, most likely because it better replicates the time constraints that the upper body has to produce force during the swing.
- Contrary to popular historical belief, flexibility was one of two physical characteristics not significantly associated with CHS. This is likely because a wide range of movement strategies are available for golfers during the swing, enabling a variety of movement solutions to be used, to achieve the desired swing technique.



Performance Research Reviews

Hockey

A machine learning approach to concussion risk estimation among players exhibiting visible signs in professional hockey. Sports Medicine, Ahead of Print: 1-10, 2024.

Background: The identification of concussion risk factors, such as visible signs and mechanisms of injury, improves concussion identification. Exploring individual risk factors, such as concussion history, may help to improve existing concussion risk models and algorithms.

Objectives: The primary aim of the current study was to use machine learning techniques to develop a comprehensive, prospectively coded concussion risk model in professional hockey among players exhibiting visible signs. The secondary aim was to examine whether including concussion history improves model performance.

Methods: Data from the National Hockey League (NHL) spotter program, including coded visible signs and mechanisms of injury associated with possible concussive events, were extracted from the 2018-2019 to the 2021-2022 seasons. Each unique spotter event was matched with data extracted from the medical record to determine whether the event was associated with a subsequent physician diagnosed concussion. We compared the ability of three machine learning-based approaches to identify the likelihood of physician diagnosed concussion: conditional inference tree, conditional inference random forest, and logistic regression.

Results: A total of 1563 unique events with visible signs were identified by spotters (183 leading to a concussion diagnosis). A randomly selected training sample had 1250 events (146 concussions) and the remaining set-aside test sample had 313 events (37 concussions). The obtained models performed at a high level with large effects in the training [area under the receiver operating characteristic curve (AUC) = 0.79] and set-aside test data (AUC = 0.82). Concussion history was retained in the tree and logistic regression models, with each additional prior concussion associated with a 1.32 times increased odds of concussion diagnosis.

Conclusions: We present simple tree and logistic algorithms for concussion screening and as diagnostic aids. Our results show that player concussion history can explain additional risk above and beyond that explained by visible signs and mechanisms of injury alone.



Performance Research Reviews

Associations between skating mechanical capabilities and off-ice physical abilities of highly trained teenage ice hockey players. European Journal of Sport Science, Ahead of Print: 1-4, 2024.

Abstract - This study examines the associations between force and velocity characteristics of forward skating and off-ice speed, agility, and power of highly trained teenage ice hockey players. Players attending the Quebec ice hockey federation's off-season evaluation camp were invited to participate in this study. Final sample consists of 107 highly trained teenage ice hockey players (Males: $n = 38$; 13.83 ± 0.38 years; Females: $n = 69$; 14.75 ± 0.90 years). Individual force-velocity profiles (F-V) were determined during a 44 m skating sprint. Off-ice speed, agility, and power were measured using 30 m sprint, 5-10-5 agility, and standing long jump. Associations between F-V mechanical capabilities and off-ice indicators were analyzed with correlational analyses and multivariate analysis of covariance (MANCOVA). Results of pooled data indicate that the three off-ice measures had moderate associations with F_0 and V_0 and large associations with P_{max} . Associations with R_{fmax} , D_{rf} , and S_{fv} were moderate to small. F_0 had stronger associations with off-ice performance in female players while V_0 was more important with male players. MANCOVA identified 5-10-5 times as the better predictor for F_0 while 30 m sprints times better predicted V_0 . To maximize physical attributes of skating ability, practitioners are encouraged to focus on a general physical preparation for highly trained teenage players. Prioritizing types of exercises that use change of direction or acceleration and linear speed should have distinct effects on F_0 and V_0 on the ice.

Highlights

- A good general physical preparation is important for highly trained teenage ice hockey players as maximal running speed, change of direction ability, and leg power in the horizontal plane are largely associated with mechanical capabilities during maximal skating performance.
- Change of direction ability tends to be associated with the ability to generate force at low velocities on the ice (F_0) while maximal running speed tends to be associated with the ability to generate force at high velocities on the ice (V_0).
- Off-ice abilities are more strongly associated to the ability to generate force at low velocities on the ice (F_0) in highly trained female players than in highly trained male players.



Performance Research Reviews

Lacrosse/Field Hockey

Relationships between relative strength, power, and speed among NCAA Division II men's lacrosse athletes. SportLogia, 20(1): 18-27, 2024.

Abstract - Lacrosse players are required to perform multiple sprints and changes of direction over the course of a game. These skills are reliant on the ability to rapidly produce lower-body force to be successful. Currently, little research examining the relationship between specific performance indicators and relative strength within this population exists. The purpose of this study was to investigate relationships between measures of lower-body strength and power to sprinting and change of direction speed (CODS) among male lacrosse players. Archived data for (n= 18) NCAA Division II male lacrosse athletes were used for this analysis. Lower-body strength was assessed using a one-repetition maximum back squat. Power was assessed using a countermovement jump (CMJ), squat jump (SJ), and standing long jump (SLJ). Sprint speed at 10 and 30 yds (i.e., 9.14 and 27.43 m) and CODS (i.e., T-Test (TT) and modified T-Test (MTT)) were also assessed. Pearson's correlation was used to determine relationships between lower-body strength and power to sprint speed and CODS. Significant relationships ($r = -0.51$ - -0.64 , $p \leq 0.05$) were discovered between all measures of power and CODS, as well as SLJ and sprint speed ($r = -0.51$; $p = 0.05$ and -0.67 ; $p \leq 0.01$, respectively). No significant relationships between relative strength and any measures of sprint speed or CODS were discovered. Although relative strength was not directly related to sprint speed or CODS performance, it may indirectly affect these measures based on its relationship to power, and power's relationship to sprint and CODS performance.

Dynamic functional ability in lacrosse players in relation to development of sport-related onset of musculoskeletal pain. International Journal of Sports Physical Therapy, 19(9): 1088-1096, 2024.

Background: Unlike other sports, the relationship between performance deficits and pain/injury in lacrosse players has not been well-investigated.

Purpose: The purposes of this study were to: 1) determine whether age and sex differences exist in dynamic physical function tests and drop jump performance among lacrosse players, and 2) determine whether pre-seasonal physical function scores predict onset of either lower extremity or low back pain over time.



Performance Research Reviews

Study design: Prospective observational study.

Methods: Lacrosse players (N=128) were stratified into three groups: 12-14.9 yrs, 15-18 yrs and >18 yrs. Thomas test (hip flexibility), Ober's test (iliotibial band tightness), and Ely's test (rectus femoris tightness) were performed. Landing Error Scoring System (LESS) scores were collected while players performed drop jumps. Sagittal and frontal plane movement from 2D video during single and double legged squats was assessed. Musculoskeletal pain symptoms or injury were tracked for six months. Age bracket, sex and physical function scores were entered into logistic regression models to determine risk factors that predicted onset of lower extremity pain and low back pain onset.

Results: LESS scores and single-leg squat movement quality test scores were lowest in the 12-14.9 yr groups and highest in the >18 yr group (all $p < 0.05$). Single leg squat performance score increased the odds risk (OR) for lower extremity pain (OR=2.62 [95% CI 1.06-6.48], $p = .038$) and LESS scores elevated risk for low back pain onset over six months (OR = 2.09 [95% CI 1.07- 4.06], $p = .031$).

Conclusions: LESS scores and single legged squat performance may help identify lacrosse players at risk for musculoskeletal pain or injury onset. Detecting these pertinent biomechanical errors and subsequently developing proper training programs could help prevent lower extremity and low back pain onset.

Soccer

The time course of injury risk after return to play in professional football (soccer). Sports Medicine, Ahead of Print: 1-9, 2024.

Background: Injury risk in professional football (soccer) is increased in the weeks following return-to-play (RTP). However, the time course of injury risk after RTP (the hazard curve) as well as its influencing factors are largely unknown. This knowledge gap, which is arguably due to the volatility of instantaneous risk when calculated for short time intervals, impedes on informed RTP decision making and post-RTP player management.

Objectives: This study aimed to characterize the hazard curve for non-contact time-loss injuries after RTP in male professional football and to investigate the influence of the severity of the index injury and playing position.

Methods: Media-based injury records from the first German football league were collected over four seasons as previously published. Time-to-event analysis was employed for non-contact time-loss injury after RTP. The Kaplan-Meier survival function was used to calculate the cumulative hazard function, from which the continuous hazard function was retrieved by derivation.



Performance Research Reviews

Results: There were 1623 observed and 1520 censored events from 646 players analyzed. The overall shape of the hazard curve was compatible with an exponential decline of injury risk, from an approximately two-fold level shortly after RTP towards baseline, with a half-time of about 4 weeks. Interestingly, the peak of the hazard curve was slightly delayed for moderate and more clearly for severe index injuries.

Conclusions: The time course of injury risk after RTP (the hazard curve) can be characterized based on the Kaplan-Meier model. The shape of the hazard curve and its influencing factors are of practical as well as methodological relevance and warrant further investigation.

Professional football training and recovery: A longitudinal study on the effects of weekly conditioning session and workload variables. PLOS ONE, 19(9): e0310036, 2024.

Abstract - The main purpose of this longitudinal study was to investigate football players' recovery status, through hormonal response, in relation to accumulated workload at two comparable time points of the first (T1) and second half (T2) of the competitive season. Moreover, this study investigated athletes' hormonal response to a typical weekly conditioning session (5 days before match: MD-5), at T1 and T2, to detect changes in players' recovery capability over time. Salivary cortisol (sC) and testosterone (sT) of 24 professional players (27.8 ± 4.1 years of age) were collected before, after, and 24 hours following MD-5 in two comparable microcycles of T1 and T2. GPS training data (total and high-intensity distance) of the 7 and 28 days before sampling were used to obtain athletes' acute and chronic workloads. Results showed a pre-training significant decrease of sT and an increase of sC ($p < 0.05$) in T2, compared to T1. Moreover, athletes showed high sC and low sT levels before, after and 24 hours following MD-5 in T2. Workload analysis revealed significant correlations of chronic load with sC ($r = 0.45$, $p = 0.056$) and T/C ratio ($r = -0.59$; $p = 0.007$). These results suggested that, in professional football, chronic workload has a greater impact on players' recovery time than acute workload over the sport season. Moreover, athletes' hormonal response to the weekly conditioning session at T2 revealed an altered anabolic/catabolic balance, highlighting the key role of continuous internal and external workload monitoring during the season.



Performance Research Reviews

An intermittent recovery test for soccer players: A validation study. Journal of Sports Medicine and Physical Fitness, Ahead of Print: 1-6, 2024.

Background: Soccer is an intermittent team sport that demands high aerobic capacity. On field, soccer players' aerobic capacity, assessed through the maximal oxygen uptake (VO_{2max}), is usually determined by an intermittent recovery test. The aim of this study was to obtain a construct validity of a new intermittent recovery test (IRT) with a fixed speed and a progressive decrement of rest period.

Methods: Twenty-five male soccer players were recruited to perform an incremental continuous test (ICT) and the new IRT, to compare their physiological data. Fifteen male soccer players were involved to perform a test-retest of IRT to assess its reliability.

Results: VE_{peak} , absolute VO_{2max} , relative VO_{2max} and VCO_{2peak} registered during ICT and IRT correlated strongly (Pearson's correlation coefficient ranges from 0.75 to 0.80, with very large as magnitude of effects and with $P < 0.001$). IRT showed reliability from good to excellent regarding VE_{peak} , absolute VO_{2max} , relative VO_{2max} , VCO_{2peak} and covered distance (ICC values ranged from 0.82 to 0.95).

Conclusions: These findings and its underlying physiological and muscular demands, suggest that IRT can be considered as a valid and reliable test to assess aerobic capacity in soccer players during the competitive period.

Softball

Multiyear improvement in batting skills following targeted perceptual cognitive training in softball. bioRxiv, <https://doi.org/10.1101/2024.08.29.610321>, 2024.

Background: Making quick, accurate decisions is crucial in competitive sports like softball, where perceptual-cognitive skills can significantly impact on-field performance. This study evaluates the long-term effectiveness of a targeted perceptual-cognitive training program, delivered through the uHIT platform, on improving batting performance in collegiate softball players.

Methods: A longitudinal analysis was conducted on data collected from both NCAA and NAIA softball teams over multiple seasons. The study used Bayesian statistical methods to assess the impact of cognitive training on on-base plus slugging percentage (OPS). The analysis incorporated weighted models to account for variability in games played and



Performance Research Reviews

differences between teams, and the influence of team and year-division effects was considered. Key metrics, including Decision AUC and Response Time, were tracked to evaluate perceptual-cognitive improvements.

Results: The results demonstrated significant improvements in OPS for teams that participated in the cognitive training intervention, with the weighted models indicating a substantial effect of the training on performance. Notably, the intervention was most effective in teams with higher training intensity, as evidenced by the permutation test results. The Bayesian analysis also revealed that the intervention led to statistically significant improvements in decision-making and response times, translating into enhanced on-field performance.

Conclusion: The findings support the effectiveness of perceptual-cognitive training in improving real-world athletic performance in softball. The uHIT platform, as an ecologically valid training tool, has demonstrated its potential to serve as a critical component of athletic development programs. Future research should explore the long-term retention of these cognitive gains and their application across different sports and competitive levels.

Effects of a simulated game and doubleheader inning on peak kinetics in softball pitching across pitch types. The American Journal of Sports Medicine, Ahead of Print: 1-12, 2024.

Background: Softball pitchers frequently pitch at high volumes. Previous research has demonstrated changes in mechanics, range of motion, and perceived levels of fatigue and pain at high workloads. To date, little research has assessed changes in kinetics at high workloads across pitch types to understand the injury risk.

Purpose: To examine changes in peak kinetics of the shoulder, elbow, and wrist of the pitching arm throughout a simulated game and doubleheader inning.

Study design: Descriptive laboratory study.

Methods: A total of 19 high school softball pitchers (mean age, 15.1 ± 1.5 years; mean height, 1.6 ± 0.2 m; mean weight, 76.3 ± 16.9 kg) participated. Pitchers threw 4 innings of 25 randomly assigned pitches to mimic a game's high pitch count. Participants then rested for 30 minutes before subsequently proceeding to pitch the first inning of a doubleheader. Each pitcher threw a fastball, drop ball, curveball, and changeup. Peak shoulder, elbow, and wrist kinetics were compared across the first, last, and doubleheader innings and pitch types.



Performance Research Reviews

Results: Compared with the first inning, significant decreases in kinetics were observed at the shoulder, elbow, and wrist in the last ($P < .016$) and doubleheader ($P < .016$) innings, particularly for shoulder and elbow compression force during the drop ball and curveball pitch types and wrist net force for all pitch types but the changeup. Significant decreases in elbow and wrist kinetics were observed during the changeup between the last and doubleheader innings ($P < .016$). Furthermore, differences in kinetics were observed between pitch types ($P < .008$); notably, the changeup had reduced kinetics compared with the fastball and breaking ball pitch types (drop ball, curveball) across innings.

Conclusion: Across innings, attenuations in select joint kinetics of the pitching arm occurred that were specific to the pitch type. Across pitch types, peak kinetics was often greater during the fastball, while the changeup displayed the lowest peak kinetics.

Clinical relevance: The joints examined in this study are common sites of overuse injuries in pitchers. This work adds to previous findings on decrements in neuromuscular function as well as self-reported fatigue and pain with tournament-style pitching that may increase the injury risk. Collectively, these findings support developing a protocol combining functional testing and player-reported outcomes to aid sports specialists' decisions for pitchers to continue to pitch or return to play, which may help prevent musculoskeletal injuries and time loss from sports participation.

Swimming

Enhancing the starting performance of elite swimmers through eight weeks of lateral entry training. Sports Biomechanics, Ahead of Print: 1-17, 2024.

Abstract - This study aims to explore the effects of 8 weeks of lateral entry training on the start performance of elite athletes and its impact on ordinary entry performance. Data were collected from 12 elite-level participants before and after the training using Kistler (9691A1) system with 3D force platform and high-speed cameras. 19 parameters of ordinary and lateral entry were assessed and analyzed using paired samples t-tests. Compared to ordinary entry, the lateral entry performance was characterized by: decrease of both vertical force (5.77%) and maximum depth (6.09%) at a significance level ($p < .01$), and increase of flight distance (4.33%), first kick distance (3.90%) and push force (14.06%) at ($p < .05$). The results show that, compared to an ordinary entry technique, the lateral entry technique provides a 3.93%, 6.14%, and 8.29% reduction in time to reaching a 5 m, 10 m and 15 m distance ($p \leq .01$), showing performance improvements at start times. The 8-week training on the lateral entry technique did not have a significant impact on the time performance of the ordinary entry technique ($p > .050$). The findings presented herein offer pertinent insights for elite-level athletes, coaches and future investigations aimed at enhancing swimming start techniques and performance.



Performance Research Reviews

Ten-year evolution of world swimming trends for different performance clusters: A Gaussian model. International Journal of Sports Physiology and Performance, Ahead of Print: 1-9, 2024.

Purpose: To analyze the evolution of the world ranking in swimming over the last 10 years, with particular attention to the effects of COVID-19 on the different levels of participating athletes.

Methods: The top 200 world-ranked entries in all swimming events (50-m pool) were collected from 2013 to 2022. A mathematical model (Gaussian model) was proposed to evaluate the ranking progression for different performance levels (clusters) according to distance, stroke, and gender. The model was applied both with and without the COVID season data.

Results: Overall results indicated a general progression in world rankings over the last 10 years, except for the COVID season and the post-Olympic year(s), with peak results in the 2021 post pandemic (Olympic) year. The gender gap in World Aquatics points scoring has shown an increasing gap in favor of males since 2017, reaching 1.5% in 2022. The top 200 positions of world rankings were grouped into 3 different clusters defined by the 23.3%, 66.5%, and 100% of ranked male swimmers (or 31.5%, 72.5%, and 100% for females) and with average World Aquatics scores of 910(12), 858 (10) and 816(11) points (907 [13], 847 [11], and 802[12] for females). The Gaussian model showed a gap averaging ~21 to ~36 points between performance curves with or without COVID season data, with larger gaps for female rankings and cluster-3 swimmers.

Conclusions: These results suggest that, given the lower relative performance of female swimmers in the different clusters of world rankings, female events may provide an opportunity to enter international-level swimming.

Tennis

Potential benefits of postactivation potentiation protocols on tennis performance: A systematic review. Strength and Conditioning Journal, Ahead of Print: 1-15, 2024.

Abstract - The study aimed to provide an overview of the benefits of postactivation potentiation (PAP) protocols on tennis performance. All procedures were in accordance with the PRISMA guidelines. After an online search, 8 studies with 133 tennis players were eligible for inclusion. Results showed that a variety of methods were used to elicit PAP in tennis players, with maximal voluntary isometric contraction showing promising results in improving serve velocity (SV) by 4.6 km/h (3.4 to 4.6%; ES 0.711) immediately after the preconditioning activity (PCA). The most favorable effects

CSCCA Performance Research Reviews



Performance Research Reviews

of PAP on sprinting time and maximal power were observed in resistance training exercises using squats as PCA, with loads near 60% of 1 repetition maximum (1RM), whereas the heavy load leg press warm-up demonstrated positive effects on agility and power. By contrast, negative effects on SV were observed with heavy 600-g ball throws. Despite limitations in match application because of the post activation performance enhancement effect duration, these protocols remain beneficial for training purposes. Calculating volume load relative to 1RM can provide helpful insights for optimal PAP. However, individualizing PAP protocols based on athletes' characteristics and training status seems crucial and should be investigated in future studies.

How does prolonged tennis playing affect lower limb muscles' activity during first and second tennis serves? *European Journal of Sport Science*, Aug. 5: 1-8, 2024.

Abstract - We examined the effect of prolonged tennis playing on lower limb muscles' activity during the execution of first and second tennis serves. Ten male competitive tennis players executed five first and second serves before (pretest) and after (posttest) a 3-h tennis match. Surface electromyographic (EMG) activity of four lower limb muscles (vastus lateralis, rectus femoris, gastrocnemius lateralis, and soleus muscles) on each leg was recorded along with maximum ball velocity measured by a radar gun and peak vertical forces recorded by a force platform. For the vastus lateralis, gastrocnemius lateralis, and soleus muscles of the left leg as well as the vastus lateralis muscle of the right leg, EMG amplitude decreased from pre- to posttests ($p \leq 0.033$). These reductions in the EMG signal were generally more pronounced in the first serve (i.e., ranging from -10% to -40%) compared to the second serve (0% to -25%). Maximum ball velocity for both first (159 ± 12 vs. 154 ± 12 km/h) and second (126 ± 20 vs. 125 ± 15 km/h) serves remained unchanged from pre- to posttests ($p = 0.638$). Similarly, peak vertical forces did not differ between pretest and posttest for both first (1.78 ± 0.30 vs. 1.72 ± 0.29 body weight) and second (1.62 ± 0.25 vs. 1.75 ± 0.23 body weight) serves ($p = 0.730$). In conclusion, a 3-h tennis match led to decreased activation levels in various leg muscles during serves, particularly in first serves compared to second serves. Despite consistent maximum ball velocity and peak vertical forces, these reductions in EMG signals suggest that skilled tennis players may adopt compensatory strategies after prolonged play.



Performance Research Reviews

Volleyball

Comparison of hand grip strength and hand-arm anthropometric measures among volleyball and basketball players – A cross-sectional study. Sport Science for Health, Ahead of Print: 1-8, 2024.

Purpose: Handgrip strength and hand–arm anthropometric measures were essential for preventing injuries and developing overall strength in player selection and practice enhancement in sports like basketball and volleyball. The purpose of the study was to assess the hand grip strength and hand–arm anthropometry measures of both players and compare the hand grip strength and hand anthropometric measures of volleyball and basketball players.

Methods: A cross-sectional study was conducted at the sports field. Data was collected over a three-month period (February–April 2019). A total of 60 players ($n = 30$ volleyball and $n = 30$ basketball) were recruited for the study based on inclusion criteria using the purposive sampling method. Hand–arm anthropometric measurements were used to measure the components of the arm, hand, and fingers, along with their grip strength. Descriptive analysis was performed to analyze the anthropometric measures and grip strength of both groups. Pearson correlation analysis was performed to ascertain the relationship between anthropometric variables and grip strength. T test was performed to compare the grip strength of both groups. Data were analyzed using SPSS version 23.

Results: There was a major difference ($MD = 3.63$) seen among volleyball and basketball players. The hand grip strength of basketball players was greater ($p = 0.021$) than the volleyball players. The finger span, finger length, and perimeter showed significant correlation ($p < 0.05$) between basketball and volleyball players.

Conclusion: The study concludes that basketball players had relatively more strength than volleyball players. A significant correlation has been seen between grip strength, finger span, and hand perimeter.

Social jetlag affects jump skills in sub-elite volleyball players. Frontiers in Sports and Active Living, 6:1443804, 2024.

Abstract - Social jetlag (SJL), resulting from misalignment between biological rhythms and social schedules, has emerged as a prevalent phenomenon in modern society, particularly among young athletes. However, the effect of SJL on performance is poorly studied. Jump and dynamic balance are two key skills in volleyball, as the first allows the player to



Performance Research Reviews

perform better both during the offense and defense phase, and the second is fundamental in landing and in injury prevention. Therefore, our aim was to investigate the effect of SJL on jump skill performance and balance in female volleyball players. Thirty female volleyball players (mean age: 17.3 ± 0.88 years) participated in the study. SJL was assessed using the Munich ChronoType Questionnaire (MCTQ), integrated with Jankowsky's sleep-corrected formula. Jump skill performance was evaluated using a standardized jump test, the Vertec Jump Test, while balance was assessed with the Y Balance Test. The tests were performed at 09:00 a.m. and at 06:00 p.m. The results revealed that players with greater SJL exhibited decreased jump performance, characterized by lower vertical jump height ($p = 0.02$). Furthermore, players with lower SJL showed the typical difference between morning and afternoon performance ($p = 0.001$), demonstrating their synchronization between biological rhythms and social commitments, while no statistically significant difference between the two sessions was shown in players with higher SJL. Regarding balance, no significant association with SJL was found, but the morning session yielded lower results than the afternoon one ($p = 0.01$). These findings highlight the detrimental impact of SJL on jump skill performance, underscoring the importance of optimizing sleep-wake schedules and circadian alignment to enhance athletic performance. Future research should explore targeted interventions, such as sleep hygiene education, to minimize social jetlag and promote optimal performance in adolescent athletes.

Wrestling/Combat Sports

Kinematic and physiological analysis of medieval combat sport using motion analysis, blood lactate measurement, and heart rate monitoring: A case study. Sensors, 24:s24113443, 2024.

Abstract: Medieval combat sport is a form of mixed martial art in which combatants engage in fighting using offensive and defensive equipment while dressed in full armor. The sport is considered extremely taxing, making it nearly impossible to maintain the same level of performance. However, this form of sport has not been thoroughly analyzed, and its impact on human physical response is largely unknown. To address this gap, the study reported here aimed to introduce and test a procedure for analyzing human physical responses within the framework of the sport. To accomplish this, two experienced combatants were asked to engage in a series of strikes, performed in the form of a set duel simulating a professional fight competition. The kinematic aspect of the procedure was examined using motion analysis with the help of an IMU suit, while the physiological aspect was evaluated based on blood lactate levels and heart rate measurements. Furthermore, an ergometer test conducted in a laboratory setting aimed to determine the lactate threshold. The dual results showed noticeable decreases in the kinematic aspects of the strikes, such as the



Performance Research Reviews

velocity of impact, and a dramatic rise in physiological aspects, such as heart rate and blood lactate levels. During the dual sets, the blood lactate surpassed the threshold level, and at the end, the heart rate exceeded the maximum age-related level. Practicing medieval combat sport has been shown to impose an extreme physical load on the bodies of combatants, noticeably affecting their performance levels.

The contribution of energy systems during 30-second lower body Wingate anaerobic test in combat sports athletes: Intermittent versus single forms and gender comparison. PLOS ONE, 19(5): e0303888, 2024.

Abstract – Combat sports, encompassing a range of activities from striking and grappling to mixed and weapon-based disciplines, have witnessed a surge in popularity worldwide. These sports are demanding, requiring athletes to harness energy from different metabolic pathways to perform short, high-intensity activities interspersed with periods of lower intensity. While it is established that the anaerobic alactic (ATP-PC) and anaerobic lactic systems are pivotal for high-intensity training sessions typical in combat sports, the precise contribution of these systems, particularly in varied training modalities such as single (SMT) and intermittent (IST) forms of the 30-second Wingate test, remains inadequately explored. This study aims at comparing performance outputs, physiological responses and gender differences during the SMT and IST forms of the 30-second Wingate test. Thirty-three highly trained combat sports athletes (17 women, 16 men; 10 boxing, 8 wrestling, 8 taekwondo and 7 karate) randomly performed SMT and IST. The IST consisted of three 10-second all-out attempts separated by 30 seconds of passive recovery, whereas the SMT was a single 30-second maximal effort. Resting, exercise and post-exercise oxygen uptake and peak blood lactate value were used to determine the metabolic energy demands via the PCr-LA-O₂ method. The findings showed that total metabolic energy expenditure (TEE), ATP-PCr system contribution and the output of mechanical variables were higher in the IST than in the SMT form (all $p < 0.05$). In combat sports, performance is not only determined by physiological and technical skills but also by metabolic energy input and efficiency. Therefore, our results can provide a comparison regarding the effects of exercise type and gender on metabolic energy metabolism to design the training of combat sports athletes.



Performance Research Reviews

UPCOMING USCAH EVENT!

ATHLETEALIVE2025 is a student athlete safety initiative, steered by a collaboration of the following organizations: The Coalition for the Registration of Exercise Professionals (CREP), NATA Intercollegiate Council on Sport Medicine (ICSM) and the U.S. Council for Athletes Health (USCAH). The purpose of this initiative is to reduce the prevalence of preventable student athlete injuries and deaths, associated with conditioning and training; inclusive of proper emergency management. This initiative reflects the requirements associated with the NCAA Interassociation Recommendations Preventing Catastrophic Injury and Death in Collegiate Athletes. The goal is to reach full compliance by all collegiate Strength and Conditioning Coaches by January 1, 2025.

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