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Characteristics of functional movement screening testing in elite handball players: Indicative data from the 9+

Running head: The 9+ data on Icelandic handball players

E. T. Rafnsson[1,2] PT, MSc, G. Myklebust[3], PT, PhD, R. Bahr[3], MD, PhD, Ö. Valdimarsson[2], MD, PhD, A. Frohm[4] PT, PhD, Á. Árnason[1,5], PT, PhD

[1]Research Centre of Movement Science, Department of Physical Therapy, School of Health Sciences, University of Iceland, Reykjavik, Iceland, [2]Orkuhusid, Physical Therapy and Medical Centre, Reykjavik, Iceland, [3]Oslo Sports Trauma Research Center, Norwegian School of Sport Sciences, Oslo, Norway, [4]Department of Neurobiology, Care Science and Society (NVS) Division of Physical Therapy, Karolinska Institutet, Huddinge, Sweden, [5]Gáski Physical Therapy, Reykjavik, Iceland

Corresponding author:
Elis Thor Rafnsson. PT, MSc.
Research Centre of Movement Science, Department of Physical Therapy School of Health Sciences,
University of Iceland,
Stapi v. Hringbraut,
IS-101 Reykjavik,
Iceland
Tel: + 354 520 0122
Fax: + 354 520 0139
e-mail: elis@sjukratjalfun.is

Abstract

Objectives: To test 9+ screening batterie's intra-rater reliability, to provide indicative data of elite handball players, and to analyze difference between age, playing positions and level of play.

Design: Descriptive study

Setting: Icelandic elite male handball players

Participants: 182 elite male handball players.

Main Outcome Measures: Nine+ screening battery.

Results: Reliability test: Intra-class correlation for the total score was 0.95. The correlation of each of the test factors varied from 0.63 to 0.91. The mean total score was 22.3±2.9 (95%CI 16.7-28.1), with no difference in total score comparing players age or level of play. Goalkeepers displayed a higher total score than other players ($F_{3,151}$=5.75, p=0.001). Junior players had a lower score than senior players in tests measuring abdominal strength and core stability; Test 5; χ^2(3, 182)=41.5, p<0.0001, Test 6; χ^2(3, 182)=55.7, p<0.0001, Test 7; χ^2(3, 182)=11.8, p<0.005, but higher scores in tests measuring trunk and shoulder mobility Test 8; χ^2(3, 182)=18.2, p<0.0001, Test 9; χ^2(3, 182)=22.2, p=0.006.

Conclusions: The 9+ intra-rater reliability was acceptable for the total score and individual tests. Age-related differences were provided in many individual tests.

Key words: 9+ screening battery, functional screening test, handball, age-related difference.

Introduction

Handball has been a professional sport for years and an Olympic sport since 1972. The popularity has been growing fast during the last decade, with many well organized events with packed arenas and live broadcasts to 200 countries [1]. Handball has matured into a fast dynamic sport; the most significant change occurring in 2000 when teams were allowed a quick throw-off to increase the speed of the game [1]. As a result, players needed to improve their physical fitness, with obvious differences between playing positions [1-5]. Even in youth handball there is a clear tendency that playing positions are determined by anthropometric and physical abilities [6]. The physical factors are becoming more important. In a study from the men's World Cup tournament in 2013 (24 participating teams), the players from the bottom eight were shorter and had less body mass than the players from the top 16 teams [7]. In recent years, researchers have presented data on physical characteristics (body mass, height, BMI, throwing mechanism, etc.) according to playing positions, level of play and level of skill [1, 5, 8]. Current handball literature aims to advance the knowledge of injuries in handball, analyze injury mechanisms as well as improve the players effort and quality in professional handball [1-3, 7-19].

In recent years, functional movement tests have been popular tools to screen athletes, focusing on "dynamic“ tests to reveal possible variations in body function [20]. One of these tools, “The 9+ Screening Battery” (9+), was developed by a Scandinavian research group as a method to screen athlete performance. It consist of five tests from the Functional Movement Screen (FMS), one from the American tennis association (USTA HPP), plus five other tests added by the group to test for mobility, dynamic trunk strength and knee control [21, 22]. In recent years, FMS has been tested for reliability [23, 24], non-contact and overuse injuries [25], comparison with previous injuries [26] and predictive ability for time loss or medical attention injuries [27-30]. “High risk“ atheltes were shown to be 51% more likely to be affected by injury than “low risk“, but with very low level of evidence [30]. Studies using 9+ on athletes have failed to show association between the player's total score and lower extremity injuries [31, 32], as well as intraindividual variability in the total score between seasons, regardless of the players injury [33]. Specific exercises based on the 9+ screening battery did not reduce short-term and seasonal injury occurrence in adolescent elite athletes [34]. However, the FMS and 9+ tests have been used considerably by coaches and physical therapists to screen for asymmetries and imbalance [35] and as a tool to measure physical capacity of athletes aimed to improve their performance,[36] in a field where more knowledge regarding physical conditions is continually required [37, 38].

Until now, no studies have used the 9+ screening battery to present indicative data for handball players in relation to their playing positions, level of play or different age groups. Furthermore, previous studies have only used the 9+ total score, but no study have used the scores of each of the 10 individual tests in the 9+ test battery to compare with injury risk, playing position, level of play or different age groups.

The purpose of this study was to test intra-rater reliability of the 9+ screening battery among junior handball players, to provide indicative data of junior and senior elite handball players, and to compare groups according to age, level of play and player position.

Methods

Participants

We contacted the male senior clubs in the two highest divisions (n=16) in Iceland during the early pre-season with written and oral information about the study; 13 of them accepted the invitation. We also invited male junior players (16 to 19 yrs.) from the clubs. National team players playing professionally abroad were also invited to participate during a training session in Iceland. A total of 182 players provided written consent, including parental consent for players <18 yrs. The study was approved by The National Bioethics Committee in Iceland (12-043) and reported to The Icelandic Data Protection Authority.

Of the 182 players included, 61 played in the premier division (no national team games), 44 in the second division (no national team games), 27 were Icelandic national team players, 8 of them current and 19 former professional European club players, now playing for Icelandic premier division clubs. Fifty were junior players from the teams, also playing for the senior teams or vying for a place in the senior team.

The junior players (n=50, 16-19 yrs., mean 17.3 ±0.7) were tested twice with the 9+ screening battery with a week interval between tests to examine the intra-rater reliability of the test, while the senior players (n=132) were tested once.

Experimental design

All the tests were performed by the same tester (ETR), an experienced sports physical therapist. Prior to the reliability tests, the tester underwent a 2-day course supervised by two of the 9+ developers.

The 9+ screening battery consists of functional exercises and complex movements. The battery is comprised of the: 1. Deep squat test, 2. Deep single leg squat test, 3. In-line lunge test, 4. Active hip flexion test, 5. Straight leg raise test, 6. Push up test, 7. Diagonal lift test, 8. Seated rotation test, 9. Functional shoulder mobility test, and 10. Drop jump test [(22)]. For each of the 10 tests, players received specific instructions and they were scored from 0 to 3 points on an ordinal scale according to their performance (3: correct; 2: correct, but with compensatory movement; 1: not correct; 0: if pain was present). Therefore, the maximum total score was 30. Research tools used were a standard set used for 9+ screening [(22)]. Players were tested barefoot, wearing a t-shirt and shorts. In tests looking for side-to-side differences, the left extremity was tested first. If side differences were present, the lower score was used for data analysis. Before each test, players were shown a photo of the optimal starting and finishing position of each exercise. They received standardized verbal instructions from the tester while performing the test and verbal corrections between attempts. Every player performed each test three times and their best score was used in the analyses. The average time to complete the test was 30 minutes per player. Player characteristics (i.e., age, height, weight, playing position, level of play) were recorded before each player was tested.

Statistical analyses

The data were analyzed using SAS Enterprise Guide 7.1. Descriptive data are presented as the mean ±SD. In the reliability study, intra-rater reliability in the two sessions total score was analyzed using intraclass correlation coefficient (ICC (3.1)). ICC varies between 0 (no reliability) and 1 (complete reliability) [39]. Spearman´s correlation was used to calculate the intra-rater reliability of the two repeated measurements in each of the ten tests. Standard error of measurement was calculated by using the formula: $SD_{diff}/\sqrt{2}$. T-tests and ANOVA were used to test for group differences in total score, and Bonferroni post-hoc test for multiple comparisons. Chi-square was used to test for differences between groups in individual tests. Linear regression analysis was used to analyze the relationship between test scores and age. The significance level was set as $p<0.05$.

Results

The 9+ screening battery total score among the 50 junior players in the reliability study varied from 16-30 points in both tests, with a high correlation between test sessions (ICC (3.1)=0.95, 95%CI 0.93-0.97, $p<0.0001$). A significant improvement (0.32, $p=0.041$) was observed in the total score between the two test sessions (test 1: 21.6±3.5; 95%CI 20.7-22.6 and test 2: 22.0±3.4; 95%CI 21.0-22.9). For each of the 10 tests in the screening battery, Spearman´s correlation showed that the intra-rater reliability ranged from 0.65 (test 10, Drop jump test) to 0.95 (test 1, Deep squat). The standard error of measurement ranged from 0.14 (test 10) to 0.37 (test 2).

Screening

The average total score for senior Icelandic handball players tested in the 9+ screening battery was 22.3±2.9 points (95%CI 16.7-28.1). No significant difference was found in the total score between players in the two Icelandic divisions ($p=0.26$). Figure 1 shows the difference in total score between playing positions where goalkeepers total score (24.3±3.5 points 95%CI 22.3-25.7) were 2.2-2.9 points higher than players in other positions. Examining the score for each of the ten individual tests, goalkeepers reached a higher score than other players in test 3; In-line lunge test (2.29±0.9 vs 2.21±0.6, $\chi^2(2, 155)=6.26$, $p=0.05$) and test 4; Active hip flexion test (2.63±0.8, vs 1.70±0.8, $\chi^2(2, 155)=35.2$, $p<0.0001$). Goalkeepers and wing players achieved a higher score than back court and pivot players in test 9; Functional shoulder mobility test (GK; 2.63±0.7, χ^2(2, 155)=8.9, p=0.01, WP; 2.45±0.7 vs other players; 2.13±0.7, χ^2(2, 155)=9.17, p=0.01).

Figure 1 near here:

There was no significant difference in the total score of the 9+ screening battery between groups (junior players, premier league players, 1st division players, national team players, p=0.26). But when examining the score for each of the ten tests, a significant difference was found in several tests with junior players scoring lower in tests requiring trunk strength and stability; Tests 1; Deep squat test; χ^2(3, 182)=11.1, p=0.0072, 5; Straight leg raise test; χ^2(3, 182)=41.5, p<0.0001); 6; Push up test; χ^2(3, 182)=55.7, p<0.0001); and 7; Diagonal lift test, χ^2(3, 182)=11.8, p=0.006) and higher in tests requiring hip, trunk and shoulder mobility (3; In-line lunge test, χ^2=13.3, p=0.0018); 8; Seated rotation test; χ^2(3, 182)=18.2, p<0.0001); and 9; Functional shoulder mobility test; χ^2(3, 182)=22.2, p<0.0001, (Table 1). National team players scored higher in tests requiring strength and stability in trunk and dynamic flexibility Tests 4; Active hip flexion test; χ^2(3, 182)=10.7, p=0.03; and 5; Straight leg raise test; χ^2(3, 182)=11.8, p=0.003) (Table 1). As seen in Figure 2, when the results from each of the 10 tests in the 9+ was compared with age as a continuous variable, a significant age-related difference was found in tests for trunk strength and stability as well as shoulder mobility (5, 6, 7 and 9).

Table 1 near here:

Figure 2 near here:

Discussion

This study provides indicative functional movement screening data on male junior, senior and national team handball players. Young players displayed lower scores in tests measuring trunk strength and stability and higher scores in tests measuring mobility. National team players scored highest in tests requiring stability and neuromuscular control in the trunk.

Screening tests

Goalkeepers scored higher than other groups of players in the 9+ screening battery due to their high scores that require mobility in hips, thighs and shoulders (Tests 3, 4 and 9). It is related to goalkeeper's requirements to be mobile to react against shots in various positions. A fundamental part of goalkeeper's training sessions consist of exercises to increase their mobility which is even more important than their strength [1]. Overall, playing handball creates muscular imbalances and tends to decrease the range of motion in the throwing shoulder compared to other athletes [10, 13]. Wing players scored higher than back court and pivot players in test 9, which requires shoulder mobility. The wing players are smaller and with less body mass than other outfield players, shooting from narrow angles using various techniques requiring appropriate range of motion in the shoulder joint [3, 7, 8, 11].

As shown in Figure 2 (Test 9), shoulder mobility declined with increased age. Researches have shown that age-related changes can be an explanation [40, 41]. Players tend to improve their strength during their career by continuous strength training [11, 15]. Repetitive movements and strain on the anterior part of the shoulder girdle (i.e. pushing and tackling opponents, ball throwing, weight lifting with emphasis on the protracting muscle groups) can create imbalance and reduced glenohumeral rotation among athletes [42]. This represents a risk factor for shoulder injuries among elite handball players but studies analyzing risk factors for shoulder injuries have shown conflicting results and our results should therefore be interpreted with caution and researched further [13, 43, 44].

Level of play

In the present study, the national players scored higher than other players in tests 4 and 5, which require adequate active hamstring flexibility, trunk strength and stability. Modern handball requires a large number of high-intensity actions, leading to neuromuscular adaptation; trunk strength and stability are believed to be key performance factors [1]. Therefore, it seems logical that the most skillful group scored highest in these two tests.

Junior players scored lower than other player groups in tests 5, 6 and 7, which all require a high amount of trunk strength and stability, and in test 1, which measures trunk stability, mobility in shoulders and hips. Considering their high score in tests 3, 8 and 9 (Table 1), which all test for mobility and flexibility, it seems reasonable to suggest that lack of trunk strength and stability plays a role in their low score in test 1. Research on Icelandic elite handball players has shown that one-third of overuse injuries resulting in absence from participation were located in the low back/pelvic region [45]. This demonstrates a need for further knowledge regarding training methods and possible risk factors. The scores in tests 5, 6, and 7 indicate age-related differences in trunk strength and stability. Age-related variability in range of motion can partially explain these differences [40], but physical maturity is believed to be an important factor in both strength and skill [7, 8]. Previous studies have indicated that physical presence and strength is a fundamental factor for necessary skills as well as reducing injury risk, even at the junior level [6, 13, 16]. When examining the score shown in figure 2, it is important to realize that it not only displays abdominal strength, but also stability and quality of movement created by the muscle groups around the spine and abdomen during flexion and extension [22]. Even though some of the junior players matched the senior players in height and weight, they had lower scores irrespective to their anthropometrics. These results raise questions about possible correlations between age related differences in trunk strength and stability and the high prevalence of time loss injuries in the low back region in Icelandic male handball [45]. Firm conclusions are not possible, but the data represent a platform for further research.

Study limitations

The study was just performed by one tester, and therefore it was not possible to look at inter-rater reliability. It should be considered that the factors behind the score in some of the 9+ tests can be related to more than one body part, for example in test 1 (shoulders, hips and trunk). This can cause difficulties using the score to compare players without knowing which body part is responsible for the compensatory movement that determines the score. Individual factors inside each test could therefore be a valid addition to increase test sensitivity. Significant difference between groups of players do not always need to be the same as practical difference. Difference that cannot be detected in movement quality are possibly not practical. However, differences that are detectable in movement quality could be classified as practical such as the difference between skill levels in tests 5, 6 and 9, where junior players would be classified one point lower (tests 5 and 6) or higher (test 9) than other players.

Perspectives

The 9+ screening battery is reliable and usable for physical therapists. The test is easy to use, and the tools used for measurement are space demanding, which makes the test convenient to use. Some of the 10 tests seem to be useful to indicate differences between players in different playing positions, level of play and age groups. Therefore, it could be used as a tool for coaches to test players and compare to indicative data, indicating their stability, strength and flexibility. Physical therapist can use it to reveal some weak links that could be useful in rehabilitation before return to play. These results could be a platform for further research as well as to provide guidance for coaches organizing their training schedule, helping them to spot factors such as imbalance in mobility and muscle strength.

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References

1. Karcher C, Buchheit M. On-court demands of elite handball, with special reference to playing positions. Sports medicine. 2014;44(6):797-814.
2. Michalsik LB, Aagaard P, Madsen K. Locomotion characteristics and match-induced impairments in physical performance in male elite team handball players. International journal of sports medicine. 2013;34(7):590-9.
3. Sibila M, Pori P. Position-related differences in selected morphological body characteristics of top-level handball players. Collegium antropologicum. 2009;33(4):1079-86.
4. Hermassi S, Chelly MS, Wagner H, Fieseler G, Schulze S, Delank KS, et al. Relationships between maximal strength of lower limb, anthropometric characteristics and fundamental explosive performance in handball players. Sportverletz Sportschaden. 2018.
5. Haugen TA, Tonnessen E, Seiler S. Physical and physiological characteristics of male handball players: influence of playing position and competitive level. J Sports Med Phys Fitness. 2016;56(1-2):19-26.
6. Zapartidis I, Kororos P, T. C, Skoufas D, Bayios I. Profile of Young Handball Players by Playing Position and Determinants of Ball Throwing Velocity. Journal of Human Kinetics 2011;27(2011):17-30.
7. Ghobadi H, Rajabi H, Farzad B, Bayati M, Jeffreys I. Anthropometry of World-Class Elite Handball Players According to the Playing Position: Reports From Men's Handball World Championship 2013. Journal of human kinetics. 2013;39:213-20.
8. Gorostiaga EM, Granados C, Ibanez J, Izquierdo M. Differences in physical fitness and throwing velocity among elite and amateur male handball players. International journal of sports medicine. 2005;26(3):225-32.
9. Wagner H, Finkenzeller T, Wurth S, von Duvillard SP. Individual and team performance in team-handball: a review. Journal of sports science & medicine. 2014;13(4):808-16.
10. Andrade MS, Vancini RL, de Lira CA, Mascarin NC, Fachina RJ, da Silva AC. Shoulder isokinetic profile of male handball players of the Brazilian National Team. Brazilian journal of physical therapy. 2013;17(6):572-8.
11. Massuca L, Branco B, Miarka B, Fragoso I. Physical Fitness Attributes of Team-Handball Players are Related to Playing Position and Performance Level. Asian journal of sports medicine. 2015;6(1):e24712.
12. Sporis G, Vuleta D, Vuleta D, Jr., Milanovic D. Fitness profiling in handball: physical and physiological characteristics of elite players. Collegium antropologicum. 2010;34(3):1009-14.
13. Clarsen B, Bahr R, Andersson SH, Munk R, Myklebust G. Reduced glenohumeral rotation, external rotation weakness and scapular dyskinesis are risk factors for shoulder injuries among elite male handball players: a prospective cohort study. British journal of sports medicine. 2014;48(17):1327-33.
14. Wagner H, Buchecker M, von Duvillard SP, Muller E. Kinematic description of elite vs. Low level players in team-handball jump throw. Journal of sports science & medicine. 2010;9(1):15-23.
15. Kvorning T, Hansen MRB, Jensen K. Strength and Conditioning Training by the Danish National Handball Team Before an Olympic Tournament. Journal of strength and conditioning research / National Strength & Conditioning Association. 2017;31(7):1759-65.
16. Wagner H, Fuchs PX, von Duvillard SP. Specific physiological and biomechanical performance in elite, sub-elite and in non-elite male team handball players. J Sports Med Phys Fitness. 2018;58(1-2):73-81.
17. Dello Iacono A, Eliakim A, Padulo J, Laver L, Ben-Zaken S, Meckel Y. Neuromuscular and inflammatory responses to handball small-sided games: the effects of physical contact. Scandinavian journal of medicine & science in sports. 2017;27(10):1122-9.

18. Dello Iacono A, Martone D, Zagatto AM, Meckel Y, Sindiani M, Milic M, et al. Effect of contact and no-contact small-sided games on elite handball players. J Sports Sci. 2018;36(1):14-22.
19. Manchado C, Garcia-Ruiz J, Cortell-Tormo JM, Tortosa-Martinez J. Effect of Core Training on Male Handball Players' Throwing Velocity. Journal of human kinetics. 2017;56:177-85.
20. Cook G. Athletic body in balance - optimal movement skills and conditioning for performance. USA: Human Kinetics; 2004.
21. Frohm A, Heijne A, Kowalski J, Svensson P, Myklebust G. A nine-test screening battery for athletes: a reliability study. Scandinavian journal of medicine & science in sports. 2012;22(3):306-15.
22. Frohm A FF, Kockum B. . 9+ Screening Batteri. Stockholm: SISU Idrottsböcker; 2013.
23. Minick KI, Kiesel KB, Burton L, Taylor A, Plisky P, Butler RJ. Interrater reliability of the functional movement screen. Journal of strength and conditioning research / National Strength & Conditioning Association. 2010;24(2):479-86.
24. Teyhen DS, Shaffer SW, Lorenson CL, Halfpap JP, Donofry DF, Walker MJ, et al. The Functional Movement Screen: a reliability study. The Journal of orthopaedic and sports physical therapy. 2012;42(6):530-40.
25. Warren M, Smith CA, Chimera NJ. Association of the Functional Movement Screen with injuries in division I athletes. J Sport Rehabil. 2015;24(2):163-70.
26. Letafatkar A, Hadadnezhad M, Shojaedin S, Mohamadi E. Relationship between functional movement screening score and history of injury. International journal of sports physical therapy. 2014;9(1):21-7.
27. Kiesel K, Plisky PJ, Voight ML. Can Serious Injury in Professional Football be Predicted by a Preseason Functional Movement Screen? North American journal of sports physical therapy : NAJSPT. 2007;2(3):147-58.
28. Chorba RS, Chorba DJ, Bouillon LE, Overmyer CA, Landis JA. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. North American journal of sports physical therapy : NAJSPT. 2010;5(2):47-54.
29. Kiesel KB, Butler RJ, Plisky PJ. Prediction of injury by limited and asymmetrical fundamental movement patterns in american football players. J Sport Rehabil. 2014;23(2):88-94.
30. Bunn PDS, Rodrigues AI, Bezerra da Silva E. The association between the functional movement screen outcome and the incidence of musculoskeletal injuries: A systematic review with meta-analysis. Phys Ther Sport. 2019;35:146-58.
31. Bakken A, Targett S, Bere T, Eirale C, Farooq A, Tol JL, et al. The functional movement test 9+ is a poor screening test for lower extremity injuries in professional male football players: a 2-year prospective cohort study. British journal of sports medicine. 2017;52(16):1047-53.
32. Leandersson J, Heijne A, Flodstrom F, Frohm A, von Rosen P. Can movement tests predict injury in elite orienteerers? An 1-year prospective cohort study. Physiother Theory Pract. 2018:1-9;DOI10.1080/09593985.2018.1513106.
33. Bakken A, Targett S, Bere T, Eirale C, Farooq A, Tol JL, et al. Interseason variability of a functional movement test, the 9+ screening battery, in professional male football players. British journal of sports medicine. 2017;51(14):1081-86.
34. Heijne A, Flodstrom F, von Rosen P. Could specific exercises based on a movement screen prevent injuries in adolescent elite athletes? Phys Ther Sport. 2019;36:28-33.
35. Marques VB, Medeiros TM, de Souza Stigger F, Nakamura FY, Baroni BM. The Functional Movement Screen (Fms) in Elite Young Soccer Players between 14 and 20 Years: Composite Score, Individual-Test Scores and Asymmetries. International journal of sports physical therapy. 2017;12(6):977-85.
36. Atalay ES, Tarakci D, Algun C. Are the functional movement analysis scores of handball players related to athletic parameters? J Exerc Rehabil. 2018;14(6):954-9.
37. Sprague PA, Mokha GM, Gatens DR. Changes in functional movement screen scores over a season in collegiate soccer and volleyball athletes. Journal of strength and conditioning research / National Strength & Conditioning Association. 2014;28(11):3155-63.

38. Kraus K, Schutz E, Taylor WR, Doyscher R. Efficacy of the functional movement screen: a review. Journal of strength and conditioning research / National Strength & Conditioning Association. 2014;28(12):3571-84.
39. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;1(8476):307-10.
40. Medeiros HB, de Araujo DS, de Araujo CG. Age-related mobility loss is joint-specific: an analysis from 6,000 Flexitest results. Age. 2013;35(6):2399-407.
41. Soucie JM, Wang C, Forsyth A, Funk S, Denny M, Roach KE, et al. Range of motion measurements: reference values and a database for comparison studies. Haemophilia. 2011;17(3):500-7.
42. Gillet B, Begon M, Blache Y, Berger-Vachon C, Rogowski I. Scapulohumeral rhythm in young tennis players. Comput Methods Biomech Biomed Engin. 2017;20(sup1):93-4.
43. Andersson SH, Bahr R, Clarsen B, Myklebust G. Risk factors for overuse shoulder injuries in a mixed-sex cohort of 329 elite handball players: previous findings could not be confirmed. British journal of sports medicine. 2018;52(18):1191-98.
44. Asker M, Brooke HL, Walden M, Tranaeus U, Johansson F, Skillgate E, et al. Risk factors for, and prevention of, shoulder injuries in overhead sports: a systematic review with best-evidence synthesis. British journal of sports medicine. 2018;52(20)1312-19.
45. Rafnsson ET, Valdimarsson O, Sveinsson T, Arnason A. Injury Pattern in Icelandic Elite Male Handball Players. Clin J Sport Med. 2017;DOI10.1097/JSM.0000000000000499.

Figures and tables

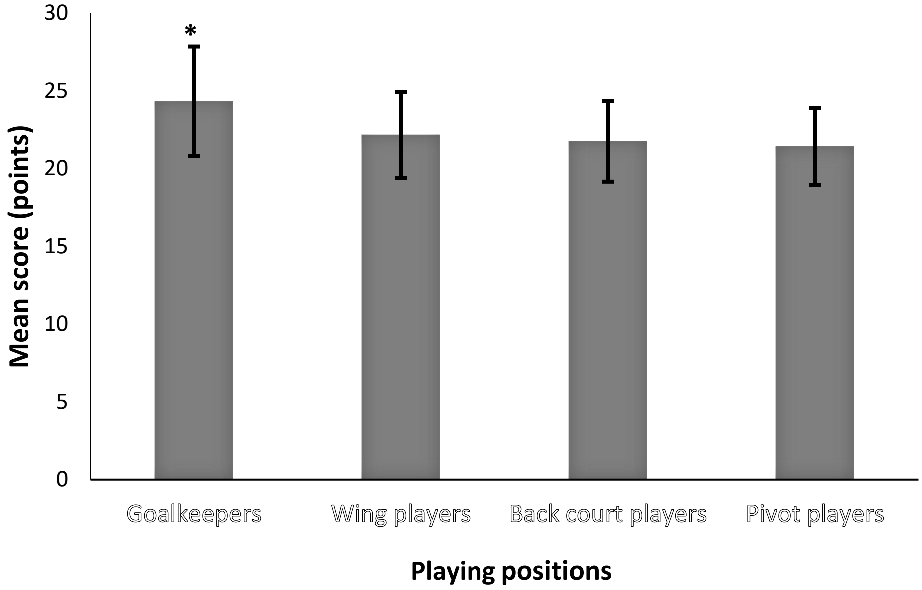

Figure 1. The average total score of the 9+ screening battery in different playing positions. Standard deviations are shown as error bars for each playing position.
*Goalkeepers had significantly higher total score than other players (p=0.0009).

Table 1. The average screening test score for each test and the average total score shown for different skill levels of players.

	1	2	3	4	5	6	7	8	9	10	Total
Junior players	2.15[a]	1.32	2.39[b]	1.71	1.29[a]	2.37[a]	2.02[a]	2.39[b]	2.80[b]	2.95	21.39
Premier division	2.24	1.47[c]	2.26	1.70	2.17	2.89	2.23	2.29	2.21	2.80	22.26
Second division	2.23	1.21	2.27	1.94	2.00	2.98	2.38	2.19	2.27	2.77	22.23
National players	2.19	1.44[d]	2.11	2.07[e]	2.59[e]	2.96	2.33	2.00	2.33	2.78	22.81
Average	2.20	1.36	2.26	1.85	2.01	2.80	2.24	2.22	2.41	2.83	22.17

[a] Significantly lower score than in other groups (p=0.007 (1), p<0.0001 (5) p<0.0001 (6), p=0.006 (7)).
[b] Significantly higher score than in other groups (p=0.001 (3), p<0.0001 (8), p<0.0001 (9)).
[c] Significantly higher score than in second division players group (p=0.006).
[d] Significantly higher score than in second division players group (p=0.03).
[e] Significantly higher score than in other groups (p=0.03 (4), p=0.003 (5)).

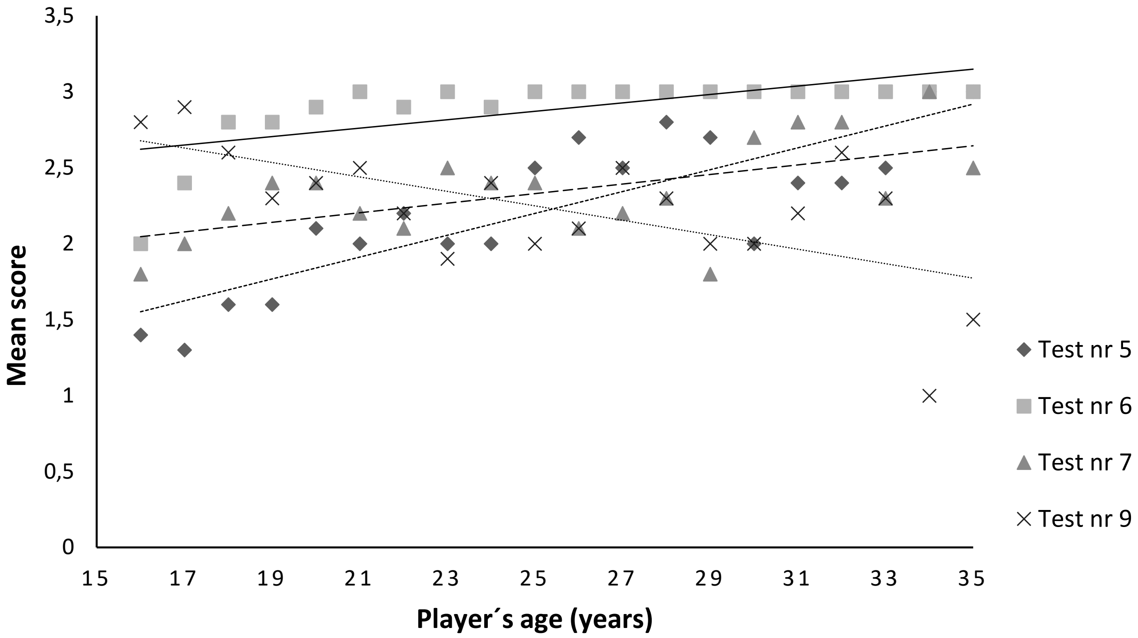

Figure 2. The relationship between age and the mean test score of each year of age in the four tests that showed significant age-related difference (β represents estimated changes in score per year). Test 5 (β=0.14, 95%CI: 0.10-0,19, p<0.0001), Test 6 (β=0.11, 95%CI: 0.05-0.17, p=0.002), Test 7 (β=0.10, 95%CI: 0.03-0.17, p=0.0068), Test 9 (β=-0.11, 95%CI: -0.17-0.05, p=0.002).