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PERFORMANCE DEMANDS ON FEMALE TEAM HANDBALL GOALKEEPERS

ZAHTEVE GLEDE USPEŠNOSTI VRATARK V EKIPNEM ROKOMETU

ABSTRACT

Success in competitive sports is limited by constitutional, conditional, coordinative, technical, psychological and tactical factors. These factors differ by position in team handball, and the differences have yet to be sufficiently specified. Especially for female goalkeepers, the demands remain unclear. Testing for goalkeeper performance demands in handball reveals that previous values do not match those of field players. Still, the goalkeepers tested played in top leagues and apparently met game standards for their position. Consequently, the core demands of the goalkeeper position must be clarified, as well as how goalkeepers differ from field players. To this end, 654 female handball players from German leagues of all performance levels were tested for the above-mentioned factors. Each player's handball-specific expertise was used as the independent variable while the performance differences between positions were seen as dependent variables, as was goalkeeper performance. There were significant differences between goalkeeper and field player performance. Core position demands for goalkeepers were experience ("anticipation expertise"), ambidexterity, low action/state orientation after malperformance and the 30m sprint (fastest of two attempts). Results also suggest that goalkeepers should orient their performance on that of field players for the following factors; sit-ups, reaction test, jump & reach, 10 and 20m sprint, Cooper test, throwing speed, wall passing, slalom dribbling, tactics test, hope for success, net hope, self-optimization, self-impediment, lack of activation, and action/state orientation after malperformance. Coaches should implement specialized training for goalkeepers.

Key Words: performance, psychological factors, positions, goalkeepers, specialization

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IZVLEČEK

V tekmovalnih športih je uspeh omejen z dejavniki, povezanimi s telesno zgradbo in pripravljenostjo ter s tehničnimi, psihološkimi in taktičnimi dejavniki.

Ti dejavniki se razlikujejo glede na položaj v ekipnem rokometu, razlike pa je treba še ustrezno opredeliti. Zlasti v primeru vratark so zahteve še vedno nejasne. Testiranje zahtev glede uspešnosti vratark v rokometu je pokazalo, da vrednosti niso enake kot pri ostalih igralkah. Ne glede na to pa so vse testirane vratarke igrale v najvišjih ligah ter so očitno izpolnjevale merila za svoj igralni položaj. Zato je treba glavne zahteve za igralni položaj vratarke natančno opredeliti ter obenem določiti, po čem se vratarke razlikujejo od drugih igralk. Da bi lahko preučili zgoraj navedene dejavnike, smo testirali 654 rokometašic, ki igrajo v nemških ligah na vseh ravneh uspešnosti. Veščine vsake igralke, značilne za rokometno igro, so bile uporabljene kot neodvisne spremenljivke, medtem ko so bile razlike v uspešnosti med različnimi položaji igralk obravnavane kot odvisne spremenljivke, npr. uspešnost vratarke. Med uspešnostjo vratarke in uspešnostjo drugih igralk so bile značilne razlike. Glavne zahteve za položaj vratarke so bile izkušnje (‚sposobnost predvidevanja'), obojeročnost, tendenca k nižjemu aktivnemu stanju po neuspehu ter 30-metrski šprint (hitrejši od dveh poskusov).

Rezultati kažejo tudi, da bi morale vratarke svojo uspešnost približati uspešnosti ostalih igralk v naslednjih dejavnikih: trebušnjaki, test odziva, skok in doseg, 10- in 20-metrski šprint, Cooperjev test, hitrost meta, prebijanje zidu, slalomsko preigravanje, test taktike, upanje na uspeh, splošno upanje, lastna optimizacija, oviranje samih sebe, pomanjkanje aktivnosti in tendenca k nižjemu aktivnemu stanju po neuspehu. Trenerji bi morali izvajati specializirane treninge za vratarke.

Ključne besede: uspešnost, psihološki dejavniki, položaji, vratarke, specializacija

INTRODUCTION

In team handball there are positional differences between the players in regards to several factors (Čavala, Trninić, Jasić & Tomljanović, 2013). Therefore players should be trained and selected to fit the specific demands of their position. It is still unclear to which extent and when specialization, position-specific selection or training should be applied.

Previous studies conducted with female players found differences between goalkeepers and field players, with goalkeepers not matching field players' values despite competing at a high level (Ignat'eva, Petracheva & Savinkov, 2002; Ignat'eva & Minabutdinov, 2014; Rogulj, Srhoj, Nazor, Srhoj & Čavala, 2005; Zapartidis, Toganidis, Vareltzis & Christodoulidis, 2009 a). It has to be mentioned that insufficient goalkeeper preparation during training may have influenced goalkeeper performance in past studies (De Castro, Sequeira & Cruz, 2011; Ignat'eva, Petracheva & Savinkov, 2002; Ignat'eva & Minabutdinov, 2014; Zapartidis, Kororos, Christodoulidis, Skoufas & Bayios, 2011). However, another reason for the difference in values between goalkeepers and field players could be that the crucial performance factors for female goalkeepers were not tested in those studies (Kajtna et al., 2011; Pori, Šibila, Justin, Kajtna & Pori, 2012). Past studies might accidentally have researched the demands of field players (Kajtna et al., 2011), probably assuming they could also be applied to goalkeepers.

Most studies so far mainly focus on male players (Karcher & Buchheit, 2014) or do not distinguish between male and female players (Wagner, Finkenzeller, Würth & von Duvillard, 2014). However, differences between male and female players are to be expected (Marczinka, 2011) and some factors crucial to goalkeeper performance in female players have been defined. At this point, experience in play and the resulting anticipation-expertise are considered important (Schorer, 2007). So are conditional factors such as being able to quickly develop the maximum amount of force when jumping (as assumed by Pori, Justin, Kajtna & Pori, 2011). Regarding constitution, goalkeepers in the European Championships are tall and heavy with a relatively high body fat percentage (Urban, Kandráč & Tàborsky, 2011). Tactics and positional play are also important (De Castro et al., 2011). In terms of psychological performance, Kajtna et al. (2011) state that male goalkeepers function in an action-orientated manner when coping with failures. Successful goalkeepers did not think about failure as long as less successful goalkeepers and concentration, fear and aggression were not particularly developed in top goalkeepers (Kajtna et al., 2011). Karcher & Buchheit (2014) analyzed literature published up to 2014 and extracted demands for male players on the different positions. It is unclear whether these are applicable to female players (Marczinka, 2011). However, some findings for female goalkeepers have been mentioned in literature (see supplemental material). Nevertheless, only few studies (Speicher, Klein Kleinöder, Schack & Mester, 2006 for cognitive speed of action; Weber & Wegner, 2016 a for constitutional factors; Weber & Wegner, 2016 b for psychological factors) have tested for connections between test results and players' actual success.

Consequently, there are only a few performance relevant factors already identified and it is not clear which other factors may be relevant in goal in female team handball. Most studies do not assess the connection between performance in testing (e. g. motor abilities) and match success (Pori et al., 2012). Most studies so far are descriptive in nature (Manchado, Tortosa, Vila, Ferragut & Platen, 2013).

As psychological demands are seen as the main performance limiting factor for goalkeepers (Kajtna et al., 2011) and are a good talent predicator (Gonçalves, Rama & Figueiredo, 2012), the exact make-up of a goalkeeper's psychological profile should also be researched. Currently, many test results for goalkeepers are caused by what is called "negative selection" when selecting for that position (Zapartidis et al., 2009 a). In youth training, players are sometimes selected for the goalkeeper position because they do not display evident handball skills or they are new to the team (Matthys, 2012; Zapartidis et al., 2009 a). Children are therefore chosen as the goalkeeper because they are overweight, tall or have motor skill deficits, while only rarely is it because a child volunteered (Šibila, Pori & Imperl, 2008). There are high demands for goalkeepers in terms of their performance, but they are often insufficiently trained since the performance limiting factors of the goalkeeper position are probably unknown (Kajtna et al., 2011) and training time is scarce (De Castro et al., 2011).

The aforementioned findings make it necessary to research positional differences in female handball players and the demands on goalkeepers in particular. The connection between position specialization and success has to be investigated. How goalkeepers' demand profiles differ from field players' needs to be specified. Furthermore, whether those differences (thought to indicate specialization) contribute to success (measured through an expertise index) also needs to be determined.

MATERIALS AND METHODS

Participants. 654 female players (18-52 years, 153-190 cm, 43-119 kg) of all German leagues from 1st Bundesliga to regional leagues were tested. Informed consent was obtained from all participants and the study complied with both the approval of the local medical research ethics committee and the current ethical standards of sports and exercise research (Helsinki Declaration).

Procedures. The players were tested using a test battery that assessed handball-relevant factors and involved conditional, constitutional, technical, tactical, psychological and biographical tests. All players and assistants were briefed before the tests. Questionnaires were distributed before testing so participants could complete them at home and bring them to the training site. The conditional, constitutional, technical and tactical profiles of the participants were recorded from May to September 2011 during their usual training.

Measurements. The test battery consisted of several tests covering a wide range of physical, psychological, technical and tactical factors relevant to handball (Table 1). In addition to two technique tests and a tactics test, there were also three psychological tests (standardized questionnaires). These covered most of the performance-relevant psychological factors: Volitional Components in Sports Questionnaire, Achievement-Motives Scale and Hakemp-Sport for action and state orientation in sports (Table 1). Also, a test battery for physiological factors was conducted (Table 1).

Body fat percentage (BF%) was measured using a caliper at the beginning of the participants' usual practice session. Calculations were done using body density (BD) and three skin folds (Siri,1956):

Table 1
Test battery with references to studies where similar tests have already been used.

Test	Factor and testing procedure
5 x 20m Sprint (photo sensor DCT/F03, Sportronic, Germany at start and finish, Hulka & Belka, 2013)	Cyclic velocity, endurance of velocity: Fastest and average time out of five attempts, slow *jog* back to starting point and immediate start of next attempt.
Jump & Reach (Moss, McWhannel, Michalsik & Twist, 2013)	Jumping strength: *Countermovement jump,* jumping height measured as difference between reaching height when standing and when jumping, accomplished height marked with chalk on the players` fingers leaving marks on the wall, best of two attempts
Sit-ups (Hatzimanouil & Oxyzoglou, 2004)	Endurance of strength (abdominal muscles): Maximum number of situps with feet on a small box
Maximum number of chin-ups with supported heels (Büsch, Schorer & Lotz, 2008)	Endurance of strength (arm muscles): Maximum number of chin-ups in angular hanging with supported heels (regional-level players would not have been able to do a number of free chin-ups sufficient for calculation)
Reaction test with Basketball (Prätorius & Milani, 2008)	Reaction speed: *Participants* have to stop a basketball rolling down a ramp within the smallest possible rolling distance *following* an audio signal (mean of two attempts, measured with a tape measure), standing with their back to the ramp at the lower *end of* the ramp, the ball being released from the upper end.
Stand & Reach (Bös, 2001, Zapartidis et al., 2009 a, b)	Flexibility hamstrings / *lower* back: Reaching down to feet or beyond while standing on a small box, distance between standing level and fingers measured with tape measure, positive distance beyond feet, negative above.
Throwing velocity with V-maxx throwing radar (EUROTronic technology, Germany)	Elasticity arm *muscles/throwing* strength: Throwing from a standing position 5m in front of the radar into the upper left corner of the goal, mean out of two attempts, figuring that throwing speed is related to strength (van den Tillaar, 2004; Zapartidis et al., 2009 a, b).
30m Sprint (Zapartidis et al., 2009 a, b) with splittimes at 5 and 10m	Cyclic velocity, start velocity, acceleration: Fastest and average out of two attempts with slow *jog* back to starting point and immediate start of next attempt.
Half Cooper Test* (6min. running, Bös, 2001)	Basic endurance: Number of elliptic rounds (74m in length, marked with shuttles in the training hall) within six minutes of running
Wall passing (Letzelter, Letzelter & Scholl, 1988)	Ball technique pass / catch: Time needed for 20 passes against a wall from a 4m distance
Slalom-dribbling with photo sensor DCT/F03, Sportronic, Germany (Letzelter et al., 1988)	Ball technique Dribbling: 30m parcours, time measured with photo sensors at start and finish
Tactics test via video (Wegner, Leptien & Geode, 2010)	Tactical ability: IVS-video-test, 45 sequences, players have to solve match situations and receive points according to their answers
Skinfold measurement (Whithers et al., 1987)	Body fat percentage: Measurement of three skinfolds (Equation 1, 2)
Achievement Motives Scale, AMS (Elbe & Wenhold, 2005)	AMS: hope for success and fear of failure (15 questions with 0-3 points each), net hope (hope for success minus fear of failure) and total achievement motive (sum of hope for success and fear of failure)
Volitional Components Questionnaire, VCQ (Wenhold, Elbe & Beckmann, 2009)	VCQ: 0 to 3 points per question: for *self-optimization* (29 questions), self-impediment (9 questions), lack of activation (13 questions) and loss of focus (9 questions)
Hakemp-Sport, Action/state orientation in sports, HOSP (Beckmann & Wenhold, 2009)	Hakemp-Sport: *action/state orientation* after malperformance, while planning a task and while performing a task, 12 questions each with 0 to 1 points per question
Players biography, leagues played each past year	Players biography: Expertise points were given for each year played on a scale from 0 to 12; also, players were asked for age, body height and weight.

* Half Cooper test was used due to restricted time available in the training halls.

BD = 1,18562 – 0,08258*lg ($\Sigma x\_Triceps, x\_Subscapular, x\_calf$)[$mm$]

Equation 1: Body density (Whithers et al., 1987).

$BF\%$ = (4,95 / BD) – 4,5

Equation 2: Body fat percentage (Whithers et al., 1987).

When investigating performance the focus should be on successful players to determine the demands of the game. Success can be measured via expertise, which can then be tested for correlations with handball performance factors or positional differences for handball-relevant factors. According to Schorer (2007), the following factors can be used to measure expertise: efficiency and outstanding performance, duration and reproduction of excellent performance, excellent performance not only by accident, expertise through experience (ten-year rule, Ericsson & Lehmann, 1996), time spent training, long preparation, striving for excellence and perfection, motivation, and competition experience. Ericsson and Lehmann (1996) postulate that expertise is best measured quantitatively through competition performance. In this study, expertise was measured by assessing the leagues a player had competed in using data from a biographical questionnaire (in accordance with Sinuany-Stern, 1988, who used national leagues to measure expertise). Participants were asked to name all the clubs they had played for during their career to calculate an individual's expertise index on a scale of zero to twelve. International experience was classified as twelve points, 1st division as eleven points, down to only training, no competitions" as zero points.

The expertise index was calculated from the mean of nine expertise-influencing elements set forth in the literature: mean value of expertise points from the leagues played at senior level, expertise points in the highest league played, mean value of leagues of current and previous seasons, points in most frequent league, total playing experience overall in years scaled to 12 points[1], points for highest league played during youth, mean value of all leagues played during youth, sum of expertise points at senior level (scaled as explained above), and sum of expertise points during youth scaled to twelve (see above).

The tested factors were measured in order to calculate specialization with a customised formula. This involved calculating whether each player differed more from all players of the same position or from all other players:

$$\left(\bar{X}_{allplayers} - value_{factor1\ player1\ position1}\right)^2 - \left(\bar{X}_{playersposition1} - value_{factor1\ player1\ position1}\right)^2$$

Formula 1: Specialization on a position.

Statistical Analyses. Oneway ANOVAs (1x5: positions) per level were performed to investigate the variables in detail. The level of significance was set at $p<0.05$ and by trend-significance at $p<0.10$. Effect size was evaluated with η^2 (ETA partial squared), where $0.01<\eta^2<0.06$ constitutes a small effect, $0.06<\eta^2<0.14$ constitutes a medium effect and $\eta^2>0.14$ constitutes a large effect (Cohen, 1988).

The leagues that players competed in, sorted into competition levels (elite, subelite, regional), will be used as control factors as they could confound the results (Bortz & Döhring, 2006). Thus, it will be possible to gain detailed knowledge on positional differences within these levels without the

[1]12 points being the value of the best player who had played the most years or reached the highest number of points, all other players scaled accordingly

results being confounded by performance level. The main aim is to test for positional differences in the whole sample and in the different levels as well as interactions between players' positions and performance levels, operationalized.

Differences between levels are expected since the tested factors are relevant for performance in female team handball. If the factors are relevant to performance, players of higher leagues will have a more fitting skill level regarding psychological skill than players of lower leagues (in accordance with Letzelter et al., 1988). Therefore, differences between levels will only be tested to prove the validity of the tests.

Correlations between each player's expertise and their values for the different performance factors were calculated via Pearson`s correlation coefficient, Spearman`s rho and Kendall's tau b. Testing for correlations between the calculated differences (Formula 1) and the expertise of the different playing levels were also conducted with correlation levels of >0.1 (weak), >0.3 (moderate) and >0.5 (strong) and a confidence-interval of 0.95 (calculated according to Rinne, 2008). Linear regression will be used to create demand profiles for each position.

When calculating whether the ANOVA differed significantly between the leagues for the tested values, it is possible to determine which factors are important to goalkeepers (being more fittingly developed at the elite level, Letzelter, Letzelter & Scholl, 1988).

Experimental approach to the problem.

Hypotheses:

- goalkeepers differ from field players regarding handball-relevant factors, to be tested via ANOVA;
- goalkeepers are specialized for some factors, revealed through correlations between specialization and expertise (Pearson, Spearman`s Rho, Kendall's Tau b);
- their expertise will correlate with some factors usually seen as limiting factors for handball performance, but not all factors, to be tested via correlations between factor values and expertise
- different factors than expected in literature will differ clearly between leagues and therefore be handball-relevant, to be tested via ANOVA
- there will be a significant set of demands for the goalkeeper position.

The Statistical analysis was performed in SPSS, version 21.0 (SPSS, Inc., Chicago, IL).

RESULTS

A Oneway ANOVA with Scheffé post hoc testing (Table 2, 3) shows that goalkeepers have higher body weights and fat percentages than players of all field positions except pivots at all performance levels. They are taller than all field players except half backs. Goalkeepers are older than wing players at global level. For several psychological factors (Fear of failure, self-impediment, lack of activation, action/state orientation after malperformance) they display values higher than those of field position players at subelite and regional level (Table 2, 3). For most conditional factors, goalkeepers performed worse than field players. Only in the fastest attempt out of two for the 30 m sprint did they outperform all field positions except wings at elite and subelite level (see Table 2, 3).

Table 2

*Descriptive statistics for anthropometric and psychological factors (Mean ± SD) and differences per competition level (Oneway ANOVA / Scheffé post hoc), only factors with significant differences to a **field position** are shown.*

Factors**	Effect η	Wingplayers (n = 197)	Half backs (n = 170)	Centre backs (n = 102)	Pivots (n = 92)	Goalkeepers (n = 91)
Body height [cm]	0.436	168.10 ± 5.53 [bcde]	174.94 ± 5.18 [acd]	171.19 ± 5.79 [ab]	170.84 ± 6.13 [abe]	173.57 ± 5.74 [ad]
Elite	0.564	167.89 ± 5.12 [bcde]	177.23 ± 4.50 [acd]	172.94 ± 6.42 [ab]	172.71 ± 5.11 [ab]	176.18 ± 5.56 [a]
Subelite	0.411	168.77 ± 5.66 [be]	175.18 ± 4.87 [acd]	171.17 ± 5.20 [b]	171.05 ± 7.11 [b]	172.36 ± 5.39 [a]
Regional	0.432	166.54 ± 5.55 [be]	171.86 ± 5.22 [ac]	167.14 ± 3.80 [b]	168.20 ± 4.27	171.83 ± 5.69 [a]
Body fat [%]	0.247	23.13 ± 3.63 [de]	23.95 ± 3.51 [e]	23.09 ± 3.38 [de]	25.02 ± 3.31 [ac]	25.54 ± 3.93 [abc]
Elite	0.346	21.87 ± 2.73 [de]	22.16 ± 3.46 [d]	22.65 ± 3.13	24.92 ± 3.00 [ab]	24.25 ± 3.42 [a]
Subelite	0.237	23.75 ± 3.70 [e]	24.51 ± 3.02	23.49 ± 3.39 [e]	25.00 ± 3.02	25.97 ± 3.57 [ac]
Regional	0.802	23.31 ± 4.12 [e]	24.64 ± 3.91 [e]	22.92 ± 3.87	25.19 ± 4.13 [e]	26.76 ± 5.48 [abd]
Body weight [kg]	0.440	62.80 ± 7.12 [bcde]	71.67 ± 9.00 [ac]	66.82 ± 6.97 [abde]	70.71 ± 8.64 [ac]	74.28 ± 12.18 [ac]
Elite	0.528	63.03 ± 7.21 [bcde]	72.53 ± 7.18 [a]	68.91 ± 7.30 [a]	74.08 ± 6.56 [a]	73.12 ± 6.65 [a]
Subelite	0.424	63.31 ± 7.27 [bde]	71.36 ± 8.92 [ac]	65.83 ± 6.61 [be]	68.46 ± 7.15 [ae]	74.21 ± 12.57 [acd]
Regional	0.459	61.10 ± 6.53 [bde]	71.43 ± 11.05 [a]	64.63 ± 6.39	71.68 ± 11.84 [a]	77.27 ± 19.65 [a]
Age [a]	0.161	23.63 ± 5.80 [de]	23.72 ± 6.59	25.04 ± 6.96	26.18 ± 7.33 [a]	26.08 ± 7.45 [a]
Elite	0.298	21.49 ± 3.81	20.90 ± 3.67 [c]	24.24 ± 6.08 [b]	24.04 ± 4.98	23.79 ± 4.69
Hope for success	.	34.48 ± 5.32	33.11 ± 6.25	33.34 ± 5.66	33.60 ± 6.56	32.90 ± 7.32
Elite	.	35.64 ± 4.99	33.95 ± 5.41	34.21 ± 6.81	33.50 ± 7.75	33.63 ± 6.64
Fear of Failure	.	10.85 ± 7.43	11.86 ± 8.01	10.15 ± 6.65	9.98 ± 7.46	11.37 ± 9.29
Elite	.	12.48 ± 7.92	12.15 ± 7.28	8.88 ± 6.47	9.42 ± 7.16	10.26 ± 5.98
Subelite	0.610*	8.44 ± 7.58	9.58 ± 5.36 [e]	10.30 ± 5.17 [e*]	10.56 ± 8.49	23.33 ± 17.04 [bc*]
Regional	.	8.65 ± 5.99 [e]	18.33 ± 7.34	9.25 ± 4.57	13.33 ± 5.51	1.00 ± 0.00 [a]
Net Hope	.	23.56 ± 10.78	21.25 ± 12.13	23.20 ± 10.38	23.73 ± 11.50	21.99 ± 3.92
Elite	.	23.28 ± 11.23	21.80 ± 11.09	25.36 ± 11.86	24.08 ± 13.31	24.78 ± 9.55
Regional	0.470	27.12 ± 7.70 [e]	22.58 ± 10.18 [e]	23.20 ± 8.39 [e*]	22.00 ± 9.54	4.66 ± 14.74 [ab*c*]
Total Achievement Motive	.	45.12 ± 7.06	44.92 ± 7.57	43.51 ± 6.67	43.37 ± 7.35	44.30 ± 9.15
Elite	0.285	47.89 ± 6.47 [cd*]	46.10 ± 6.45	43.12 ± 5.88 [a]	42.92 ± 6.74 [a*]	44.54 ± 7.70
Self-optimization	.	61.71 ± 10.58	69.52 ± 11.09	61.59 ± 12.13	61.19 ± 12.19	59.88 ± 11.80
Elite	.	63.87 ± 9.53	60.24 ± 10.89	64.91 ± 13.34	59.13 ± 15.23	61.19 ± 1.41
Self-impediment	.	11.23 ± 4.34	11.85 ± 5.09	10.90 ± 4.29	10.53 ± 4.52	10.88 ± 5.11
Elite	.	12.70 ± 4.69	12.85 ± 4.65	10.72 ± 4.33	12.13 ± 3.85	11.59 ± 4.50
Subelite	0.415	10.41 ± 3.74	13.25 ± 5.43 [c*e]	7.71 ± 2.56 [b]	9.82 ± 3.66	8.46 ± 4.14 [b]
Lack of activation	0.145	8.36 ± 5.44 [e]	10.08 ± 6.18	9.36 ± 6.55	8.68 ± 6.59	10.93 ± 7.07 [a]
Elite	.	7.06 ± 5.20	10.32 ± 6.56	8.78 ± 6.64	10.04 ± 8.50	9.42 ± 5.58
Regional	0.381	10.11 ± 6.13 [e]	11.33 ± 6.57 [e]	9.13 ± 5.55 [e]	9.63 ± 5.07 [e]	18.58 ± 9.66 [abcd]
Loss of focus	.	5.12 ± 4.02	5.65 ± 4.64	4.80 ± 4.78	4.38 ± 3.58	5.22 ± 3.95
Elite	.	4.45 ± 3.79	5.76 ± 4.93	3.81 ± 4.40	5.00 ± 3.68	4.15 ± 2.96
ASO after malperformance	.	5.28 ± 3.01	5.31 ± 3.16	4.95 ± 2.87	4.98 ± 2.76	5.94 ± 3.18
Elite	0.277	4.03 ± 2.88	4.27 ± 3.07	5.58 ± 3.20	3.73 ± 2.74	6.05 ± 3.10
Subelite	0.496	5.29 ± 3.65	4.41 ± 2.57 [e]	4.86 ± 1.95	3.33 ± 3.23 [e]	7.69 ± 2.46 [bd]
Regional	0.409	5.92 ± 3.57	5.90 ± 2.02	2.40 ± 3.78 [e]	4.71 ± 2.98	8.80 ± 3.03 [c]
ASO when planning task	.	6.99 ± 2.57	6.59 ± 2.53	6.62 ± 2.32	6.83 ± 2.32	6.56 ± 2.79
Elite	.	6.96 ± 2.49	6.59 ± 2.77	7.12 ± 2.32	6.83 ± 2.53	6.63 ± 2.50
ASO when performing	0.122*	9.06 ± 1.95 [b]	8.45 ± 2.52 [a]	8.79 ± 2.22	9.01 ± 2.07	8.44 ± 2.44
Elite	0.381	9.09 ± 2.02	7.79 ± 2.35 [d]	9.26 ± 1.73	10.43 ± 1.16 [b]	8.72 ± 2.30

*by trend; ** Only levels with differences to goalkeepers are shown in full detail, if no differences occurred, only global and elite level are shown.

[a] significant difference to wing players [b] significant difference to half backs [c] significant difference to centre backs [d] significant difference to pivots [e] significant difference to goalkeepers.

Table 3

Descriptive statistics for conditional, technical and tactical factors (Mean ± SD) and differences per competition level (Oneway ANOVA / Scheffé post hoc), only factors with significant differences to a field position are shown.

Factors **	Effect η	Wingplayers (n = 197)	Half backs (n = 170)	Centre backs (n = 102)	Pivots (n = 92)	Goalkeepers (n = 91)
Half Cooper Test [m]	0.207	1184 ± 135 [e]	1177 ± 129 [e]	1207 ± 111 [e]	1164 ± 141	1109 ± 149 [abc]
Elite	0.324	1288 ± 87 [e]	1265 ± 108 [e]	1267 ± 95 [e]	1230 ± 113	1184 ± 120 [abc]
Subelite	0.210	1174 ± 106	1183 ± 114 [e]	1189 ± 107 [e]	1167 ± 125	1113 ± 103 [bc]
Regional	0.341	1078 ± 146 [e]	1073 ± 104 [e]	1130 ± 92 [e]	1083 ± 157 [e]	933 ± 177 [abcd]
Situps	.	33 ± 19	33 ± 21	32 ± 20	30 ± 16	31 ± 21
Elite	.	45 ± 18	46 ± 24	38 ± 22	39 ± 16	42 ± 25
Chin-ups	0.224	16 ± 7 [e]	15 ± 7 [e]	17 ± 7 [e]	14 ± 7	12 ± 6 [abc]
Elite	0.298	20 ± 6 [e]	19 ± 9	19 ± 7 [e]	16 ± 6	14 ± 6 [ac]
Subelite	0.228	15 ± 7 [e]	13 ± 6	16 ± 6 [e]	14 ± 6	12 ± 6 [ac]
Throwing speed [km/h]	0.253	58 ± 7 [b]	61 ± 8 [ade]	60 ± 6	57 ± 7 [b]	57 ± 7 [b]
Elite	0.445	63 ± 6 [b]	69 ± 6 [acde]	64 ± 5 [b]	62 ± 5 [b]	61 ± 6 [b]
Subelite	0.268	57 ± 6 [b]	60 ± 7 [ae]	60 ± 6	58 ± 6	55 ± 6 [b]
Reaction-distance [m]	.	0.82 ± 0.15	0.80 ± 0.16	0.78 ± 0.15	0.80 ± 0.17	0.82 ± 0.16
Elite	.	0.75 ± 0.14	0.75 ± 0.19	0.71 ± 0.12	0.76 ± 0.16	0.78 ± 0.17
Jump & Reach [m]	0.205	0.43 ± 0.06	0.45 ± 0.07	0.44 ± 0.06	0.42 ± 0.06	0.42 ± 0.07
Elite	0.217*	0.45 ± 0.06	0.47 ± 0.06 [de]	0.43 ± 0.07	0.43 ± 0.07 [b]	0.43 ± 0.08 [b]
Subelite	0.241	0.43 ± 0.06	0.46 ± 0.06 [e]	0.45 ± 0.06	0.42 ± 0.05	0.41 ± 0.07 [b]
Stand & Reach [m]	0.126	0.06 ± 0.01	0.06 ± 0.01	0.09 ± 0.01	0.08 ± 0.01	0.09 ± 0.01
Elite	0.795*	0.07 ± 0.10	0.07 ± 0.09	0.10 ± 0.07	0.07 ± 0.10	0.09 ± 0.07
20m Minimum of 5 [s]	0.277	3.60 ± 0.25 [de]	3.62 ± 0.24 [de]	3.61 ± 0.22 [e]	3.73 ± 0.29 [ab]	3.82 ± 0.39 [abc]
Elite	0.293	3.44 ± 0.24 [e]	3.44 ± 0.21 [e]	3.51 ± 0.15	3.57 ± 0.31	3.62 ± 0.28 [ab]
Subelite	0.365	3.63 ± 0.22 [e]	3.62 ± 0.19 [e]	3.63 ± 0.22 [e]	3.74 ± 0.19	3.85 ± 0.25 [abc]
Regional	0.422	3.76 ± 0.23 [e]	3.79 ± 0.22 [e]	3.76 ± 0.24 [e]	3.90 ± 0.32 [e]	4.29 ± 0.73 [abcd]
20m Mean of 5 [s]	0.274	3.72 ± 0.27 [e]	3.73 ± 0.26 [e]	3.73 ± 0.25 [e]	3.83 ± 0.29	3.96 ± 0.41 [abc]
Elite	0.359	3.49 ± 0.17 [e]	3.51 ± 0.21 [e]	3.59 ± 0.16	3.61 ± 0.26	3.72 ± 0.26 [ab]
Subelite	0.348	3.75 ± 0.23 [e]	374 ± 0.21 [e]	3.77 ± 0.26 [e]	3.87 ± 0.22	3.98 ± 0.26 [abc]
Regional	0.448	3.92 ± 0.27 [e]	3.94 ± 0.23 [e]	3.90 ± 0.26 [e]	4.00 ± 0.30 [e]	4.51 ± 0.73 [abcd]
30m Minimum of 2 [s]	0.141	5.03 ± 0.39	5.09 ± 0.44	5.15 ± 0.42	5.14 ± 0.41	4.98 ± 0.30
Elite	0.459	4.83 ± 0.24 [bcd]	5.24 ± 0.36 [ae]	4.92 ± 0.21 [ae]	5.06 ± 0.37 [a]	4.87 ± 0.22 [bc]
Subelite	0.473	5.05 ± 0.31 [b]	5.00 ± 0.52 [acde]	5.07 ± 0.30 [b]	5.10 ± 0.34 [b]	5.05 ± 0.29 [b]
30m Mean of 2 [s]	0.293	5.03 ± 0.33 [e]	5.07 ± 0.40 [e]	5.02 ± 0.29 [e]	5.20 ± 0.43	5.38 ± 0.54 [abc]
Elite	0.338	4.82 ± 0.20 [e]	4.83 ± 0.25 [e]	5.09 ± 0.33	4.98 ± 0.39	5.07 ± 0.31 [ab]
Subelite	0.389	5.09 ± 0.32 [e]	5.07 ± 0.27 [e]	5.012 ± 0.55 [e]	5.20 ± 0.33 [e]	5.43 ± 0.37 [abcd]
Regional	0.455	5.23 ± 0.33 [e]	5.43 ± 0.57 [e]	5.19 ± 0.38 [e]	5.52 ± 0.48	6.17 ± 0.99 [abc]
Wall-passing [s]	0.179	26.51 ± 2.69	26.20 ± 2.49 [e]	25.80 ± 2.34 [e]	26.52 ± 2.60	27.41 ± 3.01 [b c]
Elite	0.214*	24.84 ± 1.85	24.55 ± 2.09	24.88 ± 2.21	24.97 ± 1.63	25.94 ± 2.41
Regional	0.326	29.10 ± 3.02	27.89 ± 2.72 [e]	27.55 ± 2.36 [e]	28.51 ± 3.18	31.04 ± 2.93 [b c]
Slalom-dribbling [s]	0.261	7.60 ± 0.56 [e]	7.56 ± 0.48 [e]	7.46 ± 0.42 [e]	7.79 ± 0.73	7.95 ± 0.71 [a b c]
Elite	0.366	7.16 ± 0.30 [e]	7.20 ± 0.33 [e]	7.23 ± 0.31 [e]	7.46 ± 0.71	7.56 ± 0.41 [a b c]
Subelite	0.361	7.66 ± 0.48 [e]	7.56 ± 0.39 [e]	7.45 ± 0.35 [e]	7.71 ± 0.34	7.99 ± 0.52 [a b c]
Regional	0.367	8.06 ± 0.56	8.00 ± 0.44 [e]	8.06 ± 0.28	8.06 ± 0.56 [e]	8.89 ± 1.24 [b d]
Tactics	.	47.72 ± 8.87	47.97 ± 9.68	49.65 ± 8.99	46.46 ± 9.34	46.99 ± 9.84
Elite	.	50.74 ± 8.57	53.46 ± 7.50	51.61 ± 9.54	50.20 ± 6.86	49.32 ± 9.16

*by trend; ** Only levels with differences to goalkeepers are shown in full detail, if no differences occurred, only global and elite level are shown.

[a] significant difference to wing players [b] significant difference to half backs [c] significant difference to centre backs [d] significant difference to pivots [e] significant difference to goalkeepers.

Table 4

*Test for performance **relevance/separation** between leagues (Oneway ANOVA), test for **correlation** between performance and **team expertise,** test for correlation between specialization and **team expertise** (strongest correlation levels out of Pearson coefficient, Spearman's rho, Kendall's tau b), descriptive statistics at elite level (Mean ± SD) and **model values** for goalkeepers in 3rd league (Calculated value ± Estimated error).*

	Separation between leagues (Effect-size η)	Correlation level performance	Correlation level specialization	Values elite level (descriptive statistics)	Model goalkeeper 3rd league (linear regression)
Half Cooper Test	0.717	0.477	- 0.479	1184 ± 102	1193 ± 122
Situps	0.490	0.413	- 0.448	42 ± 25	38 ± 20
Chin-ups	0.259*	.	.	14 ± 6	13 ± 6
Throwing-speed	0.647	0.551	- 0.549	61 ± 6	60 ± 6
20m Minimum out of 5 [s]	0.705	- 0.332	- 0.332	3.62 ± 0.28	3.67 ± 0.34
20m average out of 5 [s]	0.740	- 0.365	- 0.365	3.72 ± 0.26	3.78 ± 0.34
30m Minimum out of 2 [s]	0.517	- 0.254	0.254	4.87 ± 0.22	4.92 ± 0.29
30m average out of 2 [s]	0.738	- 0.435	- 0.435	5.07 ± 0.31	5.13 ± 0.43
Jump & Reach [m]	.	0.198*	- 0.382	0.43 ± 0.08	0.43 ± 0.08
Stand & Reach [m]	.	.	.	0.09 ± 0.07	0.09 ± 0.07 ** ***
Reaction-distance [m]	0.327	- 0.264	- 0.274	0.78 ± 0.17	0.78 ± 0.16
Body height [m]	0.107	0.301	0.306	1.76 ± 0.06	1.76 ± 0.03
Body-fat percentage [%]	0.302	.	.	24.25 ± 3.42	24.41 ± 1.93
Body weight [kg]	0.519	.	.	73.12 ± 6.65	72.79 ± 6.10***
Age [a]	0.324	- 0.259	- 0.287	23.79 ± 4.69	22.86 ± 3.47
Wall-passing [s]	0.560	- 0.547	- 0.546	25.94 ± 2.41	25.50 ± 2.58
Slalom-dribbling [s}	0.761	- 0.530	- 0.530	7.58 ± 0.41	7.50 ± 0.62
Tactics-Test	0.547	0.309	- 0.319	49.32 ± 9.16	50.67 ± 9.41
Hope for success	0.336	0.213*	- 0.219	33.63 ± 6.64	34.65 ± 7.22
Fear of failure	.	.	.	10.26 ± 5.98	10.01 ± 9.28**
Net hope	0.362	0.232	- 0.245	24.78 ± 9.55	25.81 ±13.65
Total achievement motive	.	.	.	44.54 ± 7.70	45.09 ± 9.18** ***
Self-optimization	.	.	- 0.185*	61.19 ± 10.41	62.20 ± 11.71
Self-impediment	0.522	0.162	- 0.225	11.59 ± 4.50	11.64 ± 5.11**
Lack of activation	0.455	- 0.276	- 0.294	9.42 ± 5.58	7.88 ± 6.67
Loss of focus	0.354	.	- 0.196*	4.15 ± 2.95	4.04 ± 3.85
ASO after malperformance	.	- 0.325	- 0.320	6.04 ± 2.79	5.55 ± 3.19** ***
ASO while planning a task	.	.	.	6.63 ± 2.50	6.87 ± 2.79** ***
ASO while performing a task	0.474	.	.	8.56 ± 2.36	8.92 ± 2.42

ASO = ***Action /state orientation.***

* by trend; ** p-value not sufficient; *** effect not sufficient.

. no significant results.

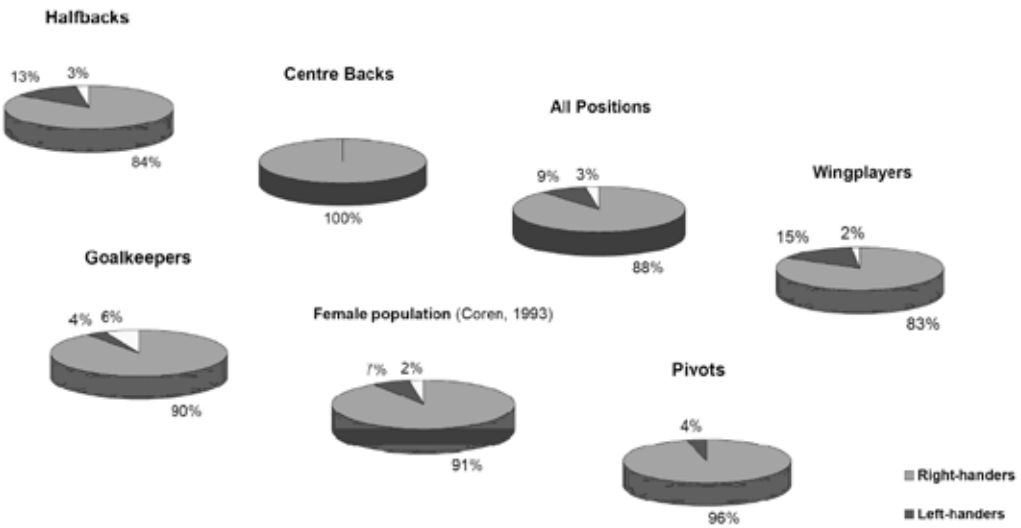
Reliability is given with ***confidence-interval*** 0.95 (Rinne, 2008).

The Oneway ANOVA separated significantly or at least by trend between performance levels for all the tested performance factors except for jump & reach, stand & reach, fear of failure, total achievement motive, self-optimization and action/state orientation after malperformance and when planning a task (Table 4).

There are strong, significant correlations between performance and expertise for throwing speed, wall passing and Slalom dribbling. Furthermore, there were moderate correlations between the two for the Half Cooper test, sit-ups, 20m sprint (fastest out of two attempts and the mean time of five runs), 30m sprint (mean out of two runs), body height, tactics skill and action control after malperformance. Finally, there were weak correlations between the two for 30m sprint (fastest time out of two), jump & reach (by trend), reaction distance, age, net hope, self-impediment and lack of activation.

The direction of the correlations should be noted, especially for self-impediment (Table 4). When considering specialization of the goalkeeper position, there are different directions for the correlations between specialization and expertise for each factor (Table 4). There were factors without correlations between specialization and expertise (Chin-ups, stand & reach, body height, body fat percentage, fear of failure, total achievement motive and action/state orientation when planning and performing a task), factors with positive correlations between specialization and expertise (30m fastest time and body height) and factors with negative correlations between specialization and expertise (all other factors, see Table 4).

All the factors, except for stand & reach, body weight, fear of failure, total achievement motive, self-impediment and action/state orientation after malperformance and while planning a task, had significant model values with sufficient effect sizes that could be calculated for German 3rd league goalkeepers (Table 4).



(Confidence interval 0.95 with d_max ± 2.15 %)

WP = Wingplayers, HB = Half Backs, CB = Centre Backs, P = Pivots, GK = Goalkeepers

Figure 1: Percentages of handedness on different positions and in female population.

Goalkeepers differ from both field position players and the female population regarding handedness (Figure 1). The percentage of right-handers in a league correlates negatively with expertise (-0.993) while being ambidextrous correlates positively with expertise (0.858) for goalkeepers.

DISCUSSION AND CONCLUSION

As delineated above, goalkeepers show a significant negative difference from field players over a wide range of factors. These represent deficits in goalkeeper fitness and coaching of psychological factors in all sectors except tactics. With negative correlations for specialization and expertise (Table 4), the assumption must be made that there are training deficits in comparison to the field players or simply no demand for several performance factors in goal. Goalkeepers match or exceed some field positions only in body height (which must be considered an advantage in play) and fastest 30m sprint out of two attempts (conflicting with the results of Ignat'eva et al., 2002; Table 2, 3). Both this study and previous research (Ignat'eva et al., 2002; Zapartidis et al., 20011) found goalkeepers are less physically fit than field players for most factors.

The factors for which the Oneway ANOVA separated significantly or at least by trend between performance levels (see results) must be considered at least slightly relevant to the goalkeeper position. However, some of the effects occur only by trend or have a relatively low effect size. The only strong significant effects recorded were for chin ups, stand & reach, body weight, body fat percentage, total achievement motive, fear of failure, self-optimization, loss of focus and action/state orientation when planning and performing a task (Table 4). Strong correlations can therefore only be found for technical factors and throwing speed. Consequently, the study suggests that several performance factors are of only moderate relevance for goalkeepers (Table 4).

When considering specialization for the goalkeeper position, specialization and expertise arise for the different factors, as reported in the results (Table 4). No correlation means that goalkeepers are not a homogenous group, which leads to doubts about the importance of those factors for the goalkeeper position. Positive correlations suggest the need for specialization. Negative correlations suggest the necessity of adjusting to meet the performance of the field positions for the concerned factors. As the factors that correlate negatively with specialization also correlate positively with expertise and differ significantly between leagues, this means that goalkeepers do not match the performance of the players on field positions (Table 2, 3).

Altogether the findings shown in table 4 suggest that goalkeeper core demands differ from those of field players across the leagues. However, considering the negative specializations in top teams with an EI of 7 or higher (Table 4), goalkeepers should evince a basic fitness and adapt to the level of their teammates to ensure a homogeneous group and adequate performance.

For several factors, significant model values with sufficient effect sizes could be calculated for players in German 3rd league players (Table 4). Therefore, the concerned factors might be relevant when wanting to play at elite level.

Goalkeepers did not achieve high values and only had a correlation by trend with expertise for the jump & reach test. Perhaps the rate at which force is developed when jumping is the relevant factor in goal and not the player's actual jumping height (as assumed by Pori et al., 2011).

Both coaches and the literature delineate flexibility as a core demand for all positions but especially for goalkeepers. However, to our knowledge this has not yet been confirmed by a research

study (Pori, Šibila, Justin, Kajtna & Pori, 2012; Rogulj et al., 2005). It must be said that results for stand & reach correlate with reaching height as measured for the jump & reach test and body height. At the subelite level, goalkeepers and centre backs are more flexible than players of other positions. This is congruent with the results of Zapartidis et al. (2011). The special status of goalkeepers in terms of flexibility as postulated by Rogulj et al. (2005) could therefore only be partially confirmed. This could possibly be caused by insufficient work with goalkeepers during training (as assumed by Zapartidis et al., 2009 a) or differences in static and dynamic flexibility. Also, a connection between flexibility and elasticity/springiness seems likely.

Literature considers goalkeepers to be relatively heavy (Šibila et al., 2008). Urban and Kandáč (2011) found the heaviest female European Championship players to be pivots, followed by goalkeepers. Šibila, Pori and Imperl (2008) assumed goalkeepers had a higher body weight than some field positions. In the present study, goalkeepers were heavier than field players at low performance levels. Urban and Kandráč (2011, female European Championship players) found that pivots had the highest percentage of body fat followed by goalkeepers, centre backs, half backs and line players (in that order). In the present study, goalkeepers also displayed the second highest percentage of body fat after pivots. It seems to be necessary to avoid obesity in female goalkeepers in lower leagues. This is seen in the negative correlation between specialization and expertise. Goalkeeper selection during youth training is in some cases a result of high body weight (obesity), greater body height and inadequate motor ability of the "chosen" child, but is rarely caused by a child volunteering (Šibila, Pori & Imperl, 2008). The results of the current study also hint that players with training deficits are placed in goal to keep them and their constitutional, tactical, technical and conditional deficits out of the attack (Matthys, 2012). Differences between field players and goalkeepers in psychological aspects might be the result of the above-mentioned mechanisms. Goalkeepers might be de-motivated by these "selection" mechanisms. A more careful selection process as well as more attention and coaching is needed to improve this process.

Literature describes goalkeepers as tall (Čavala et al., 2013; Milanese et al., 2011; Zapartidis et al., 2009 a, b). Urban and Kandráč (2011) found female elite half back players to be the tallest, followed by goalkeepers. In the current study, goalkeepers displayed values above the average of all positions in the top teams and should perhaps be specialized in regards to body height.

It has been found that successful male goalkeepers spend less time thinking about failures than less successful goalkeepers (Kajtna et al., 2011). This can also be confirmed for female players, since action/state orientation after malperfomance correlates negatively with expertise.

In the present study, no relation can be found between reaction distance and expertise for goalkeepers, who had the slowest values of all the positions. It is possible that goalkeepers were unable to produce quick accelerations on the way to the measuring point in the reaction test. Less successful goalkeepers display faster reaction times, better reaction to simple stimuli and respond faster to simple visual stimuli (Kajtna et al., 2011). Thus, anticipation might be more important than reaction-speed (Schorer, 2007). When coaches demand expertise in the goal, anticipation expertise might be what is meant (Schorer, 2007). Goalkeepers were older than field players in the present study. In the top teams the average age for each of the field positions ranges between 20 and 27 years. Goalkeepers were aged up to 32 years in Bundesliga 1 to 3 and between 22 and 30 years in the top teams.

Ignat'eva et al. (2002) have found that female adult goalkeepers are conditionally weaker than field players. Some of the conditional and technical differences are only prevalent in the lower leagues and therefore might not be desired, since at the elite level there are goalkeepers who do match the field players` performance for those factors. This can also be seen in the correlation between specialization and expertise. The psychological demands for goalkeepers are not clear yet either (Kajtna et al., 2011). Recent test batteries have found contradictory or but few significant results and have therefore probably only identified a few of the core demands for goalkeepers (Kajtna et al., 2011; Pori, Sibila, Justin, Kajtna & Pori, 2012). Zapartidis et al. (2009 b) found that there was no significant difference between goalkeepers chosen for the national team and those not chosen.

Many of the tested factors are not crucially relevant for goalkeepers. A tangible demands profile is either nonexistent or very narrow. The demands of the goalkeeper position need to be tested using a test battery that takes position specific goalkeeper demands into account, as already suggested by Kajtna et al. (2011). Only a few core demands can be identified (Table 4), such as reactive force (considering present results together with the statement of Pori et al., 2011), experience ("anticipation expertise", Schorer, 2007), ambidexterity, low action/state orientation after malperformance, throwing speed and 30m sprint (fastest time out of two). To a certain extent, technical factors (passing, catching and dribbling) as well as sprints over 20 and 30m are also relevant, as are other factors linked to basic fitness (e. g., Half Cooper, reaction distance, sit-ups) and constitutional factors such as body height, age and tactical ability. Hope for success, net hope, self-impediment and lack of activation are also of minor importance. However, there may also be other as yet unidentified factors.

Positioning tall players in goal solely due to their body height is not recommended, as important field techniques cannot be easily acquired later (Matthys, 2012), making a possibly advantageous change of position almost impossible later in a player's career. Constitutional factors especially do not seem to be entirely adequate as a selection criterion during position-specific selection (Gonçalves et al., 2012 and Moesch, Hauge, Wikman & Elbe, 2013, both preferring psychological factors; Matthys, 2012; Visnapuu & Jürimäe, 2009: only sitting height correlates with motor parameters; Zapartidis et al., 2009 b). However, some authors see them as important predicators (Čavala et al., 2013).

Position-specific selection and training are related to performance and must be carried out under consideration of gender and specialization age. Position-specific selection should not be too heavily based on constitutional parameters below senior level (see also Matthys, 2012). The development of handball-relevant psychological factors during puberty has to be researched in order to determine whether they could be a better predicator for excellence in team handball than constitutional or conditional factors, especially for female handball goalkeepers. Psychological factors might play a role in talent selection, as biological factors have disadvantages when used as predicators.

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