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Physical Performance Tests and their Predictive Value in Youth Sports – a Study Protocol

Sportmotorische Leistungstests und ihr prognostischer Wert im Jugendsport – ein Studienprotokoll

Summary

› **Objectives:** The study aims to identify modifiable risk factors for injuries and overuse complaints in youth athletes by applying a structured physical performance test battery. The goal is to support the development of sport-specific prevention strategies.
› **Methods:** This is a prospective, multi-cohort study involving youth athletes aged 11-17 years across four sports: soccer, field hockey, tennis, and golf. The test battery evaluates, mobility, balance, motor control, core stability, jump performance, strength and endurance. Injuries are recorded quarterly over two years using standardized questionnaires, with additional functional and subjective scales assessed at baseline and during follow-up. Test selection was based on clinical relevance, feasibility, and minimal equipment requirements. A standardized examiner training and SOP ensured reproducibility.
› **Key Results:** As of July 2025, 644 athletes have completed baseline testing, including 285 soccer players, 263 hockey players, 58 tennis players, and 38 golfers. Retesting has been conducted on 177 participants. Data analysis will investigate correlations between test results, injury occurrence, and individual parameters such as peak height velocity, activity level, and limb dominance.
› **Conclusion:** The study addresses a research gap in injury prevention for youth athletes. The simple, time-efficient, and widely applicable test battery may enable early identification of injury risks and support the development of long-term, evidence-based prevention strategies in youth sports.

KEY WORDS:
Injury Prevention, Risk Factors, Soccer, Field Hockey, Tennis, Golf, Questionnaire, Sports Orthopedics

Introduction

Professional sports in Germany are more popular than ever before (1). Soccer holds a leading position as the most commercially successful and widely followed sport, yet other sports such as tennis, field hockey, and golf are also gaining increasing attention (1). Parallel to this, participation rates in popular sport and especially youth sports have been steadily rising. According to the 2024 report by the German Olympic Sports Confederation (DOSB), approximately 34% of the population are now members of a sports club – a new all-time high, particularly among children and adolescents, where the numbers are even higher (13).

Regular physical activity is associated with a wide range of protective effects on both physical and mental health, including improvements in cognitive performance, a reduced risk of overweight and strengthening of the cardiovascular system (16,36).

In addition to sports injuries, the increased volume of training with high-intensity and prolonged stress in combination with inadequate regeneration management in competitive sport also leads to an increase in overuse injuries (19). Physical damage resulting from previous injuries to the musculoskeletal system is a relevant problem. For example, osteoarthritis in the ankle or knee and hip joints is often associated with joint injuries sustained in youth and many years of competitive sport (5). Injuries of the lower extremities (knee and ankle joints) occur most frequently (5, 6, 12, 38). To reduce sports injuries, various screening procedures have been established in preventive sports medicine and competitive sports to identify potential risk factors. In healthy athletes, these are primarily internal risk factors, such as muscular asymmetries or deficits in mobility, balance, motor control, core stability, jump performance, strength and endurance (11). These screening procedures prevailed in sports medicine include, for example, physical performance tests (33).

Looking at different sports, there are some differences in the establishment of injury prevention measures to date. In recent years, numerous scientific studies have evaluated the incidence and epidemiology of injuries in (mainly male) soccer and

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exercise-based injury prevention programs like the FIFA 11+ prevention program (11, 43). Those programs are often already an integral part of everyday training in soccer. Compared to soccer, the number of studies focusing on field hockey, tennis and golf is much smaller (33, 40).

Physical performance tests offer a cost-effective and practical means to identify individual deficits and potential in mobility, balance, motor control and strength all of which are crucial for high-level sports performance (5). After analyzing the data, deficits can be specifically addressed.

However, the literature shows inconsistencies regarding the predictive value of physical performance tests, largely due to a lack of standardization across studies and prevention programs (33).

While injury incidence and preventive strategies among male soccer players are already well documented, research in sports like field hockey, tennis, and golf and in females in general remains limited (4). Additionally, scientific studies with youth athletes are also outnumbered overall (32).

The study aims to establish whether there is a link between test results and the occurrence of musculoskeletal sports injuries. The study will evaluate whether deficits in the physical performance skills mobility, motor control, strength and endurance are associated with a higher injury risk based on the data evaluated during the study. The study focusses on step 1 and 2 provided by Bahr et al. (3), to assess the relationship in between a marker (or a measured deficit) from a screening test and injury risk and to examine the tests in a relevant and big enough population to find cut-off values. Based on the findings of this study, the development of sport-specific prevention strategies is intended to possibly reduce injury risks among youth athletes in soccer, field hockey, tennis, and golf.

In addition, we aim to examine the influence of individual factors such as peak height velocity (PHV), physical activity levels and limb dominance (standing leg/kicking leg/leg used for takeoff) on test performance and injury occurrence.

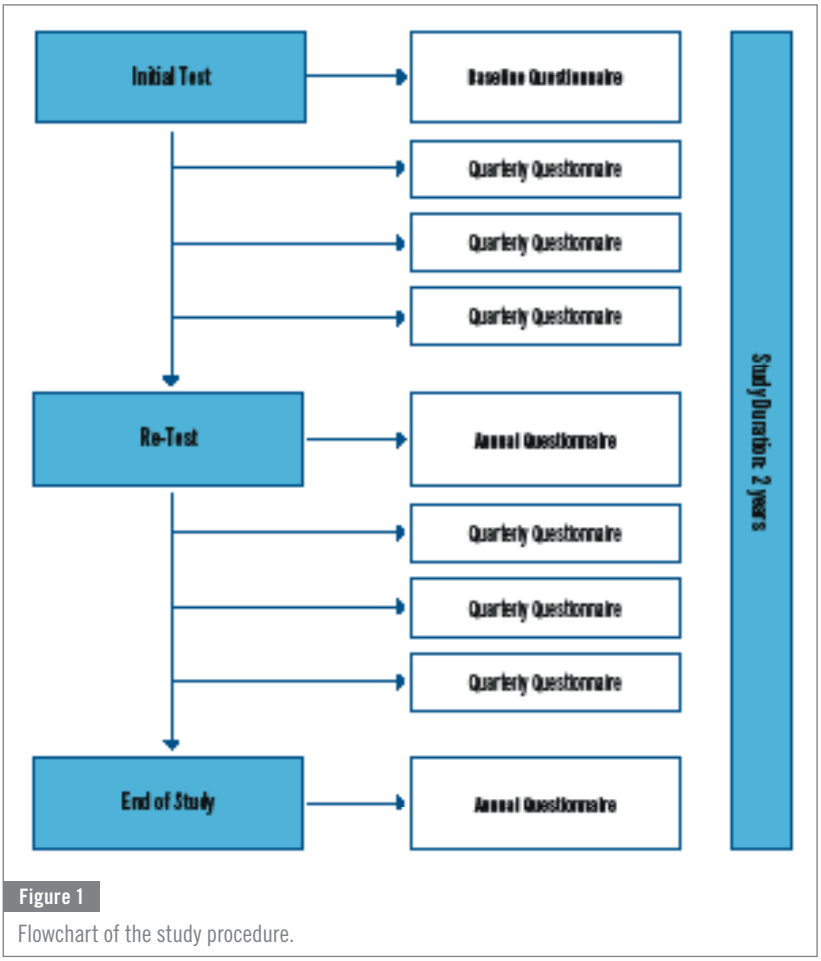

Figure 1
Flowchart of the study procedure.

Methods and Design

Study Design, Ethics, and Informed Consent

This study is a monocentric, prospective study. One year after the initial testing, a re-test will be conducted. Throughout the two-year study period, possible injuries and overuse injuries are recorded at quarterly intervals using questionnaires (figure 1).

The study was approved by the local ethics committee (ref. approval no. 2023-101108-BO-FF). The study is planned in accordance with the Declaration of Helsinki (Fortaleza version, 2013).

Written consent to participate in the study must be given by all study participants and their legal guardians prior to enrolment.

Participants

Sample Size Determination

To examine the relationship between sports-related motor skills and orthopedic injuries in youth athletes, we consider a model with a normally distributed single predictor, X, of sports-related physical performance skills. We assume that the injury rate under H_0 is $p_1 = 0.5$ (15) and that the injury rate under H_1 is $p_2 = 0.6$ when $X = 1$. The odds ratio (OR) is 1.5, indicating a small effect size (8). Using logistic regression with a two-sided significance level of 5% and a power of 80%, we determined the necessary sample sizes to be N = 208 for the soccer, field hockey, tennis, and golf groups, respectively. Assuming a dropout rate of 20%, the minimum sample size is N=250 per group.

Inclusion Criteria

Since our study was primarily designed to target ambitious youth athletes across different sports, the inclusion criteria were defined as follows:

1. Age between 11 and 17 years at the time of initial testing;
2. No injury within the past three months that resulted in a training interruption of more than two weeks
3. Full physical capacity at the time of study participation
4. Signed informed consent by the participant and a legal guardian.

Recruitment

Study participants were recruited through local sports club coaches in Hamburg and Schleswig-Holstein. As part of the recruitment process, personal contacts with managers and coaches from local sports clubs were utilized.

Enrollment

Following initial contact with the coaches of the teams, the aim, content and organization of the study were presented in the context of a study clarification. Study information is send to all participants. Written consent from all participants and their legal guardians is required prior to enrolment. ›

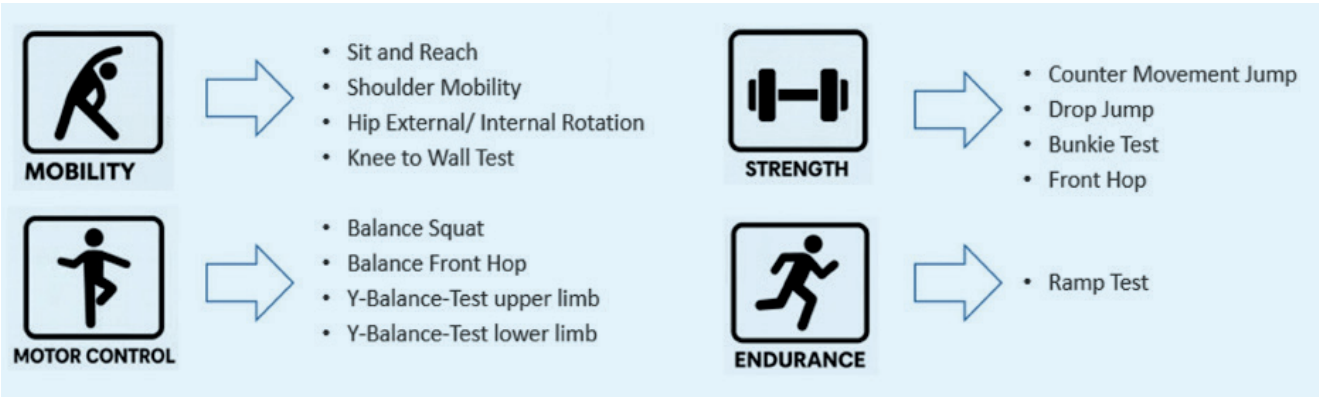

Figure 2
Tests included in the test battery assigned to the fundamental biomotor abilities

Questionnaires

A baseline questionnaire is used to collect anamnestic data on previous injuries, overuse injuries, and the participant's activity level upon inclusion. This questionnaire includes the Tegner Activity Scale (10), the Modified Squash (7), the Modified Athletes' Disability Index Questionnaire (28), the Modified Copenhagen Hip and Groin Outcome Score (HAGOS) (9), the International Knee Documentation Committee (IKDC)(10), the Ankle Instability Instrument (12) and the Tampa Scale of Kinesiophobia (29).

Data collection with these questionnaires will be repeated after one and two years. Possible injuries were surveyed at shorter 3-month intervals to include also minor and overuse injuries that might otherwise have been overlooked. Potential injuries that may occur during the course of the study are defined as any complaints affecting the musculoskeletal system caused either by an acute injury or by overuse. Among others, the location of the injury, the side affected, the severity of the complaint, the context in which the injury occurred, whether it was a contact or non-contact injury, and whether it resulted in time off from training are recorded.

Test Battery

We are exclusively using physical performance skill tests that are already used in daily clinical practice. The test battery consist of the physical performance tests (figure 2):

The selected tests assess fundamental movement patterns and characteristics that are prerequisites for high-intensity and physically demanding sports (25) (figure 3).

The test battery was arranged from low neuro-muscular demand to increasing strain so that a separate warm-up could be omitted. Testing began with mobility assessments, followed by the tests for motor control and balance, core stability and jumping performance, with the ramp test conducted last.

Deficits were assumed if the side symmetry was less than 90% based on the Return to Activity protocol by Keller et al. (20). For tests where this criterion is not applicable, such as jump height (CMJ), the results were assessed based on age, height, and gender.

The Knee to Wall Test measures maximal weight-bearing dorsiflexion of the ankle joint. Poor results in this test have been associated with a higher dynamic knee valgus, which leads to higher risk of anterior cruciate ligament injury and chronic ankle instability (24, 32). The tests for internal and external hip rotation assess mobility of the hip joint, which is linked to the occurrence of hip injuries (35).

The Sit and Reach Test is a functional assessment of dorsal myofascial chain flexibility. Restricted mobility in these muscle groups has been associated with back pain, unsteady gait and a higher risk of musculoskeletal injuries (27).

Shoulder mobility is considered to be an intrinsic risk factor for shoulder injuries. Shoulder mobility was assessed unilaterally by the Apley-Scratch-Test (2, 23).

The modified Y-Balance Test (only anterior reach) for the lower extremity is an assessment for motor control and dynamic balance and lower limb mobility. Poor performance, particularly with greater side-to-side asymmetries, has been associated with an increased risk of lower extremity injuries (17, 30). According to the review from Plisky et al. (31), it remains unclear which asymmetry and direction offers a better prediction. For logistical reasons and clinical considerations, we opted for the anterior reach. This task requires a knee-dominant squat, which biomechanically places greater stress on the knee joint, especially the retropatellar region.

The Balance Squat Test assesses neuromuscular coordination and movement quality of the knee during a single-leg squat (21). A stable movement pattern is essential for dynamic activities, while poor performance has been associated with a higher risk of lower extremity injuries (20, 39).

Similarly, the Balance Front Hop evaluates movement quality, specifically focusing on landing control following a jump (21). Adequate balance and lower limb alignment control are crucial components of injury prevention programs for lower extremity injuries (20). Since measuring the jump distance alone may be insufficient to detect deficits in knee function (22), the Balance Front Hop was performed to examine valgus alignment. This test is based on the specifications of Keller et al.(21)

The Counter Movement Jump is a squat-to-jump movement used to assess explosive power production of the lower limbs. It is often utilized to detect asymmetries in strength, flexibility and specific performance capabilities of the lower extremities (26, 42).

The Drop Jump is used to detect reactive strength and explosive jump performance and is highly correlated to linear sprint performance (14).

The single-leg front Hop measures concentric horizontal strength production, stability of the lower extremities and neuromuscular control. Poor movement quality during single-leg front hop – such as knee valgus – is considered a risk factor for ACL injuries (20, 41). The modified Y-Balance Test (only medial reach) for the upper extremity is a tool to assess shoulder control, shoulder stability, and core stability (37).

The Bunkie Test (anterior, posterior and medial chain) evaluates core muscular endurance and stability (34). In terms of motor skills, the medial stabilization line reflects the lateral support pattern. For clinical and time efficiency considerations the lateral chain was omitted.

The Ramp Test is an incremental exercise test performed on a cycle ergometer, designed to determine maximum work capacity and maximum heart rate (18).

Selection of Tests, Examiner Training, and Reproducibility

The selection of tests was conducted by an expert panel based on the following key criteria: (a) scientific evidence supporting the validity of the tests, (b) coverage of relevant domains, functions, and anatomical regions, (c) simplicity and time efficiency in execution (the full test battery had to be completed within one hour given the planned number of participants), (d) inclusion of both quantitative and qualitative test modalities, and (e) a specific focus on sport-related injury patterns, particularly in the lower extremities, while still considering the core and upper extremities.

A critical factor in the implementation of physical performance assessments is achieving high reproducibility, both in the execution and in the evaluation of the tests. To ensure this, a structured training program for all examiners was developed and implemented by the expert team under supervision. The training included test and retest sessions in various group constellations and the development of precise instructional materials. Ultimately, a standardized operating procedure (SOP) for test administration was established. This standardized work instructions provides precise instructions for conducting and evaluating each test e.g. it describes exactly the measurement method and correct test procedure, as well as the corresponding evaluation criteria. Based on previous studies and on our test and retest sessions we evaluated a high to very high interrater and intrarater reliability, indicating consistent assessments both between different raters and by the same rater over time. Regarding the different tests ICC varied from 0.76 to 0.93 for the interrater reliability and from 0.78 to 0.92 for the intrarater reliability.

Figure 3

Physical performance testing in youth athletes. Images published with informed consent from participants and their legal guardians, with all image rights reserved.

Statistical Methods

The collected data is first subjected to a data quality check to ensure that discrepancies and erroneous data are excluded from further analyses and that general data consistency is ensured. Differences are examined using the t-test or chi-square test, and correlations are examined using appropriate regression methods. The functional results of the uninjured and injured side of the injured athletes are described using descriptive statistics and tested for differences using inferential statistical methods depending on the data level. Possible cut-off values should be assessed either based on side differences, or on quantitative values in relation to e.g. gender, age and anthropometrics. The correlations between subjective and functional results are tested using correlations. Depending on the data level, Spearman's or Pearson's correlation coefficients are given. In further analysis of the data, covariates such as age, gender, peak height velocity, sport, training intensity, multisport and previous injuries will also be addressed.

Trial Status

The physical performance skill testing began in November 2023, and is currently ongoing. To date, 644 athletes have completed the baseline testing, including 285 soccer players (73 female), 263 field hockey players (190 female), 58 tennis players (18 female), and 38 golfers (10 female). Additionally, retesting has been conducted on 177 athletes. The analysis of the initial motor performance tests, including baseline questionnaires and ›

the relationship with the discussed individual parameters, is currently underway as part of ongoing research projects.

No participant has yet completed the whole study. Recruitment completion is anticipated to be July 2025, measurement completion by July 2026 and overall study completion is expected to be July 2027.

The intention is to evaluate and publish the first part of the results after the tests have been completed (including correlations between the test results and covariates such as PHV, age, multisport, etc.), and then a second part once the data on possible injuries during the study has been collected via the questionnaires and the study has been completed.

Discussion

To prevent injuries and overuse injuries in youth sports, the primary aim of the planned research project is to answer the question of whether single physical performance tests of the test battery or a combination of tests can predict injuries and overloads.
The target is to assess the correlation in between a measured deficit from a screening test and injury risk and to conduct the tests in a relevant and sufficiently large population to find cut-off values.

In addition, the inclusion of team sports as well as individual sports enables a direct comparison of the study results with regard to the different sport-specific requirements that arise, for example, from the higher dynamics in team sports. Based on this data, sport-specific requirement profiles and training recommendations for an injury-free sport are aimed to be developed.

Furthermore, data analysis will investigate correlations between test results and individual parameters such as, for example, anthropometrics, peak height velocity, sports, activity level, multisport and limb dominance.

To increase the practicability of the test battery, tests for which little or no test material was necessary were applied. An exception to this is the ramp test on the cycle ergometer, which can easily be replaced by other endurance tests such as the IFT 15/30 test. From a methodological perspective, simplicity and efficiency were considered essential to promote broad implementation in clinical and sports practice. The battery was designed to be executable within a short timeframe and by a wide range of practitioners, including those with limited resources or training. The tests were selected based on founded evidence and the aim of this study was to further improve their validity. Additionally, the objective of the study is to explore correlations among test results and to investigate whether certain combinations of tests provide greater predictive value than single tests alone. It is hypothesized that a multi-dimensional testing approach provides a more holistic understanding of functional performance and injury risk compared to isolated assessments. This test battery is also intended to enable smaller sports clubs to carry out regular, standardized and structured motor skill testing as a preventative measure.

Limitations

The aim was to include an equal number of male and female athletes in the study. Due to the different popularity of the sports among male and female athletes, a heterogeneity in the gender distribution was already apparent at the time of publication.

Because it is significantly more difficult to recruit study participants in individual sports, it can be assumed that the sample sizes of these sports will be heterogeneous as well. In addition, the study participants were recruited through personal contacts and collaborations, which may have had an impact on the study population.

Conflict of Interest
The authors have no conflict of interest.

Funding
This study was supported by the Alexander-Otto-Sportstiftung.

Ethical Approval
The study was approved by the local Ethics Committee of the University of Hamburg (Ref. No. 2023-101108-BO-FF). All procedures were conducted in accordance with the Declaration of Helsinki (Fortaleza, 2013). Written informed consent was obtained from all participants and their legal guardians prior to enrolment.
All collected data were pseudonymized before analysis and stored on secure institutional servers in compliance with the European General Data Protection Regulation (GDPR). Data access was restricted to authorized members of the research team.
Physical performance testing was performed by trained examiners following standardized Standard Operating Procedures (SOPs) to ensure participant safety and reproducibility. All participants were covered by institutional accident insurance during the testing sessions.
The study is prospectively registered with the German Clinical Trials Register (DRKS, ID: DRKS00036090).

Summary Box

Injury prevention in youth: While injury incidence and preventive strategies among male soccer players are already well documented, research in sports like field hockey, tennis, and golf and in females in general remains limited. Additionally scientific studies with youth athletes are also outnumbered overall.

Increase of injuries and overuse injuries: In addition to sports injuries, the increased volume of training with high-intensity and prolonged stress in combination with inadequate regeneration management in competitive sport also leads to an increase in overuse injuries

Physical performance tests: Physical performance tests offer a cost-effective and practical means to identify individual deficits and potential in mobility, balance, motor control and strength all of which are crucial for high-level sports performance.

References

(1) **2024 Sports Attendance Report 2024.** https://twocircles.com/gb/de/articles/2024-sports-attendance-report-germany-edition/ [Accessed July 22, 2025].

(2) **Aggarwal A, Saxena K, Palekar TJ, Rathi M.** Instrument assisted soft tissue mobilization in adhesive capsulitis: A randomized clinical trial. J Bodyw Mov Ther. 2021; 26: 435-442.

(3) **Bahr R.** Why screening tests to predict injury do not work- and probably never will...: a critical review. Br J Sports Med. 2016; 50: 776-780. doi:10.1136/bjsports-2016-096256.

(4) **Barboza SD, Joseph C, Nauta J, van Mechelen W, Verhagen E.** Injuries in Field Hockey Players: A Systematic Review. Sports Med. 2018; 48: 849-866.

(5) **Bedoya MA, Jaramillo D, Chauvin NA.** Overuse injuries in children. Top Magn Reson Imaging. 2015; 24: 67-81.

(6) **Beech J, Jones B, Hughes T, Emmonds S.** Injury Profile in Youth Female Athletes: A Systematic Review and Meta-Analysis. Sports Med. 2024; 54: 1207-1230.

(7) **Carbo MJ, Paap D, Maas F, et al.** The mSQUASH; a valid, reliable and responsive questionnaire for daily physical activity in patients with axial spondyloarthritis. Semin Arthritis Rheum. 2021; 51: 719-727. doi:10.1016/j.semarthrit.2021.05.004

(8) **Chen H, Cohen P, Chen S.** How Big is a Big Odds Ratio? Interpreting the Magnitudes of Odds Ratios in Epidemiological Studies. Communications in Statistics - Simulation and Computation. 2010; 39: 860-864. doi:10.1080/03610911003650383

(9) **Christensen KB, Clausen MB, King E, et al.** Validation of the Copenhagen Hip and Groin Outcome Score (HAGOS) using modern test theory across different cultures and languages: a cross-sectional study of 452 male athletes with groin pain. Br J Sports Med. 2022 Mar; 56(6): 333-339. doi:10.1136/bjsports-2021-104412. Epub 2021 Nov 23. PMID: 34815222.

(10) **Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM.** Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). Arthritis Care Res (Hoboken). 2011; 63: S208-S228. doi:10.1002/acr.20632

(11) **Crossley KM, Patterson BE, Culvenor AG, et al.** Making football safer for women: a systematic review and meta-analysis of injury prevention programmes in 11 773 female football (soccer) players. Br J Sports Med. 2020; 54: 1089-1098.

(12) **Docherty CL, Gansneder BM, Arnold BL, Hurwitz SR.** Development and reliability of the ankle instability instrument. J Athl Train. 2006; 41: 154-158. PMID: 16791299; PMCID: PMC1472648.

(13) **DOSB.** DOSB Bestandserhebung 2024. 2024. https://cdn.dosb.de/user_upload/www.dosb.de/Medien_Service/BE/DOSB-Bestandserhebung_2024.pdf [Accessed October 22, 2025].

(14) **Faude O, Schlumberger A, Fritsche T, Treff G, Meyer T.** Leistungsdiagnostische Testverfahren im Fußball – methodische Standards. [Performance Diagnosis in Football – Methodological Standards]. Dtsch Z Sportmed. 2010; 61: 129-133.

(15) **Fort-Vanmeerhaeghe A, Milà-Villarroel R, Pujol-Marzo M, Arboix-Alió J, Bishop C.** Higher Vertical Jumping Asymmetries and Lower Physical Performance are Indicators of Increased Injury Incidence in Youth Team-Sport Athletes. J Strength Cond Res. 2022; 36: 2204-2211. doi:10.1519/JSC.0000000000003828

(16) **Gao Z, Chen S, Sun H, Wen X, Xiang P.** Physical Activity in Children's Health and Cognition. Biomed Res Int. 2018; 2018: 8542403.

(17) **Gonell AC, Romero JA, Soler LM.** Relationship between the y balance test scores and soft tissue injury incidence in a soccer team. Int J Sports Phys Ther. 2015; 10: 955-966.

(18) **Grentzinger A, Suleiman A, Selton-Suty C, et al.** Evaluation cardiopulmonaire à l'effort; intérêt et influence de l'utilisation d'un protocole comportant des paliers de très courte durée (protocole rampe) par rapport au protocole triangulaire [Cardiopulmonary exercise evaluation: value and influence of the use of a ramp protocol versus triangular protocol]. Arch Mal Coeur Vaiss. 1994; 87: 1395-1400. French.

(19) **Jayanthi NA, LaBella CR, Fischer D, Pasulka J, Dugas LR.** Sports-specialized intensive training and the risk of injury in young athletes: a clinical case-control study. Am J Sports Med. 2015; 43: 794-801.

(20) **Keller M, Kurz E, Schmidtlein O, Welsch G, Anders C.** [Interdisciplinary Assessment Criteria for Rehabilitation after Injuries of the Lower Extremity: A Function-Based Return to Activity Algorithm]. Sportverletz Sportschaden. 2016; 30: 38-49.

(21) **Keller M, Niederer D, Schwesig R, Kurz E.** Lower extremity movement quality in professional team sport athletes: Inter-rater agreement and relationships with quantitative results from the corresponding pattern. BMC Sports Sci Med Rehabil. 2024; 16: 98 doi:10.1186/s13102-024-00886-6

(22) **Kotsifaki A, Korakakis V, Whiteley R, Van Rossom S, Jonkers I.** Measuring only hop distance during single leg hop testing is insufficient to detect deficits in knee function after ACL reconstruction: a systematic review and meta-analysis. Br J Sports Med. 2020; 54: 139-153. doi:10.1136/bjsports-2018-099918

(23) **Kurz E, Bloch H, Buchholz I, et al.** Assessment of return to play after an acute shoulder injury: protocol for an explorative prospective observational German multicentre study. BMJ Open. 2023; 13: e067073.

(24) **Lima YL, Ferreira V, de Paula Lima PO, et al.** The association of ankle dorsiflexion and dynamic knee valgus: A systematic review and meta-analysis. Phys Ther Sport. 2018; 29: 61-69.

(25) **Mandorino M, Figueiredo AJ, Gjaka M, Tessitore A.** Injury incidence and risk factors in youth soccer players: a systematic literature review. Part I: epidemiological analysis. Biol Sport. 2023; 40: 3-25.

(26) **Markovic G, Dizdar D, Jukic I, Cardinale M.** Reliability and factorial validity of squat and countermovement jump tests. J Strength Cond Res. 2004; 18: 551-5.

(27) **Mayorga-Vega D, Merino-Marban R, Viciana J.** Criterion-Related Validity of Sit-and-Reach Tests for Estimating Hamstring and Lumbar Extensibility: a Meta-Analysis. J Sports Sci Med. 2014; 13: 1-14.

(28) **Noormohammadpour P, Hosseini Khezri A, Farahbakhsh F, et al.** Reliability and Validity of Athletes Disability Index Questionnaire. Clin J Sport Med. 2018; 28: 159-167. doi:10.1097/JSM.0000000000000414

(29) Pagels L, Lüdtke K, Schäfer A. Kinesiophobie bei Schulterbeschwerden: Validierung der deutschen Version der Tampa Scale for Kinesiophobia (TSK-GV) [Kinesiophobia in shoulder disorders : Validation of the German version of the Tampa scale for kinesiophobia (TSK-GV)]. Schmerz. 2024; 38: 198-204. German. doi:10.1007/s00482-022-00678-2

(30) Plisky PJ, Gorman PP, Butler RJ, et al. The reliability of an instrumented device for measuring components of the star excursion balance test. N Am J Sports Phys Ther. 2009; 4: 92-99.

(31) Plisky P, Schwartkopf-Phifer K, Huebner B, Garner MB, Bullock G. Systematic Review and Meta-Analysis of the Y-Balance Test Lower Quarter: Reliability, Discriminant Validity, and Predictive Validity. Int J Sports Phys Ther. 2021; 16: 1190-1209. doi:10.26603/001c.27634

(32) Powden CJ, Hoch JM, Hoch MC. Reliability and minimal detectable change of the weight-bearing lunge test: A systematic review. Man Ther. 2015; 20: 524-532.

(33) Read P, Mc Auliffe S, Wilson MG, Myer GD. Better reporting standards are needed to enhance the quality of hop testing in the setting of ACL return to sport decisions: a narrative review. British Journal of Sports Medicine. 2021; 55: 23-29.

(34) Ronai P. The Bunkie test. Strength and Conditioning Journal. 2015; 37: 89-92.

(35) Ryan J, DeBurca N, Mc Creesh K. Risk factors for groin/hip injuries in field-based sports: a systematic review. Br J Sports Med. 2014; 48): 1089-1096.

(36) Sampasa-Kanyinga H, Colman I, Goldfield GS, et al. Combinations of physical activity, sedentary time, and sleep duration and their associations with depressive symptoms and other mental health problems in children and adolescents: a systematic review. Int J Behav Nutr Phys Act. 2020; 17: 72.

(37) Schwiertz G, Beurskens R, Muehlbauer T. Discriminative validity of the lower and upper quarter Y balance test performance: a comparison between healthy trained and untrained youth. BMC Sports Sci Med Rehabil. 2020; 12: 73.

(38) Stracciolini A, Casciano R, Friedman HL, Meehan WP, 3rd, Micheli LJ. A closer look at overuse injuries in the pediatric athlete. Clin J Sport Med. 2015; 25: 30-35.

(39) Ugalde V, Brockman C, Bailowitz Z, Pollard CD. Single leg squat test and its relationship to dynamic knee valgus and injury risk screening. Pm r. 2015; 7: 229-235.

(40) Valovich McLeod TC, Decoster LC, Loud KJ, et al. National Athletic Trainers' Association position statement: prevention of pediatric overuse injuries. J Athl Train. 2011; 46: 206-220.

(41) Weber M, Müller M, Mathieu-Kälin M, et al. Evaluation of hop test movement quality to enhance return to sport testing. A cross-sectional study. Front Sports Act Living. 2024; 6: 1305817.

(42) Wrona HL, Zerega R, King VG, et al. Ability of Countermovement Jumps to Detect Bilateral Asymmetry in Hip and Knee Strength in Elite Youth Soccer Players. Sports (Basel). 2023: 11.

(43) Yang J, Wang Y, Chen J, et al. Effects of the „FIFA11+ Kids" Program on Injury Prevention in Children: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2022: 19.