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Prognostic validity of talent orientation in soccer

Introduction

In long-term talent development programs, early talent orientation includes diagnostic talent screening measures as well as sports recommendation; these are the first steps of talent identification. According to Pion (2015, 2017), talent orientation is related to early talent detection in still-heterogeneous samples and "aims at motivating youngsters to choose a sport that matches the individual talent characteristics" (Pion, 2015, p. 22). Some sports require early talent orientation, given the very young age of athletes at the highest level (Papic, Rogulj, & Plestina, 2009). Following this idea, several talent screening programs in elementary schools have implemented motor diagnostics (e.g., Stemper, Bachmann, Diehlmann, & Kemper, 2009; Pion, 2015; Fuchslocher, Romann, Rüdisüli, Birrer, & Hollenstein, 2011; Golle, Muehlbauer, Wick, & Granacher, 2015) to orientate children into groups of sports; these could be either game sports, such as soccer (Pion, 2015) or specific sports, such as alpine skiing (Mueller, Mueller, Kornexl, & Raschner, 2015). The more accurately recommended sport that best suits the individual's talent make-up, the greater the chances become that a beginner will achieve success and satisfaction within his or her chosen sport. Furthermore, early talent orientation leads to a higher overall quality of the talent pool preparing for the second step: talent selection (Hohmann & Seidel, 2003). On one hand, early talent screening and sports orientation could promote fairness in the uneven race between competing sport federations for the diminishing numbers of talented sport beginners; the most professional sports, like soccer and tennis, attract the majority of children, while less popular sports receive candidates from the pool of remaining beginners. On the other hand, those children selecting popular sports—although their motor competence profile suits another discipline much more closely—might sacrifice important learning time necessary for developing the specific technical skills of their best-fitting sport. This not only limits their chances of reaching their individual performance potential, but also hinders children's opportunity to "exploit their talents to the fullest" (Pion, 2017, p. 5).

In general, there is a lack of research that investigates the prognostic value of different performance prerequisites over the entire long-term period from child to adult training. Most research is concentrated on the middle stage of juvenile performance development, but even at the advanced stage of late adolescence some studies question juvenile success as an appropriate indicator for soccer success into adulthood (Guellich, 2014). With regard to the early part of this training stage between early and late adolescence, only a few studies (Höner & Votteler, 2016; Carling, Le Gall, & Malina, 2012; Le Gall, Carling, Williams, & Reilly, 2010) comprised a prognostic period of more than three years. Doing so, Höner and Votteler (2016; see also Höner et al., 2015, and Höner, Leyhr, & Kelava, 2017) reveal that, even on the homogeneous level of the German soccer competence centres, a soccer-specific test battery (Deutscher Fußball-Bund, 2009) provides prognostic, valid, and also practically worthwhile information about the 7.2 times greater odds of the fastest and technically best third of preselected players to reach the junior national team (U15).

In soccer, early talent orientation is of great relevance, as elite soccer demands high technical proficiency, and therefore requires an early start for systematic long-term athletic development (Hohmann & Pietzonka, 2017; Papic et al., 2009). In addition to that, early talent orientation along with soccer education beginning at the elementary school level give coaches a longer observation period, which thus reduces selection errors during early adolescence.

Although reliable and valid information about the future potential of talented players on the basis of motor abilities and technical skills diagnostics is a valuable tool in talent development programs for clubs and sport federations, several studies question the long-term predictability of future success (Lidor, Cote, & Hackfort, 2009; Pankhurst & Collins, 2013; Carling & Collins, 2014). The main reasons for scientific concerns are evident in the often-undifferentiated mixture of general as well as sport-specific tests in talent identification campaigns; these concerns are also apparent from the unsystematic timing of cross-sectional diagnostics at single points in time during the long-term athletic development process. It henceforth comes as no surprise that the great variety of study design parameters have led to inconsistent research results, providing an inconsistent picture with regard to the prognostic validity of motor tests as they address general motor abilities and sport-specific technical skills. Some studies verified the prognostic validity of motor tests (Höner & Votteler, 2016; Figueiredo, Gonçalves, Coelho, Silva, & Malina, 2009; Zuber, Zibung, & Conzelmann, 2016), whereas

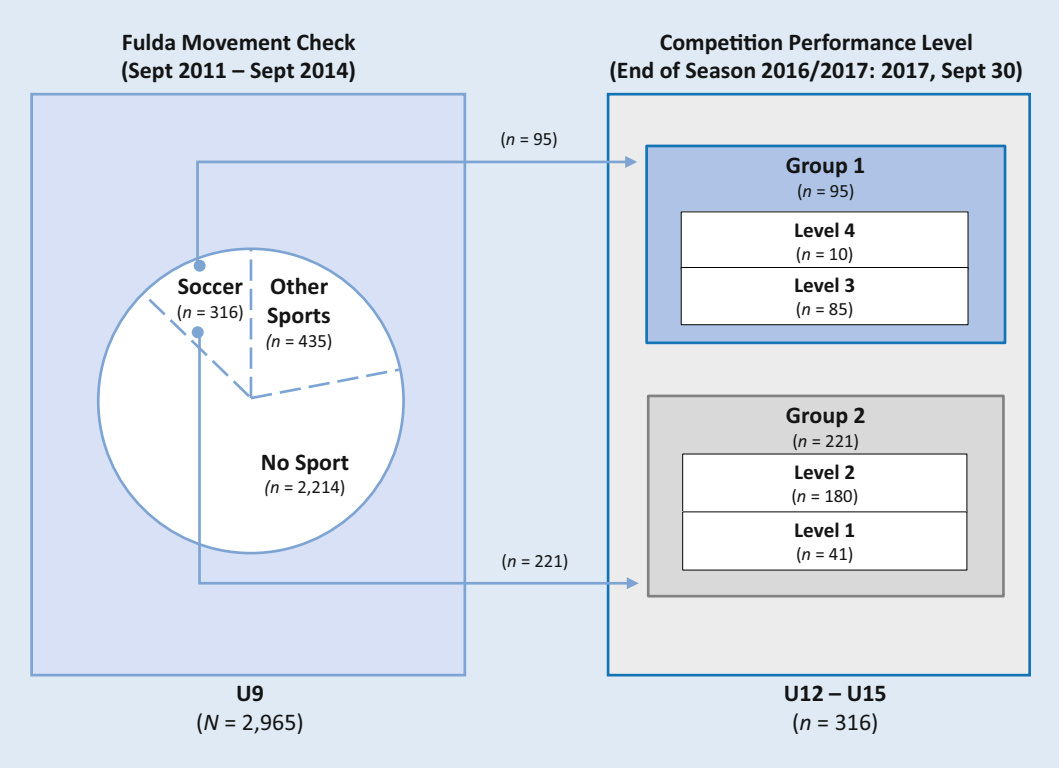

Fig. 1 ◄ Scheme of the different participants' groups of the Fulda Movement Check (2011–2014) included in this study (U9= under the age of 9 years)

others did not find significant associations between test results and later success at youth, junior, or adult soccer levels (Carling et al., 2012; Le Gall et al., 2010). Recent talent research in soccer by Höner and Votteler (2016) and Höner et al. (2017) has highlighted that a longitudinal investigation of motor predictors' prognostic relevance for long-term success is not only a key topic in talent research (Höner & Votteler, 2016; Gonaus & Mueller, 2012), but also an indispensable prerequisite for a sophisticated understanding of the changing prognostic validity of the various diagnostics at different stages of elite soccer players' long-term development.

The aim of this prospective cohort study was to evaluate the mid-term prognostic validity of general motor tests as well as that of a soccer-specific score calculated from a test battery. Therefore, the true players' success in soccer is compared with the tested performance prerequisites of young athletes as well as with the given recommendations. It was expected that children with better test results und a higher sport-specific test score in soccer would reach higher performance levels after a period of 2–6 six years. In addition, it raises the question of whether soccer players stand out in certain motor tests compared to athletes participating in other sports at the elementary school level.

Methods

General study design

According to the model of long-term talent development (see Hohmann, Fehr, & Voigt, 2015), the relevance of the predictors from the motor competence profile must be investigated in a stepwise fashion for at least three prognostic periods from the beginning of a talent development program until the full reach at the professional level. As talent development in soccer mostly starts in the U9 age group (U9= under the age of 9 years) and the elite adult level is reached at age 21, the long-term perspective should cover at least 12 years. This perspective also corresponds to the average time span of 15 years that is necessary for a player to potentially reach soccer excellence (Leite, Baker, & Sampaio, 2009).

In this study, a prognosis was calculated from the beginning of soccer training at the age of 8 years (generally second grade at the elementary level) over a middle-term time span of 2–6 years. Furthermore, this study reveals statistics regarding general anthropometric, physical, and physiological abilities. Therefore, the predictive validity of the anthropometric variables was investigated, which include body height and weight, the eight general tests of the German Motor Test (GMT) 6–18 (Boes & Schlenker, 2016), and an additional ball throw (ball weight: 80 g).

These diagnostics were administered in the FMC campaign. The FMC is a talent and health promotion campaign for children in the Fulda district (with a total of about 250,000 inhabitants), which was implemented in the year 2010 and comprises the second grade classes of all 40 elementary schools belonging to the Fulda district (Hohmann et al., 2015; Hohmann, Hohmann, Scheuring, & Zapp, 2016; see also Hohmann, Fehr, Siener, & Hochstein, 2017a; Hohmann, Fehr, Siener, & Hochstein, 2017b). For the ten most successful sport disciplines of the Fulda region (swimming, track and field, cross-country skiing, soccer, handball, water polo, tennis, table ten-

nis, judo, canoeing), a sport-specific recommendation score (SSRS) was calculated (Hohmann et al., 2015). At the end of the FMC, each participant received a diploma displaying his or her SSRS, which revealed and explained the sport disciplines that best suit each participant's individual talent make-up.

Participants

All individuals participated in motor diagnostics at the age of 7.89 ± 0.47 years during the particular time points of the respective FMC in the years 2011–2014. Regarding the current prospective cohort study, we investigated the data from $N = 2935$ male second grade school children with no more than one sample missing in the test battery. All study members participated in the FMC between the years 2011 to 2014 and were found to engage later on in soccer (soccer players: $n = 316$), other sports (other athletes: $n = 435$) or no sport at all (non-athletes: $n = 2214$) by the end of the sport season 2016/17 (September 30, 2017; **Fig. 1**).

University staff members and students conducted the motor tests. The performance development of the children in regard to the four cohorts (2011–2014) were recorded from the beginning of the season 2011/12 (October 1, 2011) through the end of the season 2016/17 (September 30, 2017) from the regional print, online media, (tournament and soccer match lists; www.torgranate.de) and the official DFB website (www.fussball.de; soccer team lists).

The U9 motor test results served as predictors for participants' later success in soccer at the early adolescent level with the U12 to U15 age group, which is between the minimum age of 11 years (U12) and the maximum age of 14 years and 11 months (U15). Due to the fact that the soccer player sample consisted of four successive cohorts, the prognostic period varied between 32 and 78 months with an average of $M = 55.4 \pm 9.4$ months.

Before entering the FMC, all children's parents provided written, informed consent for the recording and scientific use of the data collected for both the anthropometric and motor tests. The university's

Abstract · Zusammenfassung

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Abstract

Several talent-screening programs conducted within elementary schools have implemented motor diagnostics to introduce children to groups of sports including both game and specific sports, the latter of which includes gymnastics, skiing, and tennis. However, as in most other sports, the predictive value for soccer regarding such early testing is unclear. This prospective cohort study evaluated the mid-term prognostic validity of general motor tests as well as a soccer-specific score calculated from a test battery. The sample consisted of $N = 2965$ U9 age group of children from the Fulda Movement Check (FMC). The FMC is a basic check comprised of two anthropometric parameters and eight general items of the German Motor Test 6–18 by Boes and Schlenker with the addition of a ball throw. The test data were collected from the second grade classes of 2011–2014. The soccer competition performance of those children who chose soccer ($n = 316$) up to the end of the season 2016/17 (September 30, 2017) was recorded. This group of U12–U15 players was then assigned individually to four different competition levels. The prognostic validity of the motor tests was determined using analysis of variance, odds ratios, and a discriminant analysis. All diagnostic methods exhibited medium to high prognostic validity over the 2- to 6-year time span from the talent screening and talent orientation period to the later soccer competitions in the early adolescent U12–U15 age groups. The prognostic relevance of the nine general motor tests was confirmed.

Keywords

Talent · Talent screening · Sport orientation · Motor tests · Aptitude · Motor skills · Athletic performance · Soccer

Prognostische Validität der Talentorientierung im Fußball

Zusammenfassung

Üblicherweise nutzen Talentsuchprogramme, die im Grundschulalter durchgeführt werden, motorische Tests, um Kindern eine ihrem Eignungsprofil entsprechende Sportart zu zuzuweisen; darunter fallen beispielsweise Mannschaftssportarten oder Individualsportarten wie Turnen, Skilauf oder Tennis. Hierbei scheint allerdings der Erfolgswert dieser frühen Talentorientierung in den meisten Sportarten – so auch im Fußball – ungeklärt. In der vorliegenden prospektiven Kohortenstudie wurde die mittelfristige prognostische Validität allgemeiner motorischer Tests sowie eines, aus einer Testbatterie abgeleiteten, fußballspezifischen Testwertes untersucht. Die vorliegende Stichprobe besteht aus 2965 Kindern der Altersstufe U9 des Fuldaer Bewegungschecks. Beim Fuldaer Bewegungscheck handelt es sich um eine Testbatterie, bestehend aus zwei anthropometrischen Parametern und acht allgemeinen Bewegungsaufgaben des Deutschen Motorik-Tests 6–18, zusätzlich erweitert um einen Ballweitwurftest. Die Testdaten wurden in den Grundschulklassen der Jahre 2011–2014 erhoben. Für die Studie wurde nachfolgend die Wettkampfleitung zum Ende der Saison 2016/2017 (30. September) derjenigen Kinder betrachtet, die an der Testung teilnahmen und im Nachhinein die Sportart Fußball ausübten ($n = 316$). Diese Gruppe von Spielern der Altersstufe U12–U15 wurde dann individuell vier verschiedenen Wettbewerbsstufen zugeteilt. Die prognostische Validität des Motoriktests (Fuldaer Bewegungscheck) wurde anhand einer Varianzanalyse, Odds Ratios und einer Diskriminanzanalyse ermittelt. Alle diagnostischen Verfahren zeigten eine mittlere bis hohe prognostische Validität über die Zeitspanne von vier bis sechs Jahren – von der Talentsuche und Talentorientierungsphase bis zu späteren Fußballturnieren in der Altersgruppe der frühen Jugend (U12–U15). Die prognostische Relevanz der neun allgemeinen motorischen Tests wurde somit bestätigt.

Schlüsselwörter

Talent · Talentsuche · Motorische Tests · Begabung · Motorische Fertigkeiten · Sportliche Leistungsfähigkeit · Fußball

Table 1 The 4-level scale recording sport-specific participants' competition results of the Fulda Movement Check (FMC) taking part in official competitions for age groups U12 to U15 ($N = 316$)

4-level scale of U12 to U15 age group competition results		
Low soccer performance group ($N = 221$)		
Level 1	$N = 41$ (2 + 39)	Holder of an official club license in a specific sport or competition participation on the lowest local level ("Kreisklasse") at the age of U12 to U15
Level 2	$N = 180$	Competition participation at the district level ("Kreisliga") at the age of U12 to U15
High soccer performance group ($N = 95$)		
Level 3	$N = 85$	Competition participation at the county level ("Bezirksliga") at the age of U12 to U15
Level 4	$N = 10$ (8 + 2)	Competition participation at the regional level ("Verbandsliga", "Hessenliga") or national level ("Regionalliga", "Bundesliga") at the age of U12 and U15

ethics department approved the implementation of this study.

Measurements

Anthropometric characteristics and motor abilities

Aside from the motor tests of the FMC, each player's height, weight, and calendar age (measured by the month of birth within a calendar year) were registered. The motor test battery consisted of nine tests, of which one (20-m sprint) was negatively coded so that a lower value indicated a better performance. Players were tested according to the GMT 6–18 (Boes & Schlenker, 2016), including sprint[1], coordination[2], balance[3], flexibility[4], arm and upper body strength[5], leg power[6], and endurance[7]. All tests were executed according to the test description provided by Boes and Schlenker (2016). In addition to the GMT 6–18, a ball throw[8] was added to the FMC to contribute to judging talent for track and field as well as game sports like handball, water polo, volleyball, tennis etc. In the sit-up and push-up tests as well as in the 6-min run, only one trial was executed, whereas in the other tests two attempts were allowed. For these tests, the better result between the two trials was recorded except for the sideward jumping test, where the mean value of the two trials was recorded. Players were provided with sufficient time for recovery between each attempt.

Boes and Schlenker (2016) analyzed the test battery's psychometric properties for a sample consisting of nearly 50,000 school children and adolescents. The authors found good internal consistencies in terms of an average test-retest correlation coefficient of $r_{tt} = 0.82$ at the elementary school level (7–11 years), ranging from $r_{tt} = 0.52$ for balancing backward to $r_{tt} = 0.94$ for bending forward. The ball throw that was added in the FMC showed test–retest reliability of $r_{tt} = 0.82$ ($p < 0.001$; $n = 3193$) up until the end of 2015.

For the evaluation of motor predictors' prognostic validity, the age influence on the test performances should be considered (Höner et al., 2017; e.g., Meylan, Cronin, Oliver, & Hughes, 2010; Höner & Votteler, 2016; Carling & Collins, 2014). Univariate ANOVAs (analysis of variance) were conducted to check the data set for significant differences between youth athletes in regard to calendar age. As age was growing with the birth quartiles ($F(3; 3186) = 7.61$, $p < 0.05$), the calendar age (in months) was partialized out of these results through all predictors by bivariate regression analysis to avoid confounding effects in the following analysis (Willimczik, 1982; Hohmann et al., 2015; Hohmann et al., 2017a, 2017b). In the bivariate regression analysis, the test results served as dependent, and the age (in months) as independent variables (Willimczik, 1982). To allow for comparisons between the different predictors, the residuals of the bivariate regression were standardized by z-values. In all procedures, data were analyzed using SPSS version 25.0 (IBM Corp., Chicago, IL, USA), and the minimum level of significance was set at $p < 0.05$.

Aside from the single motor tests, the prognostic validity of a soccer-specific total score was derived from the general test battery being evaluated. Therefore, the mean value of a selection of only five of the general tests was calculated. Each of these five tests was hierarchically weighted by a weight factor (WF) between 1.2 and 2.0 according to their estimated validity for soccer performance. Thus, the 20-m sprint (WF 2.0), sideward jump (WF 1.8), 6-min run (WF 1.6), standing long jump (WF 1.4), and sit-up tests (WF 1.2) were used because they had proved, in a previous study, to be more soccer-related than the other four tests (see Hohmann et al., 2015). Based on this weighting, the soccer recommendation score (SRS) was calculated.

Level of sport-specific competition

The competition performance level (CPL; **Table 1**) reached by soccer players as well as by athletes of all other sports until the end of the season 2016/17 was utilized to quantify all athletes' success in early adolescence as a criterion variable. In all sports, athletes who participated in the U9 motor diagnostics, participated at minimum in one official sport-specific competition until the end of the season 2016/17, or at least held an official club license without taking part in competitions (level 1), were recorded. Based on their success in single as well as team competition events, the results reached in these competitions were ranked from level 2 up to level 4 if the athlete was playing on the national level. The performance levels for game sport athletes, however, are difficult to judge (Höner & Votteler, 2016; Go-

[1] Time for a 20 m linear running sprint; measurement by means of light gates (Brower Timing Systems; Draper, UT, USA); error correction of timing was 0.26 s; starting position was 0.3 m behind the start line.

[2] 15-s sideward jumping.

[3] 3 × 2 trials stepping backward on a 3.0, 4.5 and 6.0 cm wide beam.

[4] Bend forward.

[5] Timed push-ups and sit-ups with number of repetitions within 40 s.

[6] Standing long jump.

[7] 6-min run around a volleyball pitch.

[8] Ball weight: 80 g; both feet on ground behind a line; no step or run-up; measurement perpendicular to measuring tape; accuracy: 0.1 m.

Table 2 Descriptive statistics for the two anthropometric and nine motor diagnostics of second-grade students taking part in the Fulda Movement Check (FMC) 2011–2014 and playing soccer later on in age groups U12 to U15 until the end of season 2016/17

Variables	Groups	*N*	M	SD	SE	95%-CL		Min	Max
						LL	UL		
Calendar age (months)(U9)	Soccer players[a,b]	316	95.8	5.6	0.31	95.2	96.4	84	*124*
	Other athletes	435	94.3	4.9	0.23	94.0	95.0	80	*120*
	Non-athletes	2214	94.3	5.4	0.12	94.3	94.7	75	119
Calendar age (months)(U12–U15)	Soccer players	316	151.5	10.3	0.57	150.1	152.3	132	174
	Other athletes	435	149.3	10.3	0.50	148.1	150.0	131	178
Performance (level)(U12–U15)	Soccer players	316	2.1	0.5	0.03	2.0	2.2	1.0	4.0
	Other athletes	435	1.8	0.8	0.03	1.7	1.9	1.0	5.0
General tests of the Fulda Movement Check									
Body height (cm)	Soccer players	316	129.4	5.5	0.30	128.9	130.1	110	147
	Other athletes	434	129.4	6.2	0.30	128.8	130.0	110	146
	Non-athletes	2214	129.0	6.0	0.13	128.7	129.2	108	153
Body weight (kg)	Soccer players	316	28.0	5.0	0.28	27.5	28.6	18.6	54.8
	Other athletes	434	27.9	5.2	0.25	27.4	28.4	18.0	54.6
	Non-athletes	2214	28.1	5.7	0.12	27.9	28.3	16.4	70.0
Sideward jumping (repeats)	Soccer players[b]	316	25.2	5.8	0.32	24.6	25.9	11.0	44.0
	Other athletes[c]	434	24.5	6.2	0.30	24.0	25.1	6.5	40.0
	Non-athletes	2207	23.3	6.3	0.13	22.9	23.5	0.5	45.0
Balance backwards (steps)	Soccer players[b]	316	29.1	8.6	0.48	28.2	30.1	7.0	41.0
	Other athletes[c]	434	29.0	9.0	0.43	28.1	29.8	7.0	48.0
	Non-athletes	2212	26.7	8.9	0.19	26.3	27.0	3.0	48.0
Standing long jump (cm)	Soccer players[b]	316	136.0	16.4	0.92	134.4	137.9	70.0	173.0
	Other athletes[c]	430	134.0	16.8	0.81	132.4	135.6	79.0	185.0
	Non-athletes	2194	126.4	18.6	0.4	125.5	127.1	57.0	190.0
20-m sprint (seconds)	Soccer players	316	4.50	0.31	0.02	4.46	4.53	3.77	5.52
	Other athletes[c]	435	4.54	0.33	0.02	4.51	4.57	3.50	5.87
	Non-athletes	2214	4.57	0.38	0.01	4.56	4.59	3.50	7.15
Push-ups (repeats)	Soccer players[b]	316	14.2	3.7	0.21	13.9	14.7	1	25
	Other athletes[c]	434	14.0	3.6	0.17	13.6	14.3	4	25
	Non-athletes	2208	13.5	3.7	0.08	13.4	13.7	0	30
Sit-ups (repeats)	Soccer players[a,b]	316	20.8	4.9	0.27	20.3	21.4	0	35
	Other athletes[c]	434	19.3	5.8	0.28	18.8	19.9	0	37
	Non-athletes	2208	17.9	5.6	0.12	17.7	18.1	0	36
Bend forward (cm)	Soccer players[b]	316	1.2	5.4	0.30	0.6	1.8	–15.0	15.0
	Other athletes[c]	430	0.7	5.8	0.28	0.1	1.2	–16.0	15.0
	Non-athletes	2195	–0.1	5.9	0.13	–0.4	0.1	–23.0	20.0
6-min run (m)	Soccer players[a,b]	316	1014	122	6.87	1002	1029	558	1332
	Other athletes[c]	431	967	136	6.56	954	980	299	1332
	Non-athletes	2180	913	129	2.76	907	918	216	1269
Ball throw (m)	Soccer players[a,b]	316	16.2	4.0	0.22	15.8	16.6	5.1	27.5
	Other athletes[c]	432	14.6	4.2	0.20	14.2	15.0	6.0	29.0
	Non-athletes	2208	12.9	3.7	0.08	12.8	13.1	4.5	28.1

N number, *M* mean, *SD* standard deviation, *SE* standard error, *LL* lower level, *UL* upper level, *CL* confidence level, *Min* minimum, *Max* maximum
[a]Sign. between Soccer players and Other athletes
[b]Sign. between Soccer players and Non-athletes
[c]Sign. between Other athletes and Non-athletes

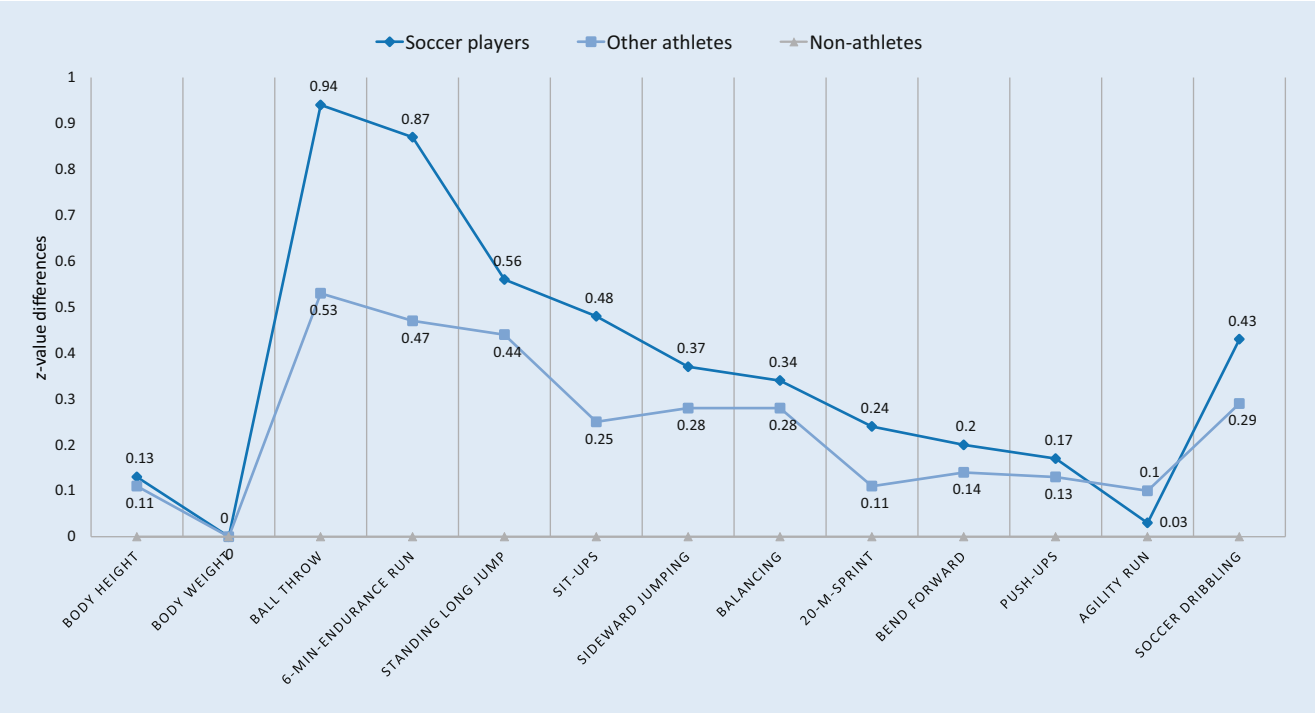

Fig. 2 ▲ Test performances (*z*-value) for later soccer players, other athletes, and non-athletes of the Fulda Movement Check (FMC) held in second grade at the elementary level

naus & Mueller, 2012; Roescher, Elferink-Gemser, Huijgen, & Visscher, 2010). To enhance the reliability of soccer players' assignments to the different competition performance levels, the records of the soccer performance development of the U12 to U15 age groups were checked by the head coach of the local competence centre; this individual was in charge of the nomination, selection, and education of soccer players promoted by the German Soccer Federation in the Fulda region during the investigation period.

Statistical analysis

All data were analyzed with SPSS (Version 25.0; SPSS Inc., Chicago, IL, USA) and statistical significance was set at $p < 0.05$. In order to obtain solid results in regard to the prognostic relevance of the predictors, the data sets of four successive second grade cohorts (2011, 2012, 2013, and 2014) were collected so that the samples of the soccer players and other athletes also achieved a sufficient number at higher competition levels. In order to achieve a greater comparability between the test values, the calendar age (in months) of the participants was partialized from the test results by means of a bivariate linear regression analysis, and then *z*-standardized residuals were used for all further analysis.

To gain insight into the prognostic relevance of the predictors of the FMC (two anthropometric variables and nine motor tests) in the soccer group, univariate ANOVAs were conducted analyzing mean differences between the different soccer performance levels. By means of a post hoc test (Bonferroni), the multiple differences between the groups were tested.

In addition, cross-tabulations were used to analyze the achievements of county level (level 3) or higher in terms of the single test results for 16 % of the best participants in the FMC. For a clearer indication of a player's relative chances to reach a higher performance level in the future (group 1), odds ratios (on the basis of the *z*-standardized residuals) were computed.

To obtain a mid-term talent prognosis in both a linear discriminant analysis and a nonlinear neural network (multilayer perceptron, MLP), five out of nine juvenile performance prerequisites of the FMC were used to predict two final groups of soccer players. The two performance groups were formed according to the performance level achieved at early adolescence in the age groups U12 to U15 (**Table 1**). Group 2 consisted of $n = 221$ players from lower levels 1 and level 2, and group 1 contained the $n = 95$ better-performing players from county level 3 up to regional and national level 4. To obtain a "true" prognosis, the talent forecasts on the basis of the stepwise discriminant analysis have to follow a cross-validation classification ("leave-one-out"). Thus, the total number of all cases minus one was used to compute the discriminant functions that were then used to determine the later-on performance group of the remaining single case. Similarly, for the multilayer perceptron (MLP) analysis, three subsets were created for (i) training and (ii) testing the predictive model as well as determining (iii) the final classification of the left-out cases. Therefore, the MLP was trained with 80 % of all cases, whereas 10 % was used to test the trained network. Finally, the classification was calculated for the hold-out of the remaining 10 % of cases. This specific kind of leave-out strategy was repeated eleven times so that each case should at

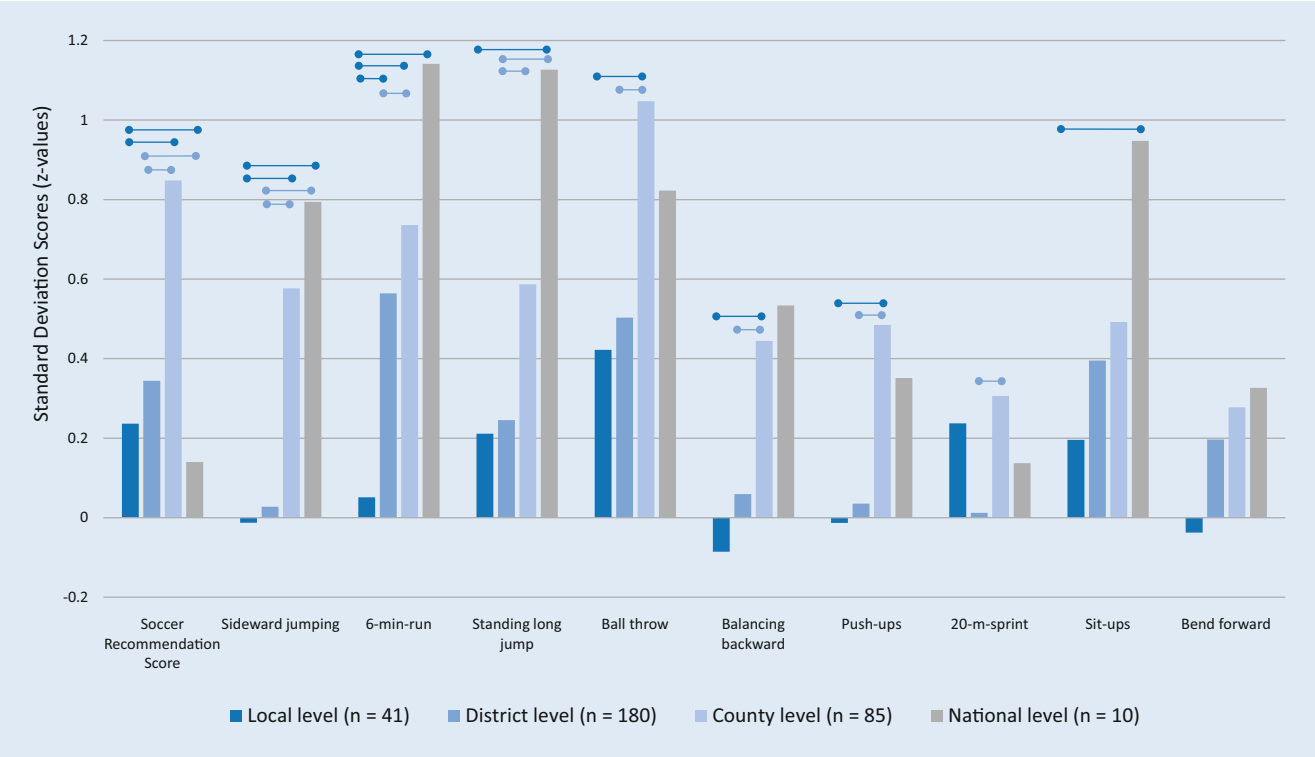

Fig. 3 ▲ Prognostic validity of the test performances of the U9 Fulda Movement Check (FMC) participants in regard to the later competition performance levels at early adolescence (U12 to U15). (Legend: Data of the 20-m sprint were transformed in a positive direction. Variances of subgroups were homogeneous [Levene; $p > 0.05$]. Significant group differences [Bonferroni; $p < 0.05$] are indicated)

least belong once to the left-out athletes who were finally classified. To quantify the validity of this talent identification strategy, the percentage of correct hits of the neural network classification was averaged over the ten trials, and the mean value was used from there on. The classification qualities of both methods were expressed by the proportion of correct hits, referring to the percentage of athletes that were assigned as true positives to their own sport. An athlete was defined as false positive if he was classified as a participant of a specific sport for which he did not practice. On the basis of the ratio of correct to erroneous hits, the prognostic validity of the test results was calculated.

Results

Test performance results for soccer players, other athletes, and non-athletes

Comparing the test results of later soccer players, other athletes, and non-athletes, it is noticeable that the tested soccer players in most of the nine tests showed the greatest conclusive performance (excluding the 6-min run). Regarding the field of anthropometric tests, there are no major differences in the results. The descriptive performance characteristics of the FMC participants are presented in **Table 2**.

The early talent screening results for the *z*-standardized predictors in **Fig. 2** demonstrate—in ten of the eleven motor diagnostics—better performances for future soccer players compared to athletes from 31 different sports (middle line) and non-athletes that served as reference groups.

Prediction of general motor tests

Comparison of different sport-specific competition levels

Within the group of soccer players ($n = 316$), the ANOVAs demonstrated significant differences in the predictors corresponding with later performance levels reached by the U12 to U15 children. Soccer players who reached the regional or national level 4 performed better in eight of nine motor tests than players who made it only to the county level 3, district level 2, or local level 1: total score[9], soccer recommendation score[10], sideward jumping[11], 6-min endurance run[12], standing long jump[13], ball throw[14], balancing backward[15], push-ups[16], 20-m sprint[17], and sit-ups[18]. In the row of general tests, only the results in the bend forward flexibility test[19] do not go hand-in-hand with the later achieved soccer performance level in the U12 to U15 age

[9] GMT in addition to Ball throw; $F(3;312) = 12.99$; $p < 0.001$; $\eta^2 = 0.111$.

[10] $F(3;312) = 10.03$; $p < 0.001$; $\eta^2 = 0.087$.

[11] $F(3;312) = 10.02$; $p < 0.001$; $\eta^2 = 0.086$.

[12] $F(3;312) = 6.83$; $p < 0.001$; $\eta^2 = 0.061$.

[13] $F(3;312) = 6.51$; $p < 0.001$; $\eta^2 = 0.057$.

[14] $F(3;312) = 6.00$; $p < 0.01$; $\eta^2 = 0.053$.

[15] $F(3;312) = 4.85$; $p < 0.01$; $\eta^2 = 0.044$.

[16] $F(3;312) = 4.81$; $p < 0.01$; $\eta^2 = 0.043$.

[17] $F(3;312) = 3.74$; $p < 0.05$; $\eta^2 = 0.034$.

[18] $F(3;312) = 2.73$; $p < 0.05$; $\eta^2 = 0.025$.

[19] $F(3;312) = 1.29$; $p = 0.278$.

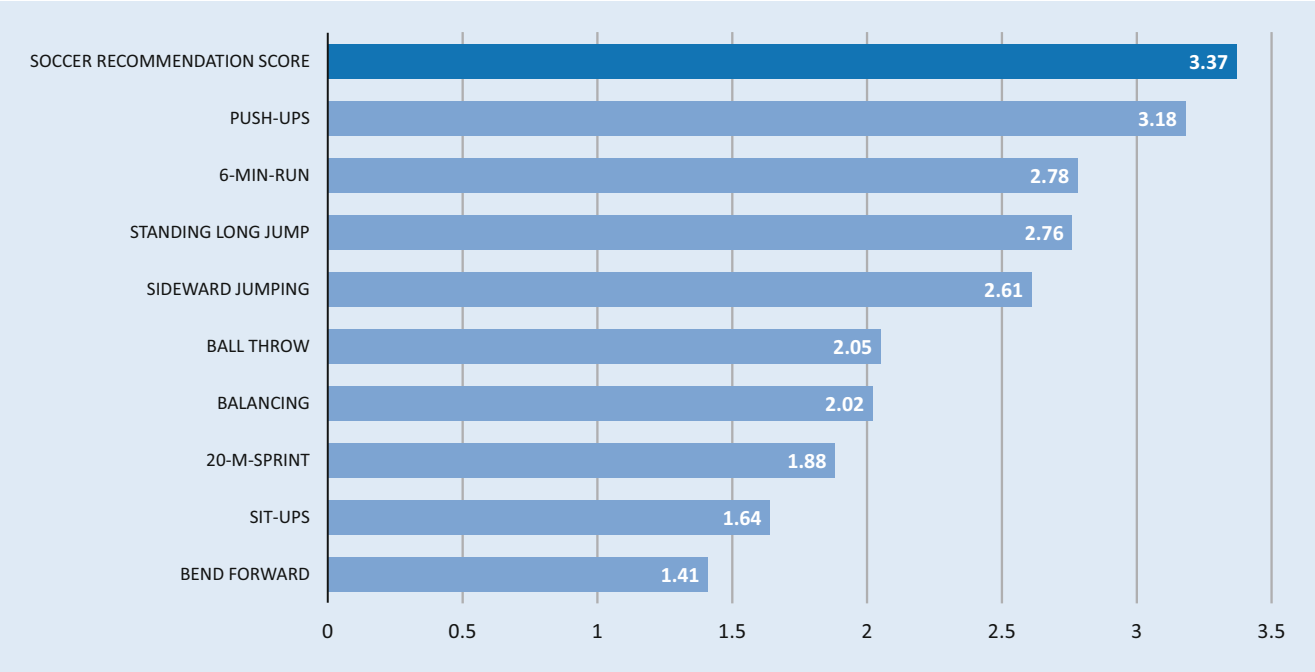

Fig. 4 ▲ Odds ratios (at the $z = 1.0$ and percentage rank [*PR*] = 84 threshold) of the nine general motor tests of the Fulda Movement Check's (FMC) basic test and the more specific SRS predict the relative chances of the U9 participants of the FMC to reach at least the county level (levels 3 or 4) of soccer competition performance by an early adolescent age (U12 to U15)

categories (**Fig. 3**). As the anthropometric characteristics body height and weight did not relate significantly to the later soccer performance, those data were not presented in the figure.

The post hoc comparison of the four subgroups showed significant mean differences in nearly all predictors, including the two overall measures of total score for the GMT added by ball throw and weighted SRS; the bend forward results are an exception (**Fig. 3**). Of the general GMT items, only the 6-min run discriminated significantly within the majority of those U9 children that later on formed the lowest U12 to U15 performance groups at both local and district levels.

Odds ratios for each test and the soccer recommendation score

Odds ratios (ORs) for each single test as well as for the SRS represent the prognostic validity of the investigated predictors and make the sport-specific relevance of the different tests comparable (**Fig. 4**). In the context of this study, the ORs quantify the relative chances of a U9 FMC participant in reaching a certain soccer performance level in early adolescence (U12 to U15). In **Fig. 4**, the OR for the SRS and any of the nine single tests were calculated for children who had achieved a total score among the best 16 % of the total group ($z \geq 1.0$ or percentage rank (PR) ≥ 84). The OR ranking in **Fig. 4** reveals the relative chances of a participant to reach at least the county soccer performance level (3 or 4) in the future.

Specificity and sensitivity

Since soccer is characterized by a great number of beginners at the elementary school level, as well as by a broad variety of demands and necessary abilities due to the complexity of the game, the quality of sports recommendation in the talent identification model is of great importance (Pion, 2015). Therefore, factors including how many non-talented athletes will be correctly classified (specificity of the testing) and how many talented youngsters will be successfully identified (sensitivity of the testing) by the test battery of the FMC are of great interest (see also Höner & Votteler, 2016). **Fig. 5** illustrates that at a test performance limit of $z = 1.0$ ($PR = 84$ respectively) in the SRS, according to the sensitivity curve, 53.6 % of the FMC participants were correctly identified as future successful soccer players (true positives), whereas in regard to specificity, 75.1 % of the non-talented players (true negatives) were excluded from talent promotion if the campaign aimed for county soccer performance level (level 3 and higher). Alternatively, even better players that will perform a minimum at the regional level 4 in the future could be sought after. In such cases, 83.3 % of the later groups of successful soccer players were correctly predicted, and 70.7 % of the non-talent individuals were sorted out.

The "true" performance prognosis by the cross-validated discriminant analysis on the basis of the five SRS tests led to a correct classification of 73.7 % of U9 soccer players into their later lower or higher performance groups at early adolescence (**Fig. 6**). In all, 205 of the 221 weaker (92.8 %) and 28 of the 95 stronger (29.5 %) soccer players were classified correctly into the performance groups that reached them more than 4 years later. The more efficient prognosis of future low-performers remaining on the local level underlines the high specificity of SRS derived from the FMC.

If an Artificial Neural Network (Multilayer Perceptron; SPSS 25.0, IBM Corp.,

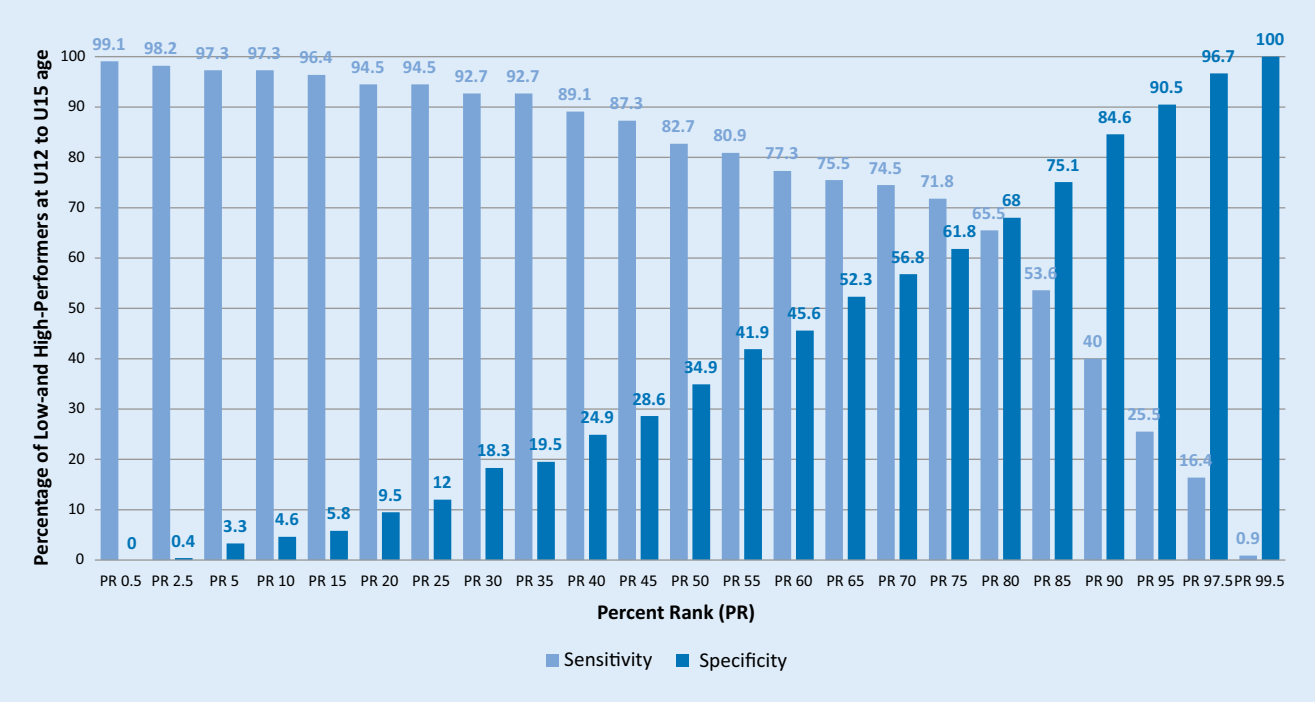

Fig. 5 ▲ Specificity and sensitivity of soccer recommendation score (SRS) of the Fulda Movement Check (FMC) U9 participants to predict a future soccer performance of at least county, regional, and national levels (3 or 4) at early adolescence (U12 to U15). *PR* percentage rank

Chicago, IL, USA) is used, the cross-validated procedure led to a somewhat lower prediction of 70.7 % correct hits. Especially evident in the group of non-talented players, the number of correct low performance predictions (88.2 % true negatives) was smaller, whereas the predictions of the later soccer players with higher performances (29.7 % true positives) remained more or less at the same value.

Discussion

It is imperative that talent screening and sports orientation campaigns based on the assessment of the performance predictors and competition performance development are closely related to a long-term talent development process, which includes proper allocation to defined stages of a complex talent development model. Compared to recent studies (Höner & Votteler, 2016; Höner et al., 2017) investigating the prognostic relevance of talent predictors in youth soccer, this study assessed a very young sample over a mid-term period from the early talent screening in second grade (U9) until the period of the talent promotion program of the German Soccer Federation at an early adolescent age (U12–U15). As a multidimensional talent screening campaign, the FMC is based on the GMT 6–18. Thus, a broad variety of physiological (e.g., endurance run), psychomotor (e.g., sideward jumping), and anthropometric (e.g., body height) predictors relevant for the talent identification in soccer were included in the study.

The present results contradict the later importance of the anthropometric variables body height and weight found by Höner et al. (2017) in early adolescence for more or less successful adult players. These findings could have resulted from two different factors. On one hand, the elimination of the calendar age from our test data by partializing out the age (in months) from all test performance data could have led to a more homogeneous "age group". On the other hand, there could certainly be a considerably lower relative age effect in the early talent development stage compared to middle or late adolescence. Due to the early stage of the talent screening campaign, the participants are still far from prepubertal acceleration regarding the development of body dimensions; this factor might reduce the impact of the anthropometric predictors on the soccer performance of younger individuals. To fully understand the relationship between biological maturity (e.g., skeletal age; Lago-Peñas, Casais, Dellal, Rey, & Domínguez, 2011) and soccer performance development from childhood to early adolescence, more differentiated analyses would be necessary. The five test results of the 20-m sprint, sideward jumping, 6-min run, agility run, standing long jump, and sit-ups form the basis of an SRS. Thus, it is not surprising that the later soccer group already exhibited in the talent screening campaign at age U9 contributed much better soccer-related performance prerequisites compared to non-athletes. Even more interesting are the leads of soccer players compared to the group of athletes from 31 other sports. The great differences in 20-m sprint, 6-min run, and the sit-ups, which are also part of the specific and highly valid SRS, might be indicators of early soccer specific athleticism that is relevant for soccer talents. One

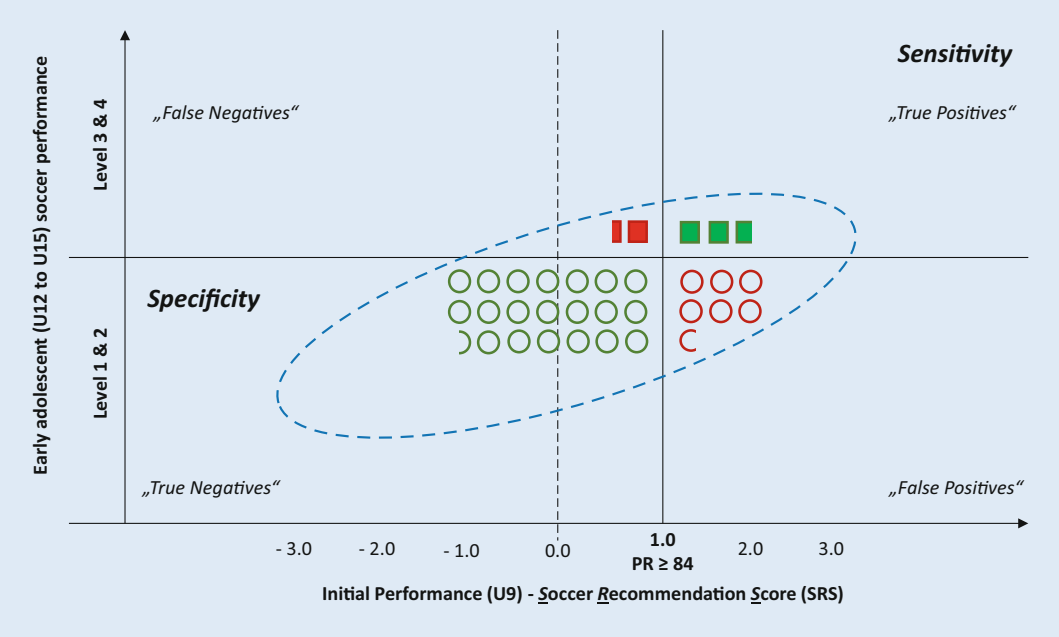

Fig. 6 ◄ Discriminant analysis to predict two later U12 to U15 soccer performance groups based on U9 performances in the five tests of the soccer recommendation scort (SRS; 20-m sprint, sideward jumping, 6-min run, standing long jump, and sit-ups) of the Fulda Movement Check (FMC) (at the limit of percentage rank [*PR*] = 84 or *z* = 1.0; each full symbol represents ten children)

reason for the somewhat surprising excellent throwing performance of the soccer group could lie in the fact that the best movers get drafted by soccer clubs at a very young age, as the soccer federation recommends and promotes a very early recruitment of promising youngsters. This also underlines that the general athleticism should be regarded in the search for soccer talents.

According to the descriptive data, the ANOVA results, and especially the odds ratios of the motor tests, this mid-term longitudinal study verified the prognostic validity of the nine general motor tests of the FMC. Although the investigation period was almost the earliest possible in children's participation, the findings for the predictive validity of the general tests of the GMT 6–18 in general were not surprising; these results were expected to be fairly high because the best movers (Gulbin, Croser, Morley, & Weissensteiner, 2013) at the elementary level generally become involved with soccer at a very early age, as it is the most popular sport in Germany.

The prognostic period of our study ends exactly when the talent selection of the German Soccer Federation (Deutscher Fußball-Bund, 2009) starts. This study may complete the picture from early talent screening in very heterogeneous samples until the talent selection stages begin focusing on very homogeneous soccer populations striving for top performance levels at junior and adult age.

Conclusion

The study provides reliable empirical knowledge on the prognostic relevance of general and soccer-related coordinative and technical skill tests in a regional talent screening and sports orientation campaign. The study shows that regional talent screening and sports orientation can be used to make valid statements in regard to young soccer players' future success. The results demonstrated motor predictors' prognostic validity over a mid-term period (on average about 4.5 years) after controlling all test data for calendar age. The specificity of a general testing in the second grade is very high and the majority of non-talented individuals are advised to pursue other sports for which they are more closely suited. However, due to the low sensitivity of the FMC for talent orientation, in the future an additional soccer-specific testing should be applied to obtain more reliable information for the sports recommendation regarding soccer. Thus, introducing elementary school children to soccer still remains a very complex practical and theoretical problem.

With a focus on practical utility of motor tests, the GMT 6–18 (Boes & Schlenker, 2016) assessing speed, endurance, and coordinative abilities turned out to be a useful tool for talent orientation as both a combination of talent screening and recommendation of suitable sports. The specificity of the general testing in the second grade is very high and the majority of non-talented individuals are advised to pursue other sports for which they are better suited. However, due to the low sensitivity of the general motor test, further sport-specific additional tests seem to be necessary for this purpose.

Further studies over longer periods of time (see also Höner et al., 2017), as well as other promising methodological approaches such as person-oriented pattern analyses (Zuber et al., 2016) and a combination of linear and nonlinear tools (Pion et al., 2016) should be examined and compared with one another to identify corresponding strengths and weaknesses. In doing so, the research on talent identification may provide coaches with more scientifically sound tools for supporting their talent identification strategies as well as offer a deeper understanding of the long-term development of talented soccer players in talent promotion.

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Compliance with ethical guidelines

Conflict of interest. A. Hohmann, M. Siener and R. He declare that they have no competing interests.

The author did not conduct any studies with human or animal participants for this article. As for other studies cited in this article, information on ethical guidelines may be found in the respective sources.

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