Der relative Alterseffekt
im deutschen Nachwuchsfußball

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Zusammenfassung

Der relative Alterseffekt (RAE) beschreibt eine Überrepräsentation relativ älterer, kurz nach dem Stichtag für die Altersklasseneinteilung geborener Kinder und Jugendlicher in Nachwuchsfördersystemen. Ein RAE entsteht, wenn relativ Ältere aufgrund ihres chronologischen Altersvorteils häufiger als talentiert eingeschätzt und folglich bei Talentselektionsmaßnahmen bevorzugt für eine intensivere Förderung auf höhere Selektionsniveaus (lokale, regionale und nationale Auswahlkader) ausgewählt werden. Die Mechanismen dieses systematischen Selektionseffekts und die Auswirkungen weiterer Einflussfaktoren auf das Ausmaß des Effekts gelten trotz zahlreicher empirischer RAE-Studien als nicht ausreichend erforscht. Hervorgehoben wird die Notwendigkeit einer umfassenden Ursachenforschung durch die seit Jahrzehnten unveränderte Verbreitung des RAE in der Praxis, trotz der Kenntnis seiner negativen Folgen für die Talentförderung. Vor diesem Ausgangspunkt ist es Ziel der vorliegenden Dissertation, die Ursachen der RAE-Entstehung im Nachwuchsfördersystem des Deutschen Fußball-Bunds (DFB) zu erforschen, um darauf aufbauend gezielte und realisierbare Interventionsmaßnahmen für die Praxis abzuleiten.

Auf Basis eines theoretischen Modells von Individuums-, Aufgaben- und Umweltbedingungen der RAE-Entstehung werden in der Dissertation zwei empirische Studien zum RAE im Nachwuchsfördersystem des Deutschen Fußball-Bundes (DFB) vorgestellt. In der ersten Studie wird die Beziehung der individuellen RAE-Bedingungen relatives Alter, körperliche Reife und motorische Leistungsfähigkeit analysiert. Die Studie untersucht 10.130 Spieler der Altersklassen U12 bis U15 auf der ersten Ebene systematischer Talentselektion im DFB-Stützpunktprogramm. Zentrales Ergebnis der Studie ist, dass nahezu keine motorischen Leistungsunterschiede zwischen relativ älteren und relativ jüngeren Nachwuchstalenten bestehen. Zudem zeigt ein Vergleich der untersuchten Spieler mit durchschnittlich zu erwartenden körperlichen und motorischer Entwicklungskurven, dass ausgewählte relativ jüngere Nachwuchstalente nicht körperlich akzeleriert sind, für ihr Alter aber motorisch besonders begabt sein müssen, um als Talente ausgewählt zu werden.

In der zweiten Studie wird anhand der Geburtsdaten von 35.390 Nachwuchstalenten die Veränderung des RAE innerhalb der Umweltstruktur des Nachwuchsfördersystems untersucht. Unter der Grundannahme, dass RAE-Veränderungen bei Talentselektionsprozessen zwischen aufeinanderfolgenden Selektionsniveaus und Altersklassen geschehen, werden querschnittliche RAE-Unterschiede zwischen vier aufeinanderfolgenden Selektionsniveaus und acht Altersklassen untersucht. Zudem wird die längsschnittliche Veränderung des RAE bei Nachwuchsspielern analysiert, die bei Talentselektionsprozessen erstmalig für das nächsthöhere Selektionsniveau oder für die nachfolgende Altersklasse desselben Selektionsniveaus ausgewählt werden. Bei der querschnittlichen Analyse stellt

sich heraus, dass das RAE-Ausmaß über die vier aufsteigenden Stufen der Talentselektion im DFB-Nachwuchsfördersystem stetig zunimmt (Geburtenanteil erste Jahreshälfte: Stützpunktprogramm ≈60%, Leistungszentrum ≈69%, Verbandsauswahl ≈72% und Jugendnationalmannschaft ≈75%). Zwischen den Altersklassen zeigen sich geringfügig ansteigende RAEs von der U12 bis zur U15 in den Stützpunkten und Leistungszentren mit einem anschließenden geringfügigen Rückgang bis zur U19 in Leistungszentren, Verbandsauswahlteams und Jugendnationalmannschaften. Die Längsschnittanalyse der RAE-Veränderung bei Talentauswahlprozessen offenbart eine Zunahme des RAE-Ausmaßes bei erstmalig für höheres Selektionsniveau ausgewählten Spielern und keine RAE-Änderungen bei Spielern, die auf demselben Selektionsniveau in die nächsthöhere Altersklasse übernommen wurden. Damit wird deutlich, dass die zeitliche RAE-Entwicklung ein komplexer, sich verstärkender Effekt eines mehrfach gestuften Talentselektions- und Talentförderungsprozesses ist, der von den Umweltbedingungen eines Nachwuchsfördersystems beeinflusst wird.

Die Erkenntnisse aus den beiden empirischen Studien liefern ein tieferes Verständnis der Bedingungen bei der RAE-Entstehung und werden in der Dissertation dafür benutzt, Vorschläge für Interventionsmaßnahmen zur Reduktion des RAE im DFB-Nachwuchsfördersystem zu entwickeln.

Inhaltsverzeichnis

1 Einleitung

1.1 Der relative Alterseffekt (RAE)

„Dezemberkinder werden selten Fußballstars“ (Zeit-Online, Fritsch, Holzki & Venohr, 2013)

„‘Gnade der frühen Geburt‘ oder Chancengleichheit?“ (Schweizer Bundesamt für Sport, BASPO, 2016)

„How to build a champion: Be born at the right time” (BBC Sport, Oakley, 2012)

Ausbildungssysteme in Bildung und Sport verwenden einen *Stichtag* (z. B. 1. Januar) zur Altersklasseneinteilung um homogene Jahreskohorten für einen fairen Leistungsvergleich und eine altersgemäße Entwicklungsumgebung zu schaffen. Für die resultierenden chronologischen Altersunterschiede innerhalb einer Jahreskohorte von bis zu 364 Tagen (Geburtstag 1. Januar gegenüber Geburtstag 31. Dezember) wurde der Begriff *„relatives Alter“* geprägt (Barnsley, Thompson & Barnsley, 1985). Aus historischer Sicht wurde bereits in den 60er Jahren im Bildungskontext unter den Namen „effect of date of birth“ oder „birth date effect“ festgestellt, dass relativ älterer Schüler aufgrund ihres Altersvorsprungs gegenüber relativ jüngeren Schülern Entwicklungsvorteile haben (Armstrong, 1966; Freyman, 1965). Insbesondere in Grundschulen zeigten sich kognitive Leistungsvorteile relativ Älterer (Fredriksson & Ockert, 2005; McPhillips & Jordan-Black, 2009; Zhong & Hoxby, 2012) und auch in höheren Klassenstufen waren (wenn auch geringere) Leistungsvorteile nachweisbar (Bedard & Dhuey, 2006; Hauck & Finch, 1993; Sprietsma, 2010). Bei relativ jüngeren Schülern wurden hingegen häufiger psychologische Störungen, wie ADHS (Elder & Lubotsky, 2009), Lernschwierigkeiten (Cobley, McKenna, Baker & Wattie, 2009; Dhuey & Lipscomb, 2010; Martin, Foels, Clanton & Moon, 2004) und eine subjektiv höher wahrgenommene schulische Belastung nachgewiesen (Fenzel, 1992). Als Langzeitwirkung zeigte sich in einer Studie sogar ein erhöhtes Selbstmordrisiko relativ jüngerer Schüler (Thompson, Barnsley & Dyck, 1999).

Weitere Studien stellten fest, dass relativ ältere Schüler bei schulischen *Selektionsmaßnahmen* im Vergleich mit ihrem Geburtenanteil in der gesamten Schülerschaft überproportional häufig ausgewählt werden. Relativ Ältere werden während der Schullaufzeit häufiger in repräsentative Ämter (z. B. Schulsprecher) gewählt (Dhuey & Lipscomb, 2008), öfter in Förderprogramme der Begabungsförderung aufgenommen (Cobley, McKenna, et al., 2009) und qualifizieren sich häufiger für weiterführende Schulen und Universitäten (Crawford, Dearden & Greaves, 2013). So haben beispielsweise in Deutschland relativ Ältere eine höhere Chance zum Ende der Grundschulzeit eine Gymnasialempfehlung zu erhalten (Jürges & Schneider, 2006). Dahingegen müssen relativ jüngere Schüler häufiger Klassenstufen wiederholen (Elder & Lubotsky, 2009; Jeronimus, Stavrakakis, Veenstra &

Oldehinkel, 2015; Pedraja-Chaparro, Santín & Simancas, 2015) und beginnen mit geringerer Wahrscheinlichkeit ein Studium (Bedard & Dhuey, 2006). Allerdings konnten negative Langzeitfolgen eines RAE bisher weder bei Leistungen in der Universität (Roberts & Stott, 2015) noch bei der Berufstätigkeit und dem Einkommen im Erwachsenenbereich (Crawford et al., 2013) nachgewiesen werden. Eine Erklärung hierfür ist, dass über die Möglichkeit der (freiwilligen) Wiederholung von Klassenstufen und der Option alternativer Ausbildungswege im Bildungssystem, der kalendarische Altersnachteil relativ Jüngerer kompensiert wird (Hauck & Finch, 1993).

Im *Sport* wurde für das Phänomen einer Überrepräsentation relativ Älterer im Vergleich zur Geburtenverteilung einer Basispopulation der Begriff *relativer Alterseffekt (RAE)* geprägt (Barnsley et al., 1985; Lames, Augste, Dreckmann, Görsdorf & Schimanski, 2008). Nach einer Anekdote aus dem Buch „Outliers“ von Malcom Gladwell über die besonderen Umstände menschlichen Erfolgs wurde der RAE im Sport erstmals im Jahr 1983 von Paula Barnsley, der Frau des kanadischen Psychologen Robert Barnsley, entdeckt (Gladwell, 2008, S. 23ff). Während eines Jugendeishockeyspiels fiel Frau Barnsley beim Durchblättern des Informationshefts auf, dass über die Hälfte der aufgelisteten Spieler in den Geburtsmonaten Januar, Februar und März geboren waren[1]. In der zwei Jahre später erschienenen ersten sportwissenschaftlichen Publikation der Barnsleys zum RAE im Eishockey im Jugend- und Erwachsenenbereich berichteten sie von einem (nahezu linearen) Rückgang der Geburtenhäufigkeit von Januar bis Dezember (Geburtsquartal Q1 bis Geburtsquartal Q4) und damit einer deutlichen Abweichung der Geburtenverteilung von der kanadischen Bevölkerung (Barnsley & Thompson, 1988; Barnsley et al., 1985).

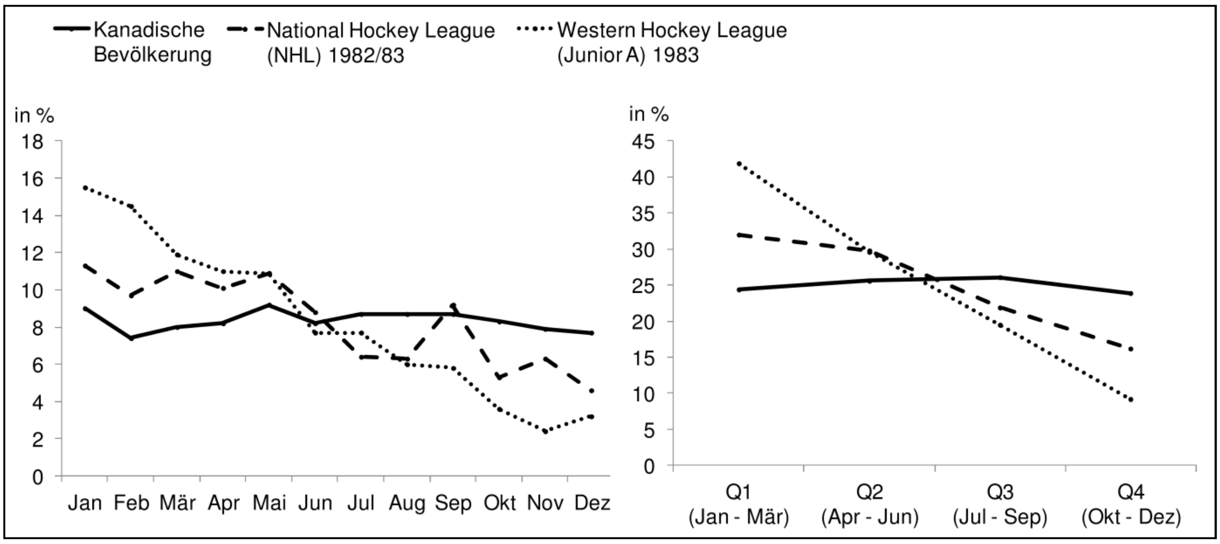

Abbildung 1: Relative Geburtenhäufigkeit pro Geburtsmonat (links) und Geburtsquartal (rechts) modifiziert nach Barnsley et al. (1985)

[1] Stichtag im kanadischen Jugendeishockey ist der 1. Januar.

Als *Ursache* eines RAE nehmen Dixon, Horton und Weir (2011) an, dass der Entwicklungsvorsprung relativ Älterer zu Vorteilen in deren (sportlicher oder kognitiver) Leistungsfähigkeit und in weiteren entwicklungsrelevanten Persönlichkeitsmerkmalen führt. Aus diesen Leistungsvorteilen relativ Älterer wiederum folgt, dass sie vermehrt bei Selektionsprozessen wie der Auswahl als sportliches Talent für eine Talentfördermaßnahme ausgewählt werden. In der Konsequenz entsteht ein wie in Abbildung 1 sichtbarer RAE mit einer Überrepräsentation relativ Älterer.

Für die *statistische Analyse des RAE* werden relative Häufigkeiten der Geburtstage mit den zeitlichen Auflösungen Geburtshalbjahr, Geburtsquartal (z. B. Till, Cobley, Wattie, et al., 2010) oder Geburtsmonat (z. B. Diaz Del Campo, Vicedo, Villora & Jordan, 2010) verwendet, wobei eine feinere zeitliche Auflösung einen höheren Informationsgehalt besitzt (Loffing, 2016) aber gleichzeitig mehr zufällige Schwankungen aufweist (vgl. Abbildung 1). Als zentrales Maß für die Geburtenverteilung einer Stichprobe werden der Median der Geburtstage (z. B. Augste & Lames, 2011) oder die relative Geburtenhäufigkeit der in der ersten Jahreshälfte geborenen Spieler angegeben (Mujika et al., 2009). Für eine Analyse des Schiefegrads der Geburtenverteilung werden in einigen Studien Korrelationskoeffizienten zwischen den Zeiteinheiten des relativen Alters und deren relativer Geburtenhäufigkeit berechnet (Helsen, van Winckel & Williams, 2005; Nolan & Howell, 2010). Die Größe der Koeffizienten kann jedoch durch die Wahl der zeitlichen Auflösung des relativen Alters manipuliert werden.

Der inferenzstatistische Nachweis eines RAE erfolgt in der Regel über Verteilungstests, wie z. B. den Chi²-(goodness-of-fit-)Test. Für diese Tests spielt die Wahl der Referenzverteilung eine große Rolle (Delorme, Boiché & Raspaud, 2010b; Delorme & Champely, 2015). Die Geburtenverteilung aller registrierten Sportler der untersuchten Sportart hat, nach Delorme und Champely (2015), gegenüber einer theoretischen Gleichverteilung der Geburten über das Kalenderjahr (z. B. Edgar & O'Donoghue, 2005) oder der empirischen Geburtenverteilung der Neugeborenen in der Bevölkerung (z. B. Diaz Del Campo et al., 2010) den Vorteil, sportartspezifische Eintritts- und Drop-Out-Effekte zu berücksichtigen. Die Autoren beziehen sich dabei auf zwei Studien, die in den Daten aller französischen Mitglieder der Sportarten Basketball und Fußball eine geringfügige Schiefe in der Geburtenverteilung auffanden (Delorme, Boiche & Raspaud, 2010; Delorme & Raspaud, 2009).

Eine weitere Veröffentlichung kritisiert ganz generell die Verwendung von Signifikanztests in RAE-Studien mit ganzen Populationen als Stichprobe, da in diesen Fällen ein inferenzstatistischer Schluss nicht notwendig oder sogar irreführend sei (Gibbs, Shafer & Dufur, 2015). Ein weiteres Problem der Signifikanztests ist, dass aufgrund der leichten Verfügbarkeit von Geburtsdaten in Online-Datenbanken in RAE-Studien häufig sehr große Stichproben untersucht werden (z. B. Romann

& Fuchslocher, 2011b), bei denen auch sehr geringe Effekte schnell signifikant werden. Deshalb ist bei der inferenzstatistischen Analyse eines RAE die Angabe von Effektgrößen von großer Bedeutung. Als Effektgröße für das RAE-Ausmaß geben viele Studien Odds-Ratios an (Cobley, Baker, Wattie & McKenna, 2009; Mujika et al., 2009; Till, Cobley, O'Hara, Chapman & Cooke, 2010). Ein Odds-Ratio für die beiden Geburtsjahreshälften vergleicht in einer Stichprobe beispielsweise die Häufigkeit der Geburten aus der ersten Jahreshälfte mit der Geburtenhäufigkeit der zweiten Jahreshälfte in Relation zu ihren Anteilen in der Basispopulation. Odd-Ratios der Größe 1,44, 2,48 und 4,27 können mithilfe einer Transformation in Cohen's d-Werte als kleine, mittlere und große Effekte eingestuft werden (Borenstein, Hedges, Higgins & Rothstein, 2011; Cohen, 1988).

Im Hinblick auf die *kritische Bewertung eines RAE*, muss die Zielstellung des betroffenen Ausbildungssystems berücksichtigt werden. Ähnlich wie in Bildungssystemen wollen Nachwuchsförderungssysteme im Sport Kindern und Jugendlichen bei gleicher Begabung gleiche Entwicklungschancen für späteren Erfolg im Erwachsenenalter geben. Gleichzeitig sollen die vorhandenen Fördermittel für eine hohe Qualität der Ausgebildeten möglichst effizient verteilt werden. Selektionsprozesse haben dabei die Funktion, die begrenzten Fördermaßnahmen (z. B. Quantität und Qualität des Trainings) möglichst optimal den vielversprechendsten Nachwuchssportlern zuzuordnen (Cobley, Schorer & Baker, 2012; Delorme, Boiché & Raspaud, 2010a; Vaeyens, Lenoir, Williams & Philippaerts, 2008). Diesen Fördermaßnahmen wird in Begabungs- und Talentmodellen eine bedeutende Rolle für die langfristige Leistungsentwicklung zugeordnet (Gagné, 2009; Ward, Hodges, Starkes & Williams, 2007). Für eine Bewertung des RAE ist nun wichtig, dass kein Grund zu der Annahme besteht, relativ Ältere seien potentiell höher begabt als relativ Jüngere (Allen & Barnsley, 1993; Lames et al., 2008). Bei Talentselektionsmaßnahmen ausgewählte Nachwuchssportler müssten demnach eine Gleichverteilung über alle Geburtsmonate aufweisen. Das Vorhandensein eines RAE bedeutet aber, dass relativ Ältere überrepräsentiert sind und die knappen Förderressourcen somit auch für einige wenig begabte relativ Ältere verwendet werden. Gleichzeitig sind bei vorhandenem RAE relativ Jüngere unterrepräsentiert. Es werden demnach einige relativ Jüngere trotz vorhandener Begabung zu wenig gefördert und gehen eventuell als Talent verloren. Somit kann ein Ausbildungssystem mit existierendem RAE als graduell unfair und ineffizient eingestuft werden (Dixon et al., 2011; Edgar & O'Donoghue, 2005).

1.2 Verbreitung des RAE im Spitzensport

Auch im Sport stellt sich nun, ähnlich wie bei der Analyse des RAE im Bildungssystem, die Frage, ob ein RAE im Nachwuchsbereich Langzeitfolgen bis in den Erwachsenenbereich hat. Als Antwort auf diese Fragen geben Tabelle 1 und Tabelle 2 einen Überblick über die Verbreitung des RAE in verschiedenen Sportarten im erwachsenen Spitzensport.

Tabelle 1: Studien zur Existenz des RAE in Spielsportarten (✓RAE vorhanden, – RAE nicht vorhanden)

Sportart	Geschlecht	Existenz RAE	Studien
Handball	M	✓	(Delorme, Boiché & Raspaud, 2009; Schorer, Cobley, Büsch, Bräutigam & Baker, 2009)
		–	(Lidor, Coté, Arnon, Zeev & Cohen-Maoz, 2010; Nakata & Sakamoto, 2011)
	W	✓	(Baker, Schorer, Cobley, Bräutigam & Büsch, 2009)
		–	(Delorme et al., 2009; Goldschmied, Cobley, Wattie, Baker & McKenna, 2011; Lidor, Arnon, Maayan, Gershon & Côté, 2014; Schorer et al., 2009)
Fußball	M	✓	(Baeumler, 2000; Besson, Poli & Ravenel, 2013; Cobley, Schorer & Baker, 2008; Costa et al., 2009; Delorme et al., 2009; Dudink, 1994; Fleming & Fleming, 2012; Helsen et al., 2012; Horn & Okumura, 2011; Ishigami, 2015; Jimenez & Pain, 2008; Nakata & Sakamoto, 2011; Ostapczuk & Musch, 2013; Wiium, Lie, Ommundsen & Enksen, 2010)
		–	(Goldschmied et al., 2011; Lidor et al., 2010)
	W	✓	(Baker et al., 2009; Romann & Fuchslocher, 2011a; Sedano, Vaeyens & Redondo, 2015)
		–	(Delorme et al., 2009; Lidor et al., 2014)
Basketball	M	✓	(Nakata & Sakamoto, 2011)
		–	(Daniel & Janssen, 1987; Delorme et al., 2009; Lidor et al., 2010; Stanaway & Mines, 1995)
	W	✓	
		–	(Delorme et al., 2009; Goldschmied et al., 2011; Lidor et al., 2014)
Volleyball	M	✓	(Campos, Stanganelli, Rabelo, Campos & Pellegrinotti, 2016; Lidor et al., 2010; Nakata & Sakamoto, 2011; Okazaki, Keller, Fontana & Gallagher, 2011)
		–	(Delorme et al., 2009)
	W	✓	
		–	(Lidor et al., 2014)
Eishockey	M	✓	(Addona & Yates, 2010; Barnsley et al., 1985; Delorme et al., 2009; Nolan & Howell, 2010; Vittorio & Philip, 2010)
		–	
	W	✓	(Molenaar, Geithner, Henriksson, Fjellman-Wiklund & Gilenstam, 2015; Weir, Smith, Paterson & Horton, 2010)
		–	(Molenaar et al., 2015)
(American) Football	M	✓	(van den Honert, 2012)
		–	(Beyer, Fukuda, Redd, Stout & Hoffman, 2016; Daniel & Janssen, 1987; Stanaway & Mines, 1995)
	W	✓	(van den Honert, 2012)
		–	
Baseball	M	✓	(Abel, Kruger & Pandya, 2011; Ishigami, 2015; Nakata & Sakamoto, 2011; Thompson, Barnsley & Stebelsky, 1991)
		–	(Werneck et al., 2016)
	W	✓	
		–	(Abel et al., 2011; Werneck et al., 2016)
Rugby	M	✓	(Delorme et al., 2009; Till, Cobley, Wattie, et al., 2010)
		–	
	W	✓	
		–	(Lemez, MacMahon & Weir, 2016)
Tennis	M	✓	(Edgar & O'Donoghue, 2005; Loffing, Schorer & Cobley, 2010; O'Donoghue, 2009)[2]
		–	
	W	✓	(Edgar & O'Donoghue, 2005; O'Donoghue, 2009)
		–	

[2] Nur für Rechtshänder, nicht für Linkshänder

Tabelle 2: Studien zur Existenz des RAE in Individualsportarten (✓ RAE vorhanden, – RAE nicht vorhanden)

Sportart	Geschlecht	Existenz RAE	Studien
Kampfsport (Judo, Boxen, Taekwando)	M	✓	(Albuquerque et al., 2013; Edginton, Gibson & Connelly, 2014)[3]
		–	(Albuquerque et al., 2013)[4] (Albuquerque et al., 2012)
	W	✓	
		–	(Albuquerque et al., 2012)
Leichtathletik	M	✓	(Besters, 2012)
		–	
	W	✓	(Besters, 2012)
		–	
Turnen	M	✓	
		–	
	W	✓	(Baker, Janning, Wong, Cobley & Schorer, 2014)[5]
		–	
Ästhetische Sportarten (Tanzen, Eiskunstlauf	M	✓	
		–	(Baker et al., 2014; van Rossum, 2006)
	W	✓	
		–	(van Rossum, 2006)
Ski alpin und nordisch	M	✓	(Baker et al., 2014)
		–	
	W	✓	(Baker et al., 2014)
		–	

Die abgebildeten Publikationen umfassen Studien mit Stichproben aus den obersten zwei Ligen oder Nationalmannschaften einer Sportart sowie von Olympischen Spielen im Erwachsenenbereich[6].Insgesamt wurden relative Alterseffekte weltweit in vielen verschiedenen Sportarten nachgewiesen. Somit gibt es also eine Langzeitwirkung des RAE in den Erwachsenenbereich. Relativ jüngere haben in vielen betroffenen Sportarten geringere Chancen, den erwachsenen Profibereich zu erreichen.

Die unterschiedlichen Ergebnisse für verschiedene Sportarten und beide Geschlechter zeigen, dass beide Merkmale einen Einfluss auf die Existenz eines RAE haben. Darüber hinaus lassen inkonsistente Befundlagen innerhalb einer Sportart und eines Geschlechts (z. B. Basketball der Männer in Studien aus verschiedenen Ländern) die Vermutung zu, dass weitere sozio-kulturelle Faktoren für die Existenz eines RAE relevant sind. Hinzu kommen weitere besondere Ergebnisse, wie ein umgekehrter RAE mit einer Überrepräsentation relativ jüngerer Athletinnen im Turnen (Baker et al., 2014), RAE-Unterschiede für verschiedene Gewichtsklassen im Judo (Albuquerque et al., 2013) sowie Unterschiede zwischen Links- und Rechtshändern im Handball und Tennis, die insgesamt verdeutlichen, dass der RAE ein sehr komplexes Phänomen mit vielen verschiedenen Einflussfaktoren ist.

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[3] Im Judo in hohen Gewichtsklassen
[4] Im Judo in unteren Gewichtsklassen
[5] Umgekehrter RAE mit Überrepräsentation relativ jüngerer Athleten
[6] Die in Tabelle 1 und 2 sind repräsentativ für den aktuellen RAE-Forschungsstand ohne einen Anspruch auf Vollständigkeit zu erheben.

Für die in dieser Dissertation zentrale Sportart *Fußball* quantifizierte eine große Untersuchung der höchsten Ligen aller europäischen Länder das RAE-Ausmaß auf 57% in der ersten Jahreshälfte geborene Spieler (Besson et al., 2013). Anhand des Beispiels Fußball kann aber auch deutlich gemacht werden, welche inhaltlichen Schwierigkeiten es bei der genauen Feststellung des RAE-Ausmaßes im Erwachsenenbereich gibt. Eine Schwierigkeit ist die Verschiebung des Stichtags von den Sommermonaten auf den 1. Januar in den Jahren 1996-1998 in mehreren Nationen (u. a. Deutschland, Frankreich, Belgien). Im Nachwuchsbereich führte der Stichtagwechsel zu einer Verschiebung des RAE von einer Überrepräsentation relativ Älterer in den Monaten August, September und Oktober während geltendem alten Stichtag zu einer Überrepräsentation relativ Älterer in den Geburtsmonaten Januar, Februar und März nach Einführung des neuen Stichtags (Helsen, Starkes & Van Winckel, 2000). In der Folge waren zum Zeitpunkt einer Untersuchung von Ostapczuk und Musch (2013) in den mehrere Jahrgänge umfassenden Kadern der deutschen Fußballbundesligisten Spielerjahrgänge vertreten, die entweder nur nach dem neuen oder nur nach dem alten Stichtag oder sogar phasenweise nach beiden Stichtagen in ihrer Nachwuchskarriere gefördert wurden. Das RAE-Ausmaß in der Fußballbundesliga war daher Ergebnis eines gemischten Effekts zweier nahezu gegenläufiger RAEs. Für eine präzise Feststellung des RAE-Ausmaßes kommt erschwerend hinzu, dass der RAE von Spielerjahrgängen in einer frühen Karrierephase zu Spielerjahrgängen in einer späteren Karrierephase abnimmt (Besson et al., 2013; Besters, 2012; Jimenez & Pain, 2008) und RAE-Unterschiede zwischen einheimischen und ausländischen Athleten einer Liga bestehen können (Schorer et al., 2009). Somit ist eine präzise Quantifizierung des RAE-Ausmaßes im Spitzenfußball nur unter Berücksichtigung der Stichtagproblematik und über eine differenzierte Betrachtung einzelner Jahrgänge und Spielernationalitäten möglich.

Die für die RAE-Entstehung verantwortliche systematische Talentselektion beginnt im DFB-Nachwuchsfördersystem in der Regel in der Altersklasse U12. Diese Selektion hatte somit für die in der Saison 2012/13 in der Fußballbundesliga aktiven deutschen Spieler der Jahrgänge 1986 und jünger zum Zeitpunkt des Stichtagwechsels im Sommer 1997 noch nicht begonnen. Der vorhandene RAE bei diesen Spielerjahrgängen geht daher allein auf den neuen Stichtag 1. Januar zurück. Das Ausmaß des RAE nimmt mit vom Jahrgang 1986 bis zu den jüngsten Jahrgängen ziemlich kontinuierlich zu (vgl. Abbildung 2). Für die Spieler der beiden jüngsten Jahrgänge, die bereits zu einem frühen Zeitpunkt, mit 18 bis 19 Jahren, den Sprung in die Fußballbundesliga geschafft haben, liegt das RAE-Ausmaß sogar bei über 70% in der ersten Jahreshälfte geborenen Spielern.

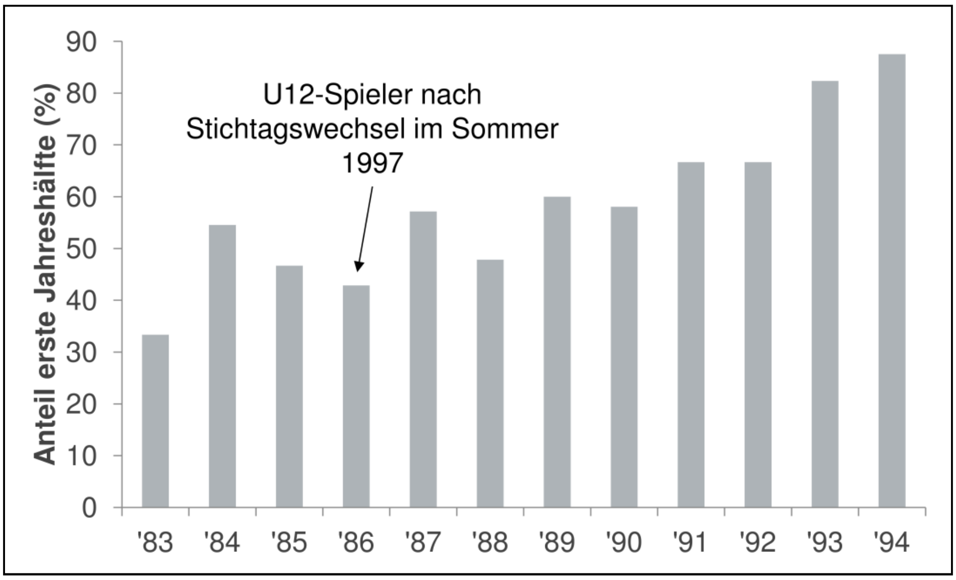

Abbildung 2: RAE in der 1. Fußballbundesliga (Saison 2012/13, deutsche Spieler, Jahrgänge mit mindestens acht Spielern, Geburtsdaten laut fußballdaten.de)

Insgesamt bleibt also festzuhalten, dass der RAE auch im erwachsenen Spitzenfußball besteht. Die Stichtageinteilung der Altersklassen in der Nachwuchsförderung verursacht somit für relativ jüngere Nachwuchsspieler geringere Erfolgschancen für das Erreichen des Spitzensportniveaus im Erwachsenenbereich, wodurch die Notwendigkeit einer Reduktion des RAE betont wird.

1.3 Der RAE im Rahmen der Talentforschung im DFB-Nachwuchsfördersystem

Die vorliegende Dissertation zum RAE im deutschen Nachwuchsfußball ist im Projekt „sportwissenschaftliche Begleitung des DFB-Talentförderprogrammes“ unter der Leitung von Prof. Oliver Höner und Prof. Klaus Roth entstanden und dem Projektschwerpunkt Talentforschung im Fußball zugeordnet (Höner & Roth, 2014). Die Talentforschung im Projekt versteht sich als anwendungsorientierte Forschung (Conzelmann & Höner, 2009), zu deren Aufgaben die Evaluation und Optimierung bestehender Strategien und Strukturen der Talentselektion und -förderung gehört (Güllich, 2013; Hohmann & Carl, 2002).

Der RAE und Talentselektion im DFB-Nachwuchsfördersystem

Eine unumstrittene Tatsache in der RAE-Forschung ist der Zusammenhang zwischen der Entstehung eines RAE und dem Prozess der Talentselektion in Nachwuchsfördersystemen (McCarthy, Collins & Court, 2016). Bei der *Talentselektion* werden Spieler mit dem Potential zukünftige Spitzenleistungen zu vollbringen identifiziert und für höhere Selektionsniveaus[7] ausgewählt (Hohmann, 2005; Malina, 2008; Williams & Reilly, 2000). Sie ist ein mehrfach gestufter Prozess, bei dem vergleichbar mit der Form einer Pyramide mit jedem aufsteigenden Selektionsniveau jeweils die vielversprechendsten Spieler ausgewählt werden (Cobley et al., 2012). Die Talentselektion wird gewöhnlich von Trainern durchgeführt, die das Potential ihrer Nachwuchsathleten für zukünftige Spitzenleistungen subjektiv bewerten (Christensen, 2009). Als zentrale Herausforderung für eine Optimierung der Talentselektion im Fußball sehen Talentforscher die Reduktion von Störeinflüssen, wie dem RAE (Unnithan, White, Georgiou, Iga & Drust, 2012; Vaeyens, Coelho e Silva, Visscher, Philippaerts & Williams, 2013).

In dieser Arbeit wird angenommen, dass die Talentselektionsprozesse, bei denen der RAE entsteht, strukturell betrachtet jeweils zwischen den aufeinanderfolgenden *Selektionsniveaus* und *Altersklassen* eines Nachwuchsfördersystems stattfinden. Der strukturelle Aufbau eines Nachwuchsfördersystems ist daher bei der Analyse der RAE-Entstehung von zentraler Bedeutung.

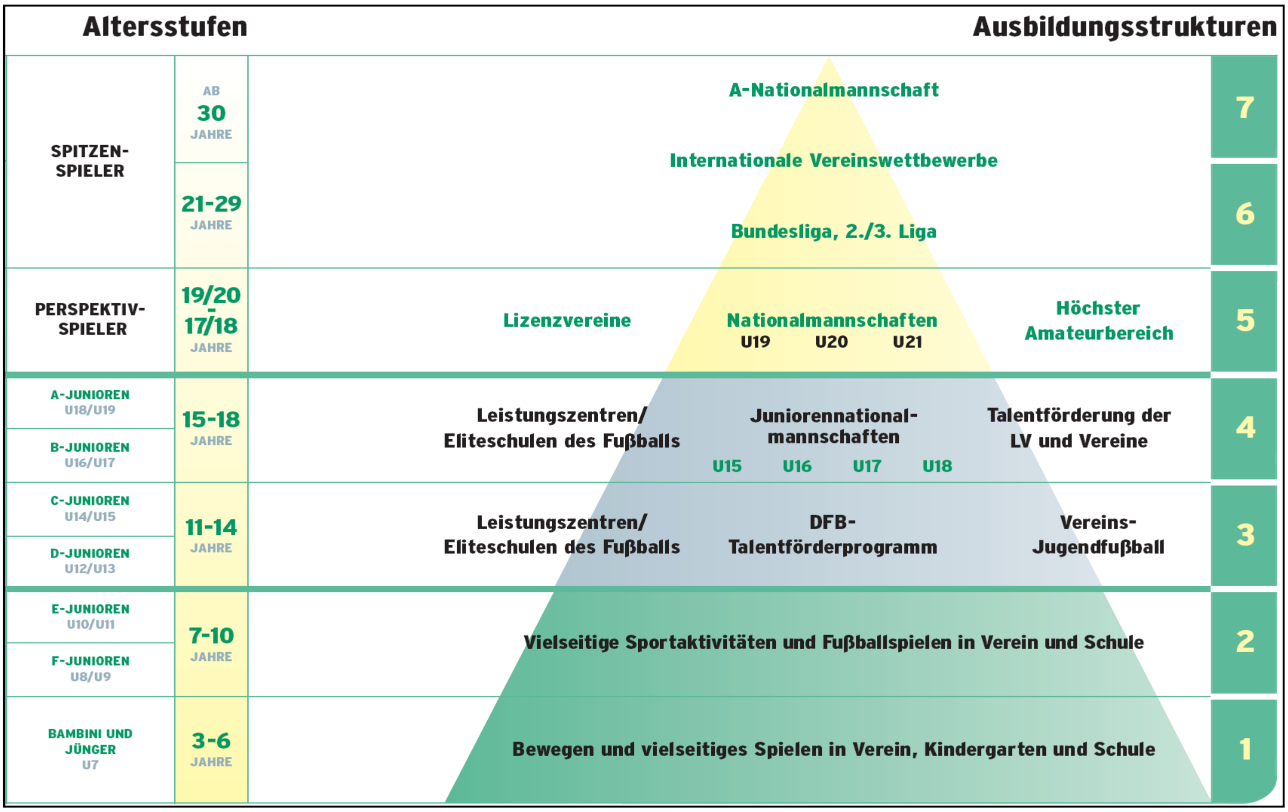

Abbildung 3: Ausbildungsstrukturen und Altersstufen im Deutschen Fußball-Bund (DFB, 2009, S. 15)

Die innerhalb des DFB-Nachwuchsfördersystems im Rahmen dieser Dissertation untersuchten Selektionsniveaus sind das vom DFB unter dem Begriff DFB-Talentförderprogramm geführte

[7] In dieser Arbeit wird für Kaderstufen oder Wettkampfklassen in Anlehnung an die Thematik Talentselektion der Begriff Selektionsniveau verwendet.

Programm 366 dezentraler Stützpunkte (im Folgenden der Eindeutigkeit halber DFB-Stützpunktprogramm genannt), die 49 zertifizierten Nachwuchsleistungszentren der Lizenzvereine[8], die Verbandsauswahlmannschaften der 21 Landesverbände und die Jugendnationalmannschaften (vgl. Abbildung 3). Im DFB-Stützpunktprogramm werden etwa 14.000 vielversprechende D-/C-Jugendspieler (Altersklassen U11 bis U15) aus Amateurvereinen mit einer zusätzlichen Trainingseinheit pro Woche bei qualifizierten Honorartrainern gefördert. Ein Anhaltspunkt für den Strenge-Grad der ersten Talentselektion in die DFB-Stützpunkte ist, dass die circa 4.500 Stützpunktspieler der Altersklasse U12 aus etwa 150.000 Amateurvereinsspielern ausgewählt werden (Schott, 2010). Zusätzlich zum DFB-Stützpunktprogramm werden pro Jahrgang etwa 800 der besten Nachwuchsspieler in den Altersklassen U12 bis U19 (D- bis zur A-Jugend) bei den Nachwuchsleistungszentren der Lizenzvereine intensiv gefördert. Die vom DFB als „Eliteförderung“ bezeichnete Förderung talentierter Spieler der Altersklassen U15 bis U19 in den Leistungszentren, wird auf Verbandsseite in den Verbandsauswahlmannschaften (etwa 350 Spieler pro Jahrgang bei zentralen DFB-Sichtungsturnieren) und auf dem höchsten Selektionsniveau in den Jugendnationalmannschaften (etwa 50-130 nominierte Spieler pro Jahrgang in einer Saison) fortgeführt.

Relatives Alter und motorische Leistungsfähigkeit als Talentmerkmal

Aufgrund des vermuteten Zusammenhangs zwischen relativem Alter, Leistungsfähigkeit und Talentselektion bei der Entstehung des RAE (vgl. Abschnitt 1.1), spielt in dieser Arbeit auch die *fußballerische Leistungsfähigkeit* eine wichtige Rolle. Im Nachwuchsbereich werden die globale Leistungsfähigkeit und ihre Teilkomponenten nicht nur in ihrer Funktion als Rückmeldung zum aktuellen Leistungsstand, sondern auch als mögliches Talentmerkmal zur Vorhersage des zukünftigen Leistungspotentials eines Nachwuchsspielers diskutiert (Hohmann, 2009).

Eine zentrale Herausforderung in dieser Diskussion ist die Auswahl und Erhebung von geeigneten Talentmerkmalen, mit denen sich das Potential für zukünftige Spitzenleistungen präziser vorhersagen lässt (Unnithan et al., 2012; Vaeyens et al., 2013). Als eine mögliche strategische Herangehensweise schlagen Gabler und Ruoff (1979) einen mehrschrittigen Forschungsprozess mit den Forschungsschritten Auswahl potentieller Prädiktoren, Bereitstellung von Messinstrumenten für deren Erhebung, Analyse des Zusammenhangs zwischen Prädiktor und Kriterium und Bewährung der Prädiktoren bei der Vorhersage zukünftiger Höchstleistungen vor. Übereinstimmend damit werden aus entwicklungspsychologischer Sicht die Merkmalsauswahl, deren Erhebung, zeitliche Stabilität und prognostische Relevanz als bedeutsam für die Vorhersage zukünftiger

[8] Anzahl Stand Saison 2013/14

Persönlichkeitsentwicklung erachtet (Nolting & Paulus, 2009). Zusätzlich gelten die Bereitstellung von Normwerten für die Merkmalsentwicklung und die Analyse der differentiellen Stabilität der Prädiktoren als wichtige Aufgaben in diesem Forschungsprozess (Hohmann, 2009; Seidel, 2005).

Bezüglich der *Auswahl potentieller Prädiktoren* ist die moderne Talentforschung sich einig, dass Talententwicklung ein sehr komplexer Prozess ist. Talentmerkmale müssen daher aus mehrdimensionalen Merkmalsbereichen stammen (Baker & Horton, 2004; Vaeyens et al., 2013) und in ihrer aktuellen Ausprägung sowie ihrer Entwicklungsdynamik und gemeinsamen Interaktion betrachtet werden (Gagné, 2013; Hohmann, 2014; Renshaw, Davids, Phillips & Kerhervé, 2012). Für die Sportart Fußball wird eine Unterscheidung in soziologische, physiologische, physische und psychologische Merkmale vorgeschlagen (vgl. Abbildung 4). Psycholgische Merkmale werden zusätzlich unterteilt in technomotorische Fertigkeiten, perzeptuell-kognitive Fähigkeiten und Persönlichkeitseigenschaften.

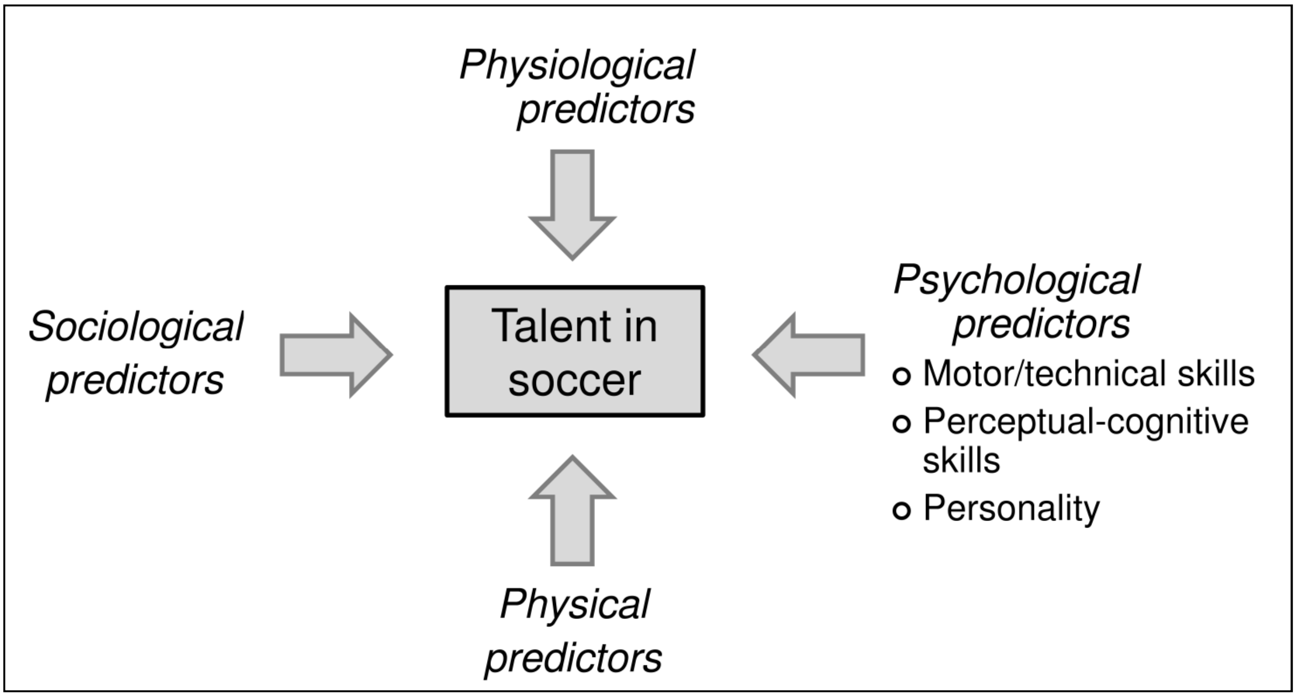

Abbildung 4: Talentmerkmale im Fußball (modifiziert nach Reilly, Williams, Richardson, Fisher & Bailey, 2008; Williams & Reilly, 2000)

Aufgrund ökonomischer Beschränkungen und den Schwierigkeiten einer standardisierten Testdurchführung in flächendeckenden Talentdiagnostiken in Nachwuchsfördersystemen, beschränken sich die meisten Studien im Fußball auf eine kleinere Auswahl an Talentmerkmalen, vorwiegend aus dem Bereich der technomotorischen Fertigkeiten (Elferink-Gemser, Huijgen, Coelho E Silva, Lemmink & Visscher, 2012; Figueiredo, Coelho e Silva & Malina, 2011; Vaeyens et al., 2006). Auch im DFB-Stützpunktprogramm beschränkt sich die Erhebung objektiver Talentmerkmale auf Schnelligkeitsfähigkeiten und fußballspezifische technische Fertigkeiten. Im Rahmen des Forschungsprojekts wurden die Ergebnisse einer im DFB-Stützpunktprogramm halbjährlich bei allen Stützpunktspielern durchgeführten technomotorischen Diagnostik erfasst. Diese technomotorische Diagnostik umfasst jeweils einen Test zum 20m-Sprint, zur Laufgewandtheit, zum Dribbling, zur Ballkontrolle, zum Torschuss und zum Balljonglieren (DFB, 2013). Die Ergebnisse dieser Einzeltests werden – mit Ausnahme des nachträglich eingeführten Balljongliertests – in einem technomotorischen Gesamtscore zusammengefasst.

Im Hinblick auf die RAE-Forschung in dieser Arbeit ist für die Analyse des Zusammenhangs zwischen dem relativen Alter und der Leistungsfähigkeit der Spieler eine ausreichende testtheoretische Güte der technomotorische Diagnostik als Messinstrument vorauszusetzen. Eine Analyse der prognostischen Validität der erhobenen motorischen Leistungsmerkmale ordnet die Bedeutung der motorischen Leistungsfähigkeit als Talentmerkmal ein.

1.4 Problemstellung und Aufbau der Dissertation

In dieser Arbeit soll das Ausmaß des RAE im DFB-Nachwuchsfördersystem quantifiziert und seine Entstehungsursachen genauer verstanden werden. Auf Basis der Ergebnisse sollen mögliche Interventionsmaßnahmen zur Reduktion des RAE in der Praxis entwickelt werden.

Der weitere Aufbau der Synopsis der kumulativen Dissertation gliedert sich in drei Abschnitte. Im folgenden Abschnitt 2 werden zur theoretischen Fundierung der Problemstellung bestehende Theorien zur RAE-Entstehung zusammengefasst (2.1) und für die empirische Analyse des RAE im DFB-Nachwuchsfördersystem für den männlichen Nachwuchsfußball konkretisiert (2.2).

Abschnitt 3 beinhaltet die in den empirischen Forschungsstand eingeordneten, eigenen empirischen Studien, die in Zeitschriften mit peer-review-Begutachtung publiziert wurden. Die Studien in Abschnitt 3.2 befassen sich mit Ursachen der RAE-Entstehung beim Talentselektionsprozess. Zur Analyse der Beziehung zwischen dem relativen Alter und der Leistungsfähigkeit eines Spielers wurden die Ergebnisse einer motorischen Diagnostik verwendet. Um die psychometrischen Eigenschaften und die Relevanz der untersuchten motorischen Leistungsfaktoren als Talentmerkmale für das zukünftige Leistungspotential abzusichern, wurden zwei vorbereitende Studien durchgeführt. Die beiden zugehörigen Publikationen (1) und (2) sind unter maßgeblicher Mitarbeit des Doktoranden als Co-Autor entstanden und werden in der Synopsis in Form einer Kurzzusammenfassung vorgestellt (vollständige Publikationen im Anhang). Den beiden vorbereitenden Studien schließt sich die Publikation (3) der ersten RAE-Studie zum Zusammenhang zwischen dem relativen Alter, der körperlichen Reife und der motorischen Leistungsfähigkeit an.

(1) Höner, O., Votteler, A., Schmid, M., Schultz, F. & Roth, K. (2015). Psychometric properties of the motor diagnostics in the German football talent identification and development programme. *Journal of Sports Sciences*, 33(2), 145-159.

(2) Höner, O. & Votteler, A. (2016). Prognostic relevance of motor talent predictors in early adolescence: a group- and individual-based evaluation considering different levels of achievement in youth football. *Journal of Sports Sciences*, 34, 2269-2278. doi: 10.1080/02640414.2016.1177658

(3) Votteler, A. & Höner, O. (2014). The relative age effect in the German Football TID Programme: Biases in motor performance diagnostics and effects on single motor abilities and skills in groups of selected players. *European Journal of Sport Science*, 14(5), 433-442.

Abschnitt 3.3 enthält die Publikation (4) mit der zweiten Studie zum RAE. Diese befasst sich mit dem Einfluss der strukturellen Eigenschaften des DFB-Nachwuchsfördersystems auf die RAE-Entstehung. In der Studie wird untersucht, zwischen welchen Selektionsniveaus und Altersklassen Änderungen im Ausmaß des RAE geschehen und welche Talentselektionsprozesse für diese Änderungen verantwortlich sind.

(4) Votteler, A., & Höner, O. (2017). Cross-sectional and longitudinal analyses of the relative age effect in German youth football. German Journal of Exercise and Sport Research. doi: 10.1007/s12662-017-0457-0

Begleitend zu diesen vier Veröffentlichungen der kumulativen Dissertation wurden im Promotionszeitraum weitere diverse Publikationen (5)-(9) vorgelegt:

(5) Votteler, A. & Höner, O. (2012). Auswirkungen des Relative Age Effects auf die motorische Leistungsfähigkeit von DFB-Stützpunktspielern. In C.T. Jansen, C. Baumgart, M. Hoppe & J. Freiwald (Hrsg.), Trainingswissenschaftliche, geschlechtsspezifische und medizinische Aspekte des Hochleistungsfußballs - Beiträge und Analysen zum Fußballsport

(6) Votteler, A. & Höner, O. (2012). Die Berücksichtigung des relativen Alters als Voraussetzung einer objektiven Talentdiagnostik anhand technomotorischer Tests im Fußball. In S. König, D. Memmert & M. Kolb (Hrsg.), Sport - Spiel - Unterricht (S. 199). Berlin: Logos.

(7) Votteler, A. & Höner, O. (2013). Der Relative Alterseffekt–ein heuristisches Modell zur Entstehung und Entwicklung in einem Nachwuchsfördersystem. In F. Mees, M. Gruber & A. Woll (Hrsg.), Sportwissenschaft Grenzenlos (S. 252). Hamburg: Czwalina.

(8) Votteler, A., Murr, D. & Höner, O. (2014). Assessing biological maturity in youth football - psychometric propterties of the maturity offset-protocol. In A. De Haan, C.J. De Ruiter & E. Tsolakidis (Hrsg.), 19th Annual Congress of the European College of Sport Science (S. 257). Amsterdam.

(9) Höner, O., Schultz, F., Schreiner, R. & Votteler, A. (2016). Prognostic validity of motor diagnostics in the German talent identification and development program. In T. Favero, B. Drust & B. Dawson (Eds.), International Research in Science and Soccer II (pp. 267-276). London: Routledge.

Im vierten Abschnitt werden die Ergebnisse der empirischen Studien zusammenfassend diskutiert (4.1) und mögliche Implikationen für eine zukünftige RAE-Forschung (4.2) sowie Interventionsmaßnahmen zur Reduktion des RAE in der Praxis erläutert (4.3).

2 Theoretischer Hintergrund

2.1 Bedingungsmodell zur Entstehung des RAE

Das Phänomen RAE wird seit über drei Jahrzehnten sportwissenschaftlich untersucht. Die Anzahl publizierter Studien zum RAE ist groß und stetig zunehmend (S. Cobley, Baker, Wattie, & McKenna, 2009; Vaeyen, Coelho e Silva, Visscher, Philippaerts, & Williams, 2013). Auch in den öffentlichen Medien wurden die negativen Folgen des RAE in Nachwuchsfördersystemen mehrfach angeprangert (Albrecht, 2013; Gladwell, 2008; Jackson, 2011; Venohr, 2013). Umso mehr erstaunt es, dass bisher keine systematische Reduktion des RAE in der Praxis feststellbar ist (Helsen et al., 2012; Nolan & Howell, 2010). Ein möglicher Grund hierfür ist, dass trotz langjähriger Forschungstradition die Gründe für die Entstehung eines RAE zu einem gewissen Grad immer noch unklar sind (Roberts, 2014).

Die meisten Publikationen zum RAE basieren auf empirischen Studien und sind geprägt von „*observational explorations*“ (Hancock, Adler & Côté, 2013, S. 630), d. h. Untersuchungen, in denen die Existenz und das Ausmaß des RAE in verschiedenen Stichproben festgestellt wurden. Die Anzahl theoretischer Beiträge mit dem Versuch einer Modellbildung zur RAE-Entstehung ist hingegen begrenzt, weshalb Cobley, Abraham und Baker (2008) den Forschungsstand zur RAE-Entstehung als *atheoretisch* charakterisieren. Ein theoretisches Modell ermöglicht es die Ursache-Wirkungs-Beziehung zwischen den beteiligten Merkmalen aufzeigen (Ashworth, 2007) und eine logisch konsistente Einordnung. Dies soll die zusammenhängende Interpretation bestehender empirischer Erkenntnisse ermöglichen sowie zur Generierung neuer, empirisch überprüfbarer Hypothesen führen (DePoy & Gitlin, 2005). Die mangelnde theoretische Diskussion limitiert somit das Verständnis der RAE-Entstehung und behindert folglich die Entwicklung von Interventionsmaßnahmen zu seiner Reduktion (Wattie, Schorer & Baker, 2015). Daher erachten Hancock, Adler, et al. (2013) die Intensivierung der theoretischen Diskussion zur RAE-Entstehung als zentralen zukünftigen Forschungsschritt.

Zwei der wenigen theoretischen Ansätze zur Entstehung des RAE (vgl. Abbildung 5) formulieren die folgenden zentralen Grundannahmen zur Entstehung eines RAE (Dixon et al., 2011; Lames et al., 2008):

- Relativ Ältere haben einen Entwicklungsvorsprung.
- Die mit dem Entwicklungsvorsprung einhergehende höhere Leistungsfähigkeit führt zu einer vermehrten Auswahl relativ Älterer bei Talentselektionsmaßnahmen.
- Ausgewählte Talente erhalten auf höherem Selektionsniveau eine bessere Förderung.

- Die vermehrte Selektion relativ Älterer in Verbindung mit einer besseren Förderung auf höheren Selektionsniveaus führt zu einem sich verstärkenden Kreislauf.

Zwei Erklärungen für eine höhere Leistungsfähigkeit relativ Älterer sind eine durchschnittlich höhere (physische und psychische) Reife („maturation-selection"-Hypothese) sowie eine umfassendere Unterstützung ihrer Leistungsentwicklung durch die Trainer, z. B. im Form vermehrter Spielanteile und intensiverem Feedback (Baker, Schorer & Cobley, 2010; Grossmann & Lames, 2013; Simmons & Paull, 2001). Während relativ Ältere häufiger bei Talentselektionsmaßnahmen ausgewählt werden, scheiden relativ Jüngere aufgrund einer negativeren Selbsteinschätzung häufiger freiwillig aus einer Sportart aus (Boiché & Sarrazin, 2009; Delorme et al., 2010a; Delorme, Chalabaev, & Raspaud, 2011; Fenzel, 1992).

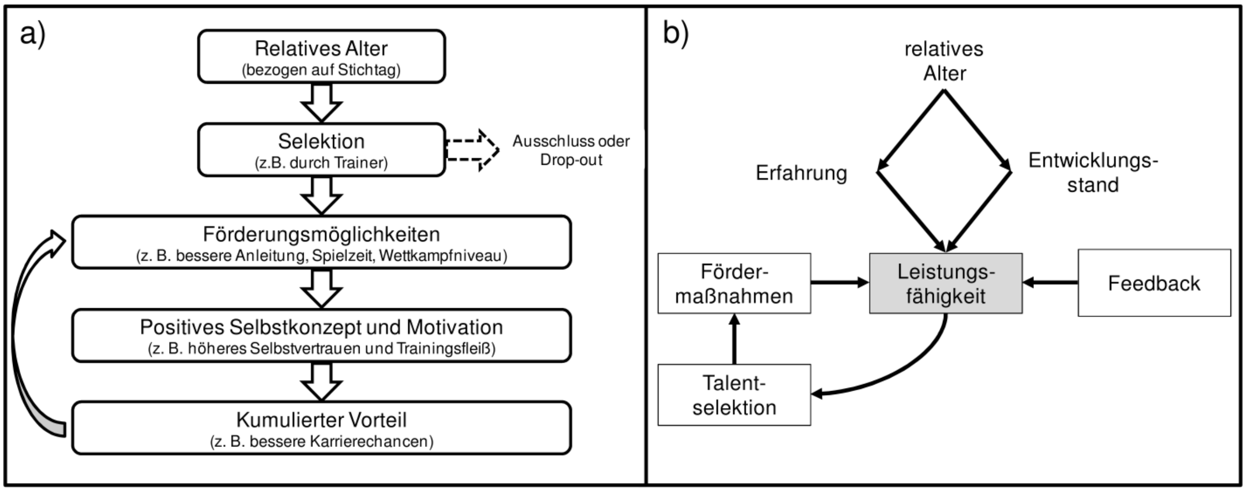

Abbildung 5: Dynamische Modelle zur Entstehung des RAE (a) modifiziert nach Dixon et al. (2011) und (b) modifiziert nach Augste und Lames (2011)

Einen weiteren theoretischen Ansatz liefern Hancock, Adler, et al. (2013), indem sie sozio-psychologischen Theorien auf die in der RAE-Problematik beteiligten sozialen Akteure Spieler, Eltern und Trainer übertragen. Ein Pygmalion-Effekt bei der RAE-Entstehung würde beispielsweise bedeuten, dass relativ Ältere eine bessere Leistungsentwicklung zeigen, weil Trainer von ihnen auch höhere Leistungen erwarten und einfordern.

Nach Ansicht von Wattie et al. (2015) sind diese theoretischen Ansätze nicht umfassend genug, da sie nicht alle bei der RAE-Entstehung beteiligten Einflussfaktoren (z. B. Geschlecht) berücksichtigen. Außerdem sei ein Modell, wie das von Hancock, Adler, et al. (2013) nicht spezifisch genug, um die bisher erzielten Ergebnisse sportwissenschaftlicher RAE-Studien konsistent erklären zu können. Dies führt zur Schlussfolgerung, dass „a theoretical framework that describes the breadth and complexity of relativ age effects (RAEs) in sport does not exist in the literature" (Wattie et al., 2015, S. 83).

In einem aktuellen Theoriebeitrag präsentieren die genannten Autoren daher ein *umfassendes theoretisches Rahmenmodell* zur RAE-Entstehung im Sport, basierend auf Newells Entwicklungsmodell der Personen-, Aufgaben- und Umweltbedingen (Newell, 1986)[9] und den Grundprinzipien der Theorie der Entwicklungssysteme (Lerner, 2007).

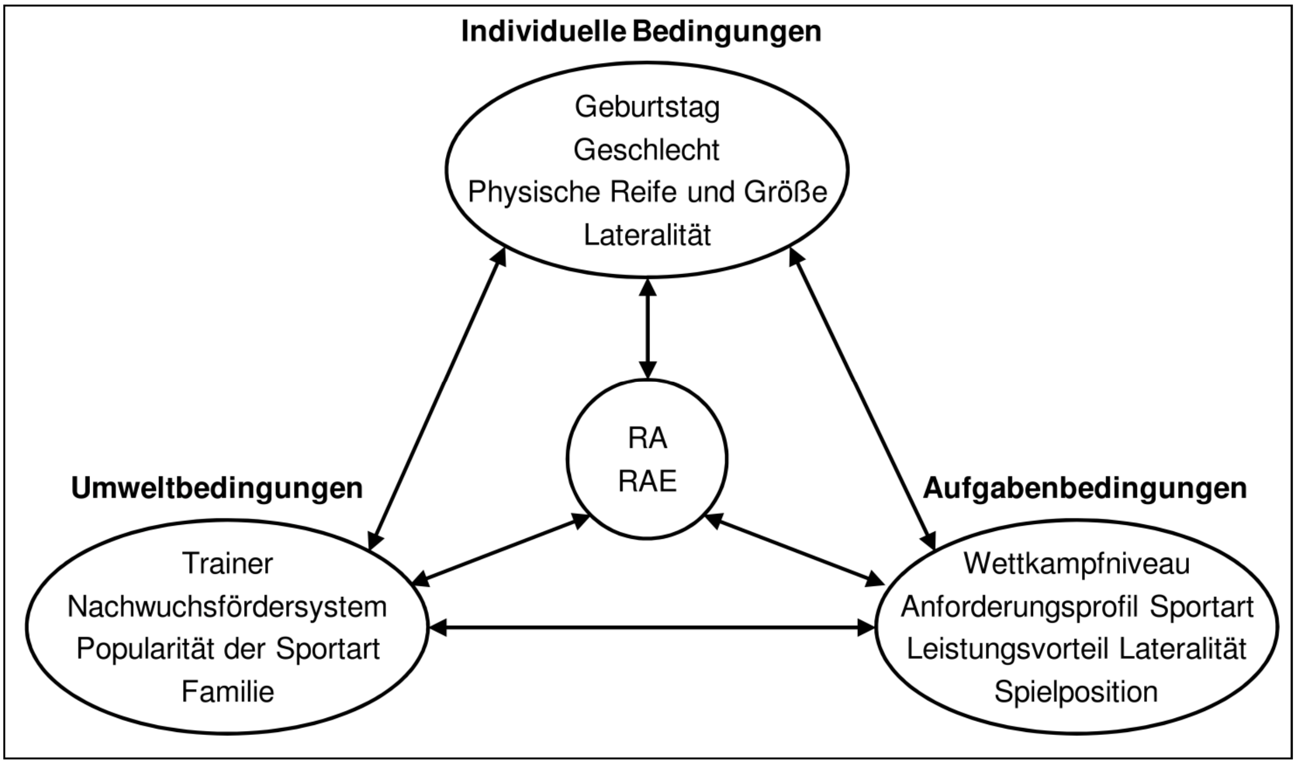

Abbildung 6: Bedingungsmodell für die Entstehung des relativen Alterseffekts (RAE) im Sport. Fiktive Spezifikation der Bedingungen für interaktive Mannschaftssportarten modifiziert nach Wattie et al. (2015, S. 90). RA relatives Alter.

Individuelle Bedingungen

Der Geburtstag eines Individuums ist eine strukturelle (unveränderbare) individuelle Bedingung für die RAE-Entstehung. Er wird durch die Interaktion mit der institutionellen Umweltbedingung „Altersklasseneinteilung anhand eines Stichtags“ zum relativen Alter eines Individuums. Als weitere individuelle Bedingung für die Entstehung eines RAE gilt die biologische Früh- und Spätreife (Unterschied zwischen chronologischem und biologischem Alter). Individuen mit früherem Beginn des adoleszenten Wachstumsschubs und höherer Größenwachstumsgeschwindigkeit während der Adoleszenz werden beispielsweise von Eishockeytrainern eher als talentiert eingeschätzt und daher häufiger selektiert (Sherar, Baxter-Jones, Faulkner & Russell, 2007). Eine biologische Frühreife kann auch den zeitlichen Entwicklungsrückstand eines relativ Jüngeren kompensieren. Als Indiz dafür fanden eine Eishockeystudie keine Größen- und Gewichtsunterschiede zwischen relativ älteren und

[9] Ähnlich dem Person-Aufgabe-Umweltbezug im handlungstheoretischen Systempostulat von Nitsch (2004)

relativ jüngeren Nachwuchstalenten nach vorherigen Talentselektionsmaßnahmen (Baker, Cobley, Montelpare, Wattie & Raught, 2010).

Das Geschlecht ist ebenfalls eine individuelle Bedingung der RAE-Entstehung. Im Vergleich zu Männern wurden bei Frauen tendenziell weniger häufig und eher geringere relative Alterseffekte nachgewiesen (Cobley, Baker, et al., 2009). Allerdings fand man in manchen Stichproben auch Effekte gleichen Ausmaßes für beide Geschlechter (Edgar & O'Donoghue, 2005; Raschner, Müller, & Hildebrandt, 2012; Romann & Fuchslocher, 2013; Weir, Smith, Paterson, & Horton, 2010). Ein weiterer Sonderfall bei Frauen ist ein umgekehrter RAE mit einer Überrepräsentation relativ jüngerer Mädchen in Sportarten wie Turnen, in denen eher kleinere, androgyne Athletinnen bevorteilt sind (Hancock, Starkes & Ste-Marie, 2016). Vermutete Ursachen für Auswirkungen des Geschlechts auf die RAE-Entstehung sind Unterschiede im Timing und Tempo von Reifeprozessen und deren geschlechtsspezifische Folgen für die Leistungsfähigkeit (McManus & Armstrong, 2011). Eine weitere Rolle bei der Wirkung des Geschlechts spielen soziale Geschlechterrollen (Vincent & Glamser, 2006) und geschlechtsspezifische Unterschiede in der Popularität einer Sportart und damit dem Konkurrenzkampf bei Talentselektionsprozessen (Baker et al., 2009).

Aufgabenbedingungen

Das Wettkampfniveau, auf dem eine Sportart betrieben wird, ist eine Aufgabenbedingung für die RAE-Entstehung (Cobley, Baker, et al., 2009). Eine Erklärung für diese Bedingung ist, dass nur bei vorhandenem Konkurrenzkampf um die geringere Anzahl vorhandener Plätze auf höherem Wettkampfniveau, die Grundvoraussetzung für die RAE-Entstehung bei Selektionsmaßnahmen gegeben ist (Musch & Grondin, 2001). Weitere Aufgabenbedingungen bei der RAE-Entstehung im Sport sind das Anforderungsprofil und die Regeln der Sportart, ausdifferenziert in manchen Sportarten in Besonderheiten einzelner Spielpositionen oder unterschiedlicher Teildisziplinen. In Sportarten, die große oder körperlich durchsetzungsfähige Athleten erfordern (z. B. Eishockey, Handball, Fußball, etc.), werden zumeist große relative Alterseffekte nachgewiesen (vgl. Tabelle 1 in Abschnitt 1.2). Dahingegen zeigen Sportarten, in denen kleine, körperlich weniger weit entwickelte Athleten im Vorteil sind (z. B. Tanzen, Eiskunstlauf oder rhythmische Sportgymnastik), keine oder sogar umgekehrte Effekte (vgl. Tabelle 2 in Abschnitt 1.2). Eine Ausnahme bilden kraftbetonte Zweikampfsportarten mit Gewichtsklasseneinteilung (z. B. Judo), bei denen die Beschränkung des Körpergewichts den Reifevorteil relativ Älterer limitiert (Albuquerque et al., 2013; Delorme, 2013). Auf Spielpositionen und in Teildisziplinen mit dominant-physischen Anforderungen fand man höhere relative Alterseffekte als bei eher technisch-koordinativ fordernden Aufgaben (García, Aguilar, Romero, Lastra & Oliveira, 2012; Hollings, Hume & Hopkins, 2012; Romann & Fuchslocher, 2011a). Eine Erklärung hierfür ist, dass physiologische Leistungsfaktoren, wie z. B. Kraft, stärker vom körperlichen Entwicklungsstand und damit vom relativen Alter abhängig sind als technisch-koordinative Leistungsfaktoren (Malina, Coelho e Silva & Figueiredo, 2013).

Die individuelle Bedingung „Lateralität eines Athleten“ wirkt in Interaktion mit der Aufgabenbedingung „Sportart“ (Spielposition) auf die RAE-Entstehung. Linkshänder zeigten im Vergleich zu Rechtshändern geringere relative Alterseffekte, wenn sie aufgrund ihrer Lateralität in der Sportart Leistungsvorteile gegenüber Rechtshändern haben und gleichzeitig aufgrund ihres geringeren Bevölkerungsanteils einem kleineren Konkurrenzdruck ausgesetzt sind (Loffing, Schorer, & Cobley, 2010; Schorer, Cobley, et al., 2009).

Umweltbedingungen

Zu den globalen Umweltfaktoren bei der RAE-Entstehung werden die nationale Popularität einer Sportart, strukturelle Besonderheiten des Nachwuchsfördersystems und der Einfluss der Sozialagenten Trainer und Eltern gezählt (Wattie et al., 2015). Die nationale Popularität einer Sportart hat einen Einfluss auf den Konkurrenzkampf bei Selektionsprozessen. So fand man beispielsweise keinen RAE in Israel, wo zusätzlich zu einer geringen Bevölkerungsdichte der Sport eine weniger ausgeprägte kulturelle Bedeutung hat (Lidor et al., 2010). Bemerkenswerterweise konnte auch in den hochkompetitiven US-amerikanischen Profiligen NBA und NHL im Basketball und American Football kein RAE gefunden werden (Côté, Macdonald, Baker & Abernethy, 2006; Daniel & Janssen, 1987). Grund hierfür ist vermutlich das Ausbildungssystem in diesen Sportarten, das sich deutlich von den europäischen Nachwuchsfördersystemen unterscheidet. Im US-Football werden beispielsweise Kinder und Jugendliche nicht nur nach ihrem chronologischen Alter sondern auch nach Gewichtsklassen eingeteilt, was ähnlich wie im Judo zu einer Reduktion der Reifevorteile relativ Älterer führt.

Die Eltern gehören zu den Umweltbedingungen der RAE-Entstehung, da sie Einfluss auf die Sportpartizipation ihres Kindes nehmen können. Ein RAE in der jüngsten Altersklasse auf Amateurniveau im Eishockey suggeriert, dass die Eltern relativ Jüngerer ihrem Kind weniger häufig den Einstieg ins Eishockey zutrauen (Hancock, Ste-Marie & Young, 2013). Nach dem Sportarteneintritt nimmt der Einfluss der Eltern auf den Karriereweg ab und dafür der Einfluss des Trainers zu. Der Trainer bestimmt bei Talentselektionsprozessen durch seine Selektionsstrategie, welche Nachwuchsathleten Zugang zu höheren Selektionsniveaus erhalten. Nach Jimenez und Pain (2008) erhöht insbesondere eine auf kurzfristigen mannschaftlichen Erfolg abzielende Selektionsstrategie eines Trainers, mit Fokus auf die aktuelle Leistungsfähigkeit seiner Spieler, das Risiko für die Entstehung eines RAE.

Interagierende Bedingungen, Diversität und Plastizität

Die individuellen Bedingungen, Aufgabenbedingungen und Umweltbedingungen interagieren im Modell von Wattie et al. (2015) bei der RAE-Entstehung miteinander. Konkrete Beispiele für Interaktionen sind die tennis- und handballspezifischen Leistungsvorteile für Linkshänder und die geschlechtsspezifische Popularität einer Sportart.

Um den empirischen Forschungsstand konsistent erklären zu können, wurden zudem die Prinzipien Diversität und Plastizität der Systemtheorie für Entwicklung dem Modell hinzugefügt (Wattie et al., 2015). *Plastizität* bedeutet, dass sich das Bedingungssystem mit der Zeit verändern kann. Ein Beispiel für plastische individuelle Bedingungen bei der RAE-Entstehung ist, dass in einer Gruppe selektierter Nachwuchstalente mit bereits vorhandenem RAE die Unterschiede in der körperlichen Reife geringer werden als auf Amateurniveau (Malina et al., 2013). Eine zeitliche Veränderung des individuellen Bedingungsgefüges zeigt auch der Zusammenhang zwischen biologischer Reife und Leistungsfähigkeit, der in einer Stichprobe von Jugendfußballern zwischen verschiedenen Altersklassen variiert (Figueiredo, Coelho e Silva, & Malina, 2011). Aus diesem Grund haben Wattie et al. (2015) die Bedingung „bereits existierender RAE“ als zeitliche Entwicklungsbedingung in ihr Modell aufgenommen.

Das Prinzip *Diversität* berücksichtigt interindividuelle Unterschiede in der Wirkung des Bedingungsgefüges. Aufgrund der sehr vielfältigen Entwicklungsbedingungen und komplexen Interaktionsmuster innerhalb und zwischen den Bedingungsbereichen weist jeder Nachwuchssportler ein individuelles Bedingungsgefüge auf. Ein Beleg für die Diversität ist, dass auch viele relativ jüngere Nachwuchsathleten trotz ihres zeitlichen Entwicklungsrückstands den Weg durch Nachwuchsfördersysteme in den Spitzensport finden. Wattie et al. (2015, S. 89) schlagen daher vor, die Wirkung der Bedingungen bei der RAE-Entstehung probabilistisch aufzufassen: „relative age (dis)advantages are probabilistic rather than deterministic“.

2.2 Konkretisierung der Bedingungen zur Analyse des RAE im DFB-Nachwuchsfördersystem

Das Modell von Wattie et al. (2015) liefert einen theoretischen Rahmen zur konsistenten Einordnung bisheriger RAE-Studien und zeigt zukünftige Forschungsansätze auf. Eine Schlussfolgerung der Autoren ist, dass eine zukünftige Erforschung des komplexen Bedingungsgefüges der RAE-

Entstehung „the systematic study of multiple constraints within a particular developmental system“ beinhalten und dazu multivariate statistische Methoden einsetzen sollte (Wattie et al., 2015, S. 91).

Im Rahmen dieser Dissertation werden mehrere Bedingungen der RAE-Entstehung im Nachwuchsfördersystem des Deutschen Fußball-Bundes untersucht. Ungeachtet der Forderung nach einem umfassenden multivariaten Ansatz, müssen bei der Operationalisierung des Modells für die empirischen Studien dieser Dissertation aus untersuchungsökonomischen Gründen einige Bedingungen fixiert und damit der Geltungsbereich der Ergebnisse eingeschränkt werden. Die Übertragbarkeit der Ergebnisse auf andere Ausprägungen dieser Bedingungen bleibt gegeben, wenn sie mit den in dieser Dissertation vorliegenden Ausprägungen funktional (im Hinblick auf die RAE-Entstehung) übereinstimmen. Zudem werden einige Bedingungen (mit vorheriger Begründung) nicht kontrolliert.

Individuelle Bedingungen des RAE im DFB-Nachwuchsfördersystem

Das relative Alter als Interaktion der individuellen Bedingung Geburtstag mit der Umweltbedingung Altersklasseneinteilung anhand eines Stichtags zu modellieren ist aus theoretischer Sicht konsequent. Zudem fördert diese Betrachtungsweise das Verständnis der Effekte eines Stichtagwechsels auf den RAE (Ostapczuk & Musch, 2013) und die Konzeption von Reduktionsmaßnahmen (Baker, Schorer, et al., 2010). Da der in Deutschland im Jahr 1997 vollzogene Stichtagwechsel die in dieser Dissertation untersuchten Spielerjahrgänge nicht betrifft, wird zur Vereinfachung des Modells auf die formale korrekte Darstellung verzichtet und stattdessen das relative Alter als individuelle Bedingung aufgenommen. Die Festlegung der individuellen Bedingung Geschlecht auf männliche Nachwuchsspieler geht auf die mit dem Projektpartner DFB vereinbarten Forschungsschwerpunkte für das Projekt „sportwissenschaftliche Begleitung des DFB-Talentförderprogamms“ zurück. Funktionale (veränderbare) individuelle Bedingungen, werden von Wattie et al. (2015) nicht aufgeführt, gehörten aber ebenfalls zu den Einflussfaktoren bei der RAE-Entstehung. Als Merkmale für die körperliche Reife werden in dieser Dissertation die Körpergröße und das Körpergewicht verwendet. Eine weitere zentrale individuelle Bedingung ist die aktuelle Leistungsfähigkeit des Nachwuchsathleten, da sie bei Talentselektionsprozessen als zentraler Indikator für das Talentpotential eines Spielers verwendet wird (Emrich et al., 2008). Als Merkmale der sportlichen Leistungsfähigkeit wurden die Testergebnisse der DFB-Stützpunktspieler in der technomotorischen Diagnostik (vgl. Abschnitt 1) verwendet.

Aufgabenbedingungen des RAE im DFB-Nachwuchsfördersystem

Die Aufgabenbedingung Sportart wird auf Fußball festgelegt. Nicht kontrollierbare Aufgabenbedingungen in den empirischen Studien der Dissertation sind die Spielposition und die Lateralität der Nachwuchsspieler. Eine Kontrolle der Spielposition ist schwierig, da die Positionen im Kinder- und Jugendbereich sehr häufig gewechselt werden. Da das Grundlagentraining im unteren Jugendbereich eher positionsunspezifisch ist, kann man aber davon ausgehen, dass die fehlende Kontrolle der Bedingung Spielposition keine gravierende Schwäche der empirischen Studien ist. Die ebenfalls nicht kontrollierte Lateralität spielt aufgrund einer eher beidfüßigen Ausbildung im Fußball – wenn überhaupt – nur in Verbindung mit der Bedingung Spielpositionen eine Rolle. Da aber die Bedingung Spielposition nicht kontrolliert wird, ist eine Betrachtung der Lateralität in diesem Fall unnötig. Eine zusätzliche Aufgabenbedingung in den empirischen Studien der Dissertation ist das Anforderungsprofil der Tests aus der technomotorischen Diagnostik. Die Diagnostik erfasst sowohl physiologische Schnelligkeitsfähigkeiten als auch fußballspezifische technische Fertigkeiten der untersuchten DFB-Stützpunktspieler (vgl. Abschnitt 1.3).

Umweltbedingungen des RAE im DFB-Nachwuchsfördersystem

Die Umweltbedingungen werden über die Wahl der Stichprobe auf die Verhältnisse im DFB-Nachwuchsfördersystem festgelegt. Gleichzeitig wird damit auch die Popularität der Sportart und der damit verbundene Konkurrenzdruck bei Selektionsmaßnahmen auf die Ausprägungen im deutschen Nachwuchsfußball fixiert. Der Einfluss der Eltern beim Sportarteneintritt ist für diese Dissertation wenig relevant, da die in den folgenden empirischen Studien untersuchten Nachwuchsspieler zu Beginn der systematischen Talentselektion im DFB-Nachwuchsfördersystem in der Altersklasse U11 bzw. U12 sind und in der Regel bereits mehrere Jahre auf Vereinsniveau Fußball gespielt haben. Eine bedeutsame, nicht kontrollierte Umweltbedingung ist der Einfluss des Trainers. Da der Prozess der Talentselektion eine Grundvoraussetzung für die RAE-Entstehung ist, ist die Strategie, mit der ein Trainer die Begabung der Nachwuchsspieler identifiziert, von zentraler Bedeutung. Der plausiblen Annahme, vor allem die aktuelle Leistungsfähigkeit eines Nachwuchsspielers sei für den Trainer zur Einschätzung seiner Begabung wichtig, fehlt in der Regel eine empirische Bestätigung. Mögliche weitere Annahmen zur Selektionsstrategie des Trainers auf der Basis von Informationen über seinen Ausbildungsstand, über den auf ihn lastenden kurzfristigen Erfolgsdruck und über die Selektionsphilosophie der jeweiligen Talentförderinstitution sind äußerst spekulativ. Daher bleibt die Selektionsstrategie des Trainers, wie in vielen anderen RAE-Studien auch, eine nicht kontrollierte Bedingung.

Plastizität und Diversität

Eine große Rolle in den empirischen Studien dieser Dissertation spielt das Prinzip der (zeitlichen) Plastizität der Entwicklungsbedingungen, das Wattie et al. (2015) mit der Entwicklungsbedingung relatives Alter bzw. RAE in das Modell integrieren. In dieser Dissertation wird diese zeitliche Entwicklungsbedingung mit der Annahme modifiziert, dass die RAE-Entstehung bei Talentselektionsprozessen stattfindet und Talentselektion in systematisch organisierten Nachwuchsfördersystemen ein mehrfach gestufter Prozess ist, der jeweils beim Übergang zwischen Altersklassen und Selektionsniveaus stattfindet (Till, Cobley, Wattie, et al., 2010). Anstelle der Bedingung RAE werden daher die Altersklasse und das Selektionsniveau als zeitliche Bedingungen in das Modell aufgenommen. Insgesamt ergibt sich für die empirischen Studien dieser Dissertation somit das in Abbildung 7 dargestellte heuristische Modell.

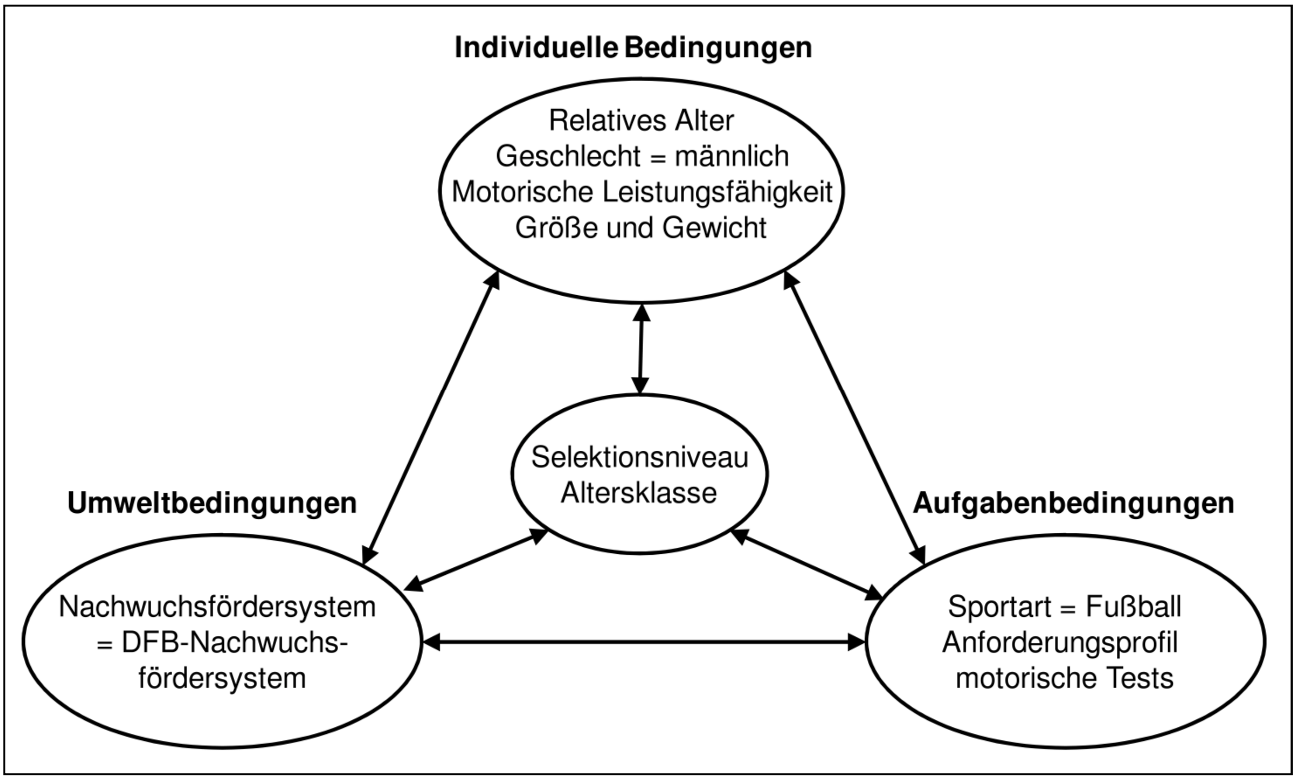

Abbildung 7: Bedingungsmodell der RAE-Entstehung mit fixierten und kontrollierten Bedingungen in der vorliegenden Dissertation in Anlehnung an das Modell von Wattie et al. (2015)

3 Empirische Studien der Dissertation

3.1 Problemstellung der empirischen Studien

Die kumulative Dissertation enthält vier Publikationen. Die beiden ersten Publikationen beinhalten *Vorstudien* zur testtheoretischen Güte der technomotorischen Diagnostik im DFB-Stützpunktprogramm (Abschnitt 3.2.1) und zur prognostische Validität der erhobenen Merkmale für zukünftige Spitzenleistungen (Abschnitt 3.2.2).

Die *erste Studie* zum RAE im DFB-Nachwuchsfördersystem untersucht den Zusammenhang zwischen den individuellen Bedingungen relatives Alter, körperliche Reife und motorische Leistungsfähigkeit bei Stützpunktspielern des DFB-Talentförderprogramms (Abschnitt 3.2.3). Besonderheit der Analyse ist ein Vergleich der motorischen Leistungsunterschiede zwischen Spielern unterschiedlichen relativen Alters innerhalb einer Altersklasse mit einer über die Altersklassen U12 bis U15 reichenden Entwicklungskurve motorischer Leistungsfähigkeit.

Im Fokus der *zweiten Studie* zum RAE steht die Rolle der zeitlichen Entwicklungsbedingungen Selektionsniveau und Altersklasse bei der RAE-Entstehung (Abschnitt 3.3). Die quer- und längsschnittliche Studie untersucht, zwischen welchen Selektionsniveaus und Altersklassen im DFB-Nachwuchsfördersystem Veränderungen im Ausmaß des RAE geschehen und durch welche Talentselektionsprozesse die Veränderungen des RAE Ausmaßes verursacht werden.

3.2 Analyse der individuellen RAE Bedingungen relatives Alter, Reife und motorische Leistungsfähigkeit

3.2.1 Zusammenfassung Vorstudie 1: Testtheoretische Güte der motorischen Diagnostik

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Routledge
Taylor & Francis Group

Psychometric properties of the motor diagnostics in the German football talent identification and development programme

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Abbildung 8: Titelseite des Originalartikels publiziert in Journal of Sport Science, 33(2), 145-159.

Ein wichtiger Bestandteil bei der Bereitstellung von Messinstrumenten für ausgewählte Talentmerkmale ist die Analyse der testtheoretischen Güte und der differentiellen Stabilität. Eine ausreichende Reliabilität und differenzielle Stabilität liefern wichtige Informationen über die Messgenauigkeit und die für motorische Merkmale während der Pubertät zu erwartenden hohen inter- und intraindividuellen Fluktuationen in der Entwicklung (Abbott & Collins, 2002; Malina, Bouchard & Bar-Or, 2004). Weiterhin erfordert eine gehaltvolle Interpretation von Testergebnissen deren Validität und die Bereitstellung standardisierter Normwerte (Kline, 2000). Trotzdem wurde die testtheoretische Güte der eingesetzten Messinstrumente in vielen (Fußball-)Studien nicht oder nur unzureichend beschrieben (Ali, 2011; O'Reilly & Wong, 2012).

Die Studie untersucht die Reliabilität, differentielle Stabilität und Validität der im Rahmen der technomotorischen Diagnostik am DFB-Stützpunktprogramm durchgeführten Tests für Schnelligkeitsfähigkeiten (Sprint, Laufgewandtheit) und fußballspezifische technische Fertigkeiten (Dribbling, Ballkontrolle, Torschuss und Balljonglieren) sowie des Gesamtscores und stellt Normwerte für eine standardisierte Interpretation der Testergebnisse bereit (Höner, Votteler, Schmid, Schultz & Roth, 2015). Die Stichprobe bestand aus N=68,158 für das Stützpunktprogramm ausgewählten Spielern der Altersklassen U12 bis U15, die im Zeitraum Frühjahr 2004 bis Frühjahr 2012 an mindestens einer der 17 halbjährlichen Erhebungen der technomotorischen Diagnostik teilgenommen haben.

Der Gesamtscore und die Schnelligkeitstests zeigten über alle Messzeitpunkte hinweg hohe interne Konsistenzen und Retest-Reliabilitäten, vergleichbar mit ähnlichen Studien (Hulse et al., 2013; Kutlu, Yapıcı, Yoncalık & Çelik, 2012; Mirkov, Nedeljkovic, Kuxom, Ugarkovic & Jaric, 2008). Die differentielle Stabilität nahm bei allen Tests in nahezu paralleler Weise mit zunehmender Zeitspanne ab. Der Gesamtscore und die Tests Sprint, Laufgewandtheit und Dribbling zeigten sich dabei potentiell relevant für die Vorhersage zukünftiger Leistungen. Die Analyse der faktoriellen Stabilität kam zu inhaltlich plausiblen und stabilen Ladungen auf zwei empirische Faktoren „Schnelligkeit" und „Technik". Die Analyse der Kriteriumsvalidität zeigte die größten Testunterschiede zwischen Spielern zweier unterschiedlicher Leistungsklassen für den Gesamtscore und die Techniktests Dribbling und Ballkontrolle. Da beide untersuchten Leistungsklassen aus bereits selektierten Talenten bestanden, ist die eindeutige Trennkraft der Tests höher zu bewerten als in anderen Studien, die Amateure mit selektierten Talenten verglichen (Vaeyens et al., 2006) (Coelho e Silva et al., 2010).

Die damit insgesamt nachgewiesene testheoretische Güte der Tests ist eine wichtige Voraussetzung für eine wissenschaftlich fundierte Einschätzung der aktuellen motorischen Leistungsfähigkeit der Spieler. Gleichzeitig zeigt die Vorstudie, dass die Ergebnisse der technomotorischen Diagnostik geeignet sind für die angestrebte RAE-Studie zum Zusammenhang der motorischen Leistungsfähigkeit und dem relativen Alter.

3.2.2 Zusammenfassung Vorstudie 2: Prognostische Valididät der motorischen Diagnostik


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Prognostic relevance of motor talent predictors in early adolescence: A group- and individual-based evaluation considering different levels of achievement in youth football

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Abbildung 9: Titelseite des Originalartikels publiziert in Journal of Sports Science, 34, 2269-2278

Die Analyse der prognostischen Validität eines Merkmals für die zukünftige Leistungsfähigkeit ist im Rahmen der kontroversen Debatte über die "real-world utility and possible pitfalls" (Carling & Collins, 2014, S. 1207) motorischer Tests bei der Talentselektion von zentralem Interesse. Während einige Forscher die Vorhersagekraft motorischer Tests für zukünftigen Erfolg aufgrund des komplexen Anforderungsprofils von Spielsportarten und der inter-individuellen Entwicklungsunterschiede von Nachwuchsspielern anzweifeln (Lidor, Côté & Hackfort, 2009; Pankhurst & Collins, 2013), konnten Längsschnittstudien aus dem Fußball eine generelle prognostische Relevanz fußballspezifischer Fähigkeiten und Fertigkeiten für das Erreichen zukünftiger Wettkampfniveaus auf Gruppenebene nachweisen (Gonaus & Müller, 2012; B. Huijgen, M. Elferink-Gemser, K. Lemmink & C. Visscher, 2014; Huijgen, Elferink-Gemser, Post & Visscher, 2009; Le Gall, Carling, Williams & Reilly, 2010). Da Trainer bei der Talentselektion in der Praxis Einzelfallentscheidungen treffen, müssen über die prognostische Relevanz motorischer Tests auf Gruppenebene hinaus Informationen über die Vorhersagekraft der Tests auf individueller Ebene bereitgestellt werden. Prognoseaussagen auf Einzelfallebene sind jedoch Wahrscheinlichkeitsaussagen (Ackerman, 2014), womit eine deterministische Entscheidung im Sinne von talentiert oder nicht talentiert von vornerein ausgeschlossen ist. Obwohl damit die Spezifikation fester Schwellenwerte (Cut-off-Werte) für eine motorische Diagnostik als Talentscreening-Instrument illusorisch bleibt, (Lidor et al., 2009), können Informationen über die Sensitivität und Spezifität der Diagnostik bei fiktiven Cut-off-Werten (Anteil korrekt selektierter Talente und korrekt nichtselektierter Nichttalente) für Sportverbände hilfreich sein. Eine Einsatzmöglichkeit dieser Informationen wäre die Optimierung von Talentselektionsraten zur Verteilung der verfügbaren Förderressourcen auf die talentiertesten Spieler (Vaeyens et al., 2008).

Die Studie behandelt drei Fragestellungen zur Vorhersagekraft der technomotorischen Diagnostik im DFB-Stützpunktprogramm für das Erreichen vier verschiedener zukünftiger Selektionsniveaus im bisher kaum untersuchten mittelfristigen Prognosezeitraum von der frühen bis zum Beginn der späten Adoleszenz. Auf Gruppenebene wurde die prognostische Relevanz der Tests als Mittelwertsunterschied zwischen verschiedenen Selektionsniveaus analysiert. Auf individueller Ebene wurden individuelle Selektionswahrscheinlichkeiten für das Erreichen der zukünftigen Selektionsniveaus und die Sensitivität und Spezifität der Diagnostik bei fiktiven Cut-off-Werten analysiert.

Die Stichprobe bestand aus 22,843 U12-Stützpunktspielern, die zu den Top 4% ihrer Altersklasse im deutschen Fußball gehörten. Die Ergebnisse der technomotorischen Diagnostik in der Altersklasse U12 fungierten als Prädiktoren für die zukünftigen Selektionsniveaus der Spieler in der U16 bis U19 (Jugendnationalmannschaft, Verbandsauswahl, Leistungszentrum, nicht selektiert). Das relative Alter wurde als Kovariate verwendet, um auf relative Altersunterschiede zurückgehende Leistungsunterschiede in den Prädiktoren zu berücksichtigen. Es zeigte sich jedoch kein signifikanter Einfluss der Kovariate.

Die Gruppenmittelwerte zwischen den verschiedenen Leistungsniveaus belegen die prognostische Relevanz aller Prädiktoren über einen mittelfristigen Zeitraum. Die Effektgrößen des Gesamtscores ($0{,}29 \leq d \geq 0{,}90$) waren größer als in vergleichbaren Studien (Gonaus & Müller, 2012; B. Huijgen et al., 2014) (Figueiredo, Gonçalves, Coelho e Silva & Malina, 2009a; Le Gall et al., 2010). Die Trennkraft der Einzeltests variierte zwischen den Leistungsniveaus und zeigte sich im Vergleich mit anderen Studien stichproben- und designspezifisch. Die geringen individuellen Selektionswahrscheinlichkeiten zeigten eine beschränkte Vorhersagekraft der Diagnostik für den Einzelfall auf. Diese war aufgrund der geringen durchschnittlichen Selektionsraten für höhere Leistungsniveaus nicht unerwartet (Ackerman, 2014) und deutet nicht notwendigerweise auf eine geringe prognostische Validität der Diagnostik hin. Dass Spieler mit einem Prozentrang von über 99%[10] in den Testergebnissen eine 12fach höhere Chance hatten, Jugendnationalspieler zu werden als Spieler mit einem geringeren Prozentrang, deutet darauf hin, dass die Diagnostik insbesondere für Ergebnisse auf Top-Niveau hohe prognostische Relevanz hat. Die Spezifität der Diagnostik wird bei einer simulierten Steigerung von Cut-off-Werten im Gesamtscore erhöht. Die damit gleichzeitig verursachte geringere Sensitivität würde aber einen theoretischen Verlust von tatsächlichen Talenten bedeuten.

Die Ergebnisse der verschiedenen Ansätze zur prognostischen Validität der Tests zeigen sowohl Chancen als auch Risiken einer bundesweiten Diagnostik motorischer Leistungsmerkmale. Auf Trainerseite kann die Diagnostik das geschulte subjektive Auge des gutausgebildeten Jugendtrainers bei der Talentselektion nicht ersetzten, ihm jedoch nützliche Wahrscheinlichkeitsaussagen als Zusatzinformation liefern. Aus Sicht der Sportverbände können die Ergebnisse zur Sensitivität und Spezifität eine Orientierung für die Steuerung von Selektionsraten geben.

Für die folgende RAE-Studie zum Zusammenhang zwischen dem relativen Alter und der motorischen Leistungsfähigkeit bleibt festzuhalten, dass die Ergebnisse in der technomotorischen Diagnostik über eine reliable und valide Rückmeldung zum aktuellen motorischen Leistungsstand hinaus, als Talentmerkmale eine gewisse Aussagekraft für das zukünftige Leistungspotential der Nachwuchsspieler haben.

[10] Ein Prozentrang von 99% bedeutet, dass die Leistung eines Spielers besser war als die von 99% der anderen Spieler.

3.2.3 Studie 1: Zusammenhang relatives Alter – Reife – motorische Leistungsfähigkeit

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ORIGINAL ARTICLE

The relative age effect in the German Football TID Programme: Biases in motor performance diagnostics and effects on single motor abilities and skills in groups of selected players

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Abbildung 10: Titel Page of the Original Article published in European Journal of Sport Science, 14(5), 433-442

Abstract

This study examined the disturbing effects of relative age on the talent identification process in the talent development programme of the German Football Association. The bias in the selection rate was examined via the extent of relative age effects. The bias in motor performance diagnostics was analysed by comparing the motor performance of selected players with normal motor development. The mechanisms underlying the relative age biases in motor performance were examined by modelling the direct and indirect effects of relative age on single motor performance tests for sprint, running agility, dribbling, ball passing and control and shooting. Data from 10,130 selected football players from the U12 to U15 age groups were collected in autumn 2010. The birth distribution differed significantly from the reference population with approximately 61% of the players born in the first half of the year. The selection probability was approximately two times higher for players born in the first quarter of the year than for players born in the last quarter. Revised motor performance diagnostics showed better results on average for relatively younger players. Path analysis revealed significant direct and indirect relative age effects for physiologically demanding tests and almost no effects for technically demanding tests. Large sample sizes allowed high resolution in relative age with additional informational content and multivariate modelling of the complex relationships among relative age, physical development and motor performance. The results are discussed on

how relative age affects the effectiveness and fairness of talent identification and development processes.

Introduction

The effectiveness of talent identification and development programmes (TID programmes) in sports depends on the efficient allocation of available support to the most talented youths. For this purpose, players are already scouted and selected for further developmental support at an early age (Williams & Reilly, 2000). Players are distributed into age cohorts based on cut-off dates during this process, aiming to provide homogenous groups for a fair comparison of individual performance levels and creating an age-appropriate training environment.

In conjunction with biased talent identification and less-efficient TID programmes, *the relative age effect (RAE)* has been discussed for almost three decades (Cobley, Baker, et al., 2009). The RAE is characterised by a systematically skewed birth distribution in a group of selected players. RAEs emerge, when a disproportionate high number of players born shortly after the cut-off date are selected because of their developmental advantages. RAEs reduce the efficiency of TID processes by choosing the currently best performing rather than the most talented players. Unfairly, some relatively younger talented players do not receive support because of their age handicap.

RAEs have frequently been found in athletically demanding sports, such as ice hockey (Nolan & Howell, 2010), team handball (Schorer et al., 2009), basketball (Delorme & Raspaud, 2009), rugby (Till, Cobley, Wattie, et al., 2010) and tennis (Loffing et al., 2010).

In male youth football, RAEs were found internationally in every age group at all performance stages above the club level (Meylan, Cronin, Oliver & Hughes, 2010). The extent of the RAE in youth football is moderated by the selection level. Amateur and locally selected youth teams showed RAEs with 57% to 65% of the players born in the first six months after the cut-off date (Romann & Fuchslocher, 2011b). In elite youth academies and international club tournaments, 67% to 72% of the youth players were born before mid-year (Augste & Lames, 2011; Helsen et al., 2005). The largest RAEs exist in youth national teams, with 70% to 79% of the players born in the first half of the year (Jimenez & Pain, 2008; Williams, 2010).

Currently, youth players are more frequently subjected to additional *objective tests to examine further potential football talent predictors,* some of which already have proven prognostic validity for becoming a professional in adulthood (Huijgen et al., 2009; Le Gall et al., 2010). In particular, potential physical, physiological and technical talent predictors such as height, weight, endurance, strength and sprint speed, as well as football-specific technical skills are tested to identify talented players (Williams & Reilly, 2000). Despite being more objective than evaluations of global game performance by coaches, the results of these tests are *still biased by differences in the relative age and physical development* among players. A study by Carling, le Gall, Reilly und Williams (2009) revealed that relatively older players are advanced in physical development and have better aerobic and anaerobic endurance and superior football specific strength than their younger counterparts. The lack of significant differences in sprint speed was explained by the high performance level required for inclusion in the sample. Other studies revealed that precocious players were on average taller and heavier, possessed longer legs, reduced body fat percentage and performed better in explosive strength, sprint and aerobic endurance (Figueiredo, Gonçalves, Coelho e Silva & Malina, 2009b; Vaeyens et al., 2006), but showed only minor or no advantages in football specific skills (Figueiredo et al., 2009b; Malina et al., 2005). Otherwise, relative age proved to be a significant predictor for a motor performance score, which tested several technical skills (Figueiredo et al., 2011). In this study, two-year groups with large variances in relative age were used. A study concerning the influence of relative age on the technical capacity of youth football players in de facto important one-year groups is not available yet.

Differences in the selection levels, in the age of examined players, in the bandwidth of the age groups, and the diversity in measuring biological maturity (Malina, Coelho e Silva, Figueiredo, Carling & Beunen, 2012) complicate a comparative interpretation of previous studies' results. However, some trends can be highlighted: the physical and physiological characteristics of young football players depend to a considerable extent on relative age and physical development within each age class. Technical skills in samples of selected players have weaker relationships with physical development but depend on differences in relative age within two-year groups. To optimise the effectiveness of TID, relative age, physical development and their relation to performance characteristics should be monitored (Meylan et al., 2010). Therefore, the possibly nonlinear, complex causal relationship between these variables must be taken into account. In addition, the interaction among relative age, physical development stage and football-specific performance measures depends on the specific requirements of the tests used.

The German Football Association (DFB) runs what is most likely the *world's largest sport-specific TID programme*. In the U12 category about 3.8% (5.000 competence centre players and 800 youth elite academy players) of nearly 150.000 eligible players are selected for the German TID programme. In the U12 to U15 one-year age categories, approximately 14,000 players nationwide are promoted with one additional training session per week at 366 regional competence centres, primarily to improve their motor skills (Schott, 2010). To support the talent identification and development process, the football-specific (techno-)motor abilities and skills of all selected players are half-annually tested .

To further analyze relative age biases, this study examined *the extent of RAEs* in the four core age groups from U12 to U15 after players' entrance into the TID programme. The *relative age bias in motor performance diagnostics* of already selected players must be considered for further talent development and selection processes. Therefore, the age-related performance differences within age groups were compared with the cross-sectional performance development ranging above all age groups. Subsequently, the - in relation to a postulated normal developmental curve - acceleration or retardation of global motor performance was compared between players born in different months. To develop a more substantiated understanding of the complex *mechanisms underlying relative age biases in motor performance,* the influence of relative age, directly and via physical development, on the results of five single football-specific motor tests were analysed.

Methods

Study Sample

The sample consisted of 10,130 players in the age groups U12 (year of birth 1999, N=3,606), U13 (N_{1998}=3,064), U14 (N_{1997}=2,138) and U15 (N_{1996}=2,138). Competence centres from the North-East German Football Association (except Berlin) were excluded because their age-grouping was affected by the age-grouping procedure of the regional school systems, which use cut of dates between June and September.

Measures

Based on the chronological age, the independent variable *relative age* was defined as the birth date of a player within his age group, according to January 1st as the cut-off date. The birth distribution of competence centre players was compared with the birth distribution of all eligible youth players extracted from an extended member statistics provided by the DFB (internal data request from 13.03.2011).

For a comparison with other studies, half years and birth quarters were used to analyse the extent of the RAE. Additionally, the large sample sizes in this study allowed higher resolution in relative age (months, weeks) with increased informational content, when the birth frequency was examined. For statistical procedures using metric anthropometry and motor performance variables, the statistical requirements even allowed using relative age measured in days.

Height and *weight* were gathered as indicators of physical development and used as mediators between relative age and motor performance.

The results of five motor performance tests served as dependent variables: time for a 20 m *sprint*; time for running *agility* and time for *dribbling* with a ball in a slalom course; time for *ball control* (for each test the best of two attempts counted) and passing during six passes and points for goal *shooting* accuracy and speed from eight shots (Lottermann et al., 2003). For this sample, internal consistency ($\alpha_{Cronbach}$) was high for sprint and agility (α=.95 respectively α=.91), almost acceptable for dribbling and ball control (α=.58 respectively α=.69) and low for shooting (α=.37). All tests were combined into a global – prognostically and diagnostically valid (Höner, 2010) – (techno-)motor *score*. The resulting internal consistency for score (first attempts versus second attempts) was high (α=.89). The stability values of the variables within a retest interval of six months ($r_{tt(height)}$=.96, $r_{tt(weight)}$=.96, $r_{tt(sprint)}$=.80, $r_{tt(agility)}$=.62, $r_{tt(dribbling)}$=.58, $r_{tt(ball\ control)}$=.52, $r_{tt(score)}$=.77) serve as a conservative estimate of the test-retest reliabilities. Again, the stability of shooting ($r_{tt(shooting)}$=.33) was low and nonsufficient (Höner, 2010). Consequently, the shooting test was excluded from the analysis of the single motor tests. Since, however, the shooting test increases the bandwidth of the motor score but does not affect its reliability ($\alpha_{score\text{-}shooting}$ = .89 = α_{score}), the shooting test was retained in the global motor score.

For height, weight and score, non-linear average growth curves spanning the whole age range of U12 to U15 were calculated to regard the presumably non-linear cross-sectional progress. These curves, which indicate the expected “normal” development, were built using a continuous approximation function, based on four nodes. The interpolation with a quadratic polynomial matched with the available data. To ensure the independence of the data, the nodes of the function for score, height and weight were based on the standard values for each age group, attained from the results of all former players who have been tested with the motor test battery (Lottermann, et al., 2003) in the competence centres during the scientific support of the TID programme since 2004.

Procedure

All motor performance tests for this study were conducted during the second test period of the year 2010 (27th September to 28th November) according to a standardised test manual. The tests were conducted in all competence centres and were supervised by approximately 1,000 licensed coaches and their full-time competence centre coordinators. The tests were conducted in the gym. The complete test procedure took approximately 90 minutes for each group of players. All selected players who took part in at least one test were registered. For different reasons (e.g. injury during test) 14% of players missed at least one test. Cases with missing values did not show relevant differences from cases with complete datasets in the remaining variables. All players’ parents provided informed consent for recording data and scientific usage. The ethics department of the Faculty of Behavioural and Cultural Studies at the University of Heidelberg and the scientific board of the DFB approved the implementation of this study.

Statistical analysis

All issues in this study were analysed using different statistical procedures (level of significance $\alpha=.05$). To test *the extent of the RAE*, the relative birth frequency per quarter of birth was calculated and compared with the birth distribution of all eligible youth players of the corresponding year with a chi-squared test (Goodness-of-Fit). Odds-ratios (*ORs*) between birth quarters one and four were calculated as the effect size (Cobley, Baker, et al., 2009). The linear reduction of birth rate from January to December was analysed with Pearson correlation coefficient between relative age (in weeks) and birth frequency.

The relative age bias in motor performance diagnostics within age groups of selected players was analysed in relation to the normal development of the score, height and weight. Therefore, Pearson correlations between chronological age (in days) and all three variables were calculated, including the results from all players before and after controlling for year of birth.

Biases in the performance diagnostics caused by relative age and physical development were revised in a stepwise procedure. The score, height and weight results were adjusted for the exact relative age of each player, by subtracting the observed results for each variable from the values from the normal development curve at the exact birth date of each player (step 1). Thus, the resulting differences indicate accelerated or retarded development in each variable. To account for the effects of accelerated or retarded physical development on motor performance, the resulting difference values of the score were statistically controlled for the difference values of height and weight using multiple regression analysis (step 2). As a measure of the revised motor performance, the final regression residuals of the score were standardised by their overall standard deviation (step 3).

The *mechanisms underlying relative age biases in motor performance* were examined by modelling the direct and indirect effects of relative age and physical development on single motor performance tests (sprint, agility, dribbling, ball control) with path models, calculated separately with MPLUS (Version 5.2.1) for each age group. Because of the inconsistent research results, a theory-based deduction of the allowed model paths was not possible. Thus, we randomly cut the available sample in half stratified by months and conducted a gradual path analysis with three steps. In step one, the first half of the sample was used to exploratorily create a restrictive model that fit the empirical data from a completely saturated basic model. The basic model was built with the plausible assumption that motor performance is directly and indirectly (mediated by physical development) affected by relative age. The modified chi-squared difference test for nested models and MLR estimators were used as criteria for eliminating model paths (Satorra & Bentler, 2001). In step two, the second half of the sample was used to cross-validate the covariance structure of the path model by multiple group comparison (Byrne, 2012). Third, the entire sample was used to estimate model fit and path coefficients for each age group. The model fit was determined by common fit indices (*CFI/TLI*, *RMSEA*, *SRMR*). The significance of direct and indirect effects was examined with Sobel test (Sobel, 1982). Missing values were accounted for using the FIML setting (Muthén & Muthén, 2010).

Results

Extent of RAE

Descriptive statistics for birth frequency, anthropometry and motor performance variables are presented in Table 3. Generally, the percentage of players born in the first half of the year was approximately 61% in all age groups. The birth distributions of all competence centre players differed significantly (p<.05) from the population of eligible players. The probability of being selected for the competence centres was approximately two times higher for players born in the first quarter compared with players born in the fourth quarter (1.98≤*OR*≤2.31). All age groups showed significant high linear correlations (.85≤r≤91) between birth rate and relative age.

Relative age biases in motor performance diagnostics of selected players

Chronological age correlated positively with the score (r=.59) above all age groups but had only a minimal influence after controlling for the year of birth (r=.06). In contrast, the correlation between chronological age and anthropometric variables stayed positive for height (r=.20) and weight (r=.18) after controlling for year of birth. Within each of the four age groups U12 to U15 the correlations of relative age and score (.05≤r≤.08), height (.19≤r≤.21) and weight (.17≤r≤.21) were similar.

The values of the cross-sectional development curve increased continuously, whereas the score means followed the trend of a step function, which was characterised by small performance differences within the age groups and leaps in performance between birth years (Figure 11). The means of relatively younger players lay above the normal development curve, whereas the means of relatively older players lay on or under that curve. The mean results for height and weight tended to run parallel to their corresponding normal development curves.

Table 3: *Birth Distribution and the Means of Anthropometric and Motor Variables Per Quarter of Birth in Age Groups U12 to U15*

Age group	Quarter of birth[a]	*N* (%)	χ^2	*df*	*p*	*OR [95% CI]*	r_{xy}[b]	Height (*M* ± *SD*)	Weight (*M* ± *SD*)	Sprint (*M* ± *SD*)	Agility (*M* ± *SD*)	Dribbling (*M* ± *SD*)	Ball control (*M* ± *SD*)	Shooting (*M* ± *SD*)	Score (*M* ± *SD*)
U12	4	528 (14.6)	1221.76	3	<.01	2.14 [1.93, 2.37]	0.91	146.9 ± 6.6	36.6 ± 5.4	3.72 ± 0.18	8.57 ± 0.45	11.77 ± 1.07	11.96 ± 1.71	17.6 ± 3.6	41.80 ± 2.01
	3	890 (24.7)						147.7 ± 6.2	37.5 ± 5.2	3.72 ± 0.18	8.56 ± 0.45	11.69 ± 0.96	11.91 ± 1.66	17.3 ± 3.4	41.95 ± 1.94
	2	944 (26.2)						149.4 ± 6.2	38.3 ± 5.3	3.70 ± 0.17	8.56 ± 0.43	11.7 ± 1.01	11.78 ± 1.74	17.4 ± 3.6	42.06 ± 1.97
	1	1244 (34.5)						150.3 ± 6.4	39.1 ± 5.4	3.68 ± 0.17	8.52 ± 0.43	11.63 ± 1.01	11.77 ± 1.72	17.4 ± 3.6	42.26 ± 2.02
U13	4	462 (15.1)	1090.98	3	<.01	2.11 [1.89, 2.36]	0.91	152.3 ± 7.0	40.4 ± 6.0	3.62 ± 0.17	8.33 ± 0.45	11.13 ± 0.88	10.70 ± 1.31	16.8 ± 3.8	43.64 ± 2.07
	3	737 (24.1)						152.7 ± 7.0	41.0 ± 6.0	3.60 ± 0.17	8.33 ± 0.38	11.15 ± 0.82	10.85 ± 1.48	16.5 ± 3.7	43.68 ± 1.93
	2	816 (26.6)						155.1 ± 7.5	42.2 ± 6.3	3.59 ± 0.16	8.30 ± 0.41	11.11 ± 0.89	10.89 ± 1.67	16.5 ± 3.8	43.82 ± 2.07
	1	1049 (34.2)						155.8 ± 7.7	43.4 ± 6.9	3.57 ± 0.17	8.32 ± 0.42	11.11 ± 0.87	10.78 ± 1.51	16.5 ± 3.8	43.87 ± 2.02
U14	4	328 (15.3)	741.71	3	<.01	1.98 [1.74, 2.26]	0.87	158.9 ± 7.9	45.2 ± 7.1	3.51 ± 0.15	8.21 ± 0.41	10.79 ± 0.83	10.13 ± 1.47	15.9 ± 4.2	45.02 ± 2.09
	3	512 (23.9)						159.6 ± 8.5	46.4 ± 7.8	3.48 ± 0.16	8.19 ± 0.40	10.79 ± 0.79	10.12 ± 1.34	16.0 ± 4.0	45.12 ± 2.03
	2	579 (27.1)						162.0 ± 8.3	48.1 ± 7.4	3.45 ± 0.17	8.18 ± 0.42	10.75 ± 0.78	10.11 ± 1.47	15.9 ± 3.9	45.32 ± 2.14
	1	719 (33.6)						163.0 ± 8.8	49.6 ± 8.5	3.44 ± 0.17	8.18 ± 0.39	10.78 ± 0.78	10.10 ± 1.47	16.0 ± 4.1	45.29 ± 2.01
U15	4	204 (15.4)	514.57	3	<.01	2.31 [1.96, 2.72]	0.85	165.1 ± 9.0	52.5 ± 9.7	3.39 ± 0.17	8.07 ± 0.42	10.55 ± 0.77	9.77 ± 1.19	15.7 ± 4.1	46.19 ± 2.08
	3	303 (22.9)						168.2 ± 8.4	54.8 ± 8.9	3.34 ± 0.17	8.09 ± 0.41	10.6 ± 0.68	9.73 ± 1.25	15.4 ± 3.6	46.33 ± 2.12
	2	355 (26.9)						169.5 ± 8.3	55.5 ± 8.5	3.33 ± 0.16	8.09 ± 0.41	10.59 ± 0.81	9.82 ± 1.39	15.2 ± 4.0	46.35 ± 2.30
	1	460 (34.8)						170.6 ± 8.9	56.8 ± 9.3	3.31 ± 0.17	8.08 ± 0.40	10.68 ± 0.77	9.66 ± 1.29	15.2 ± 4.1	46.49 ± 2.05

Note. For all performance variables except the score, lower values indicate better performance. [a]The quarter of birth, grouped by months: December to October (4), September to July (3), June to April (2) and March to January (1). [b]Relative age in weeks correlated with birth frequency.

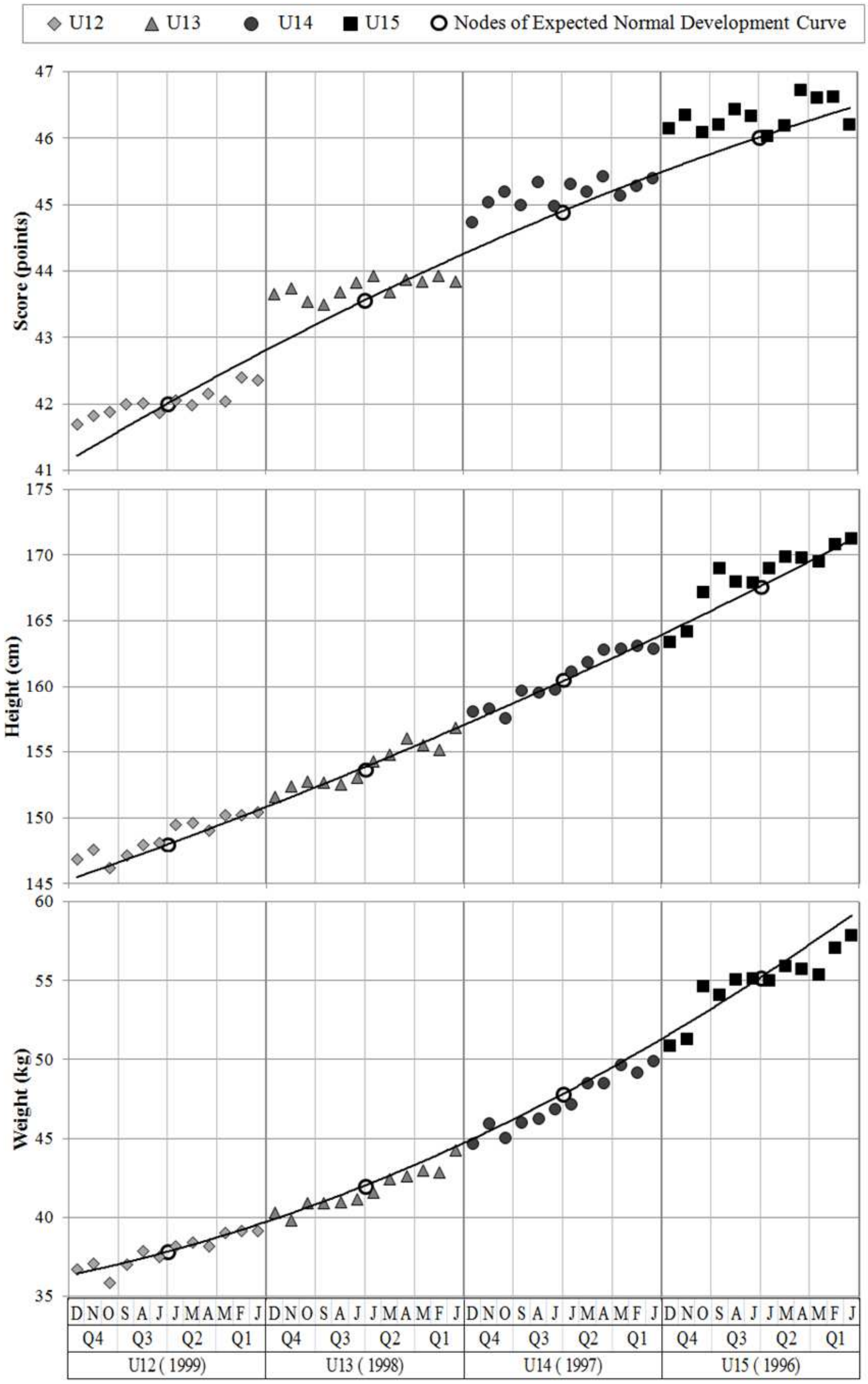

Figure 11: Means of score, height and weight by month of birth for all age groups (U12-U15) in comparison with their corresponding normal development curve (mean values of former cohorts from the years 2004-2009, nodes in the middle of each year). Months in each year are displayed from December (D) to January (J) to retain the progressive order of relative age. General deviations from the normal development curves of height and weight result from differences between actual and postulated mean births of former cohorts. For score, former cohorts additionally performed slightly lower than the actual cohort. General results are not affected.

The motor score was adapted to the exact relative age of each player and controlled for physical development. For players born in the last birth quarter, the standardised means of the revised score (d_{Dec}=.27, d_{Nov}=.29, d_{Oct}=.22) showed accelerated development of motor performance. The mean scores of relatively older players were below the expected normal development values (d_{Mar}=-.09, d_{Feb}=-.05, d_{Jan}=-.14). Standardised means of height and weight were small (|d|<.10) and did not show systematic differences between months of birth.

Mechanisms underlying relative age biases in single motor performances of selected players

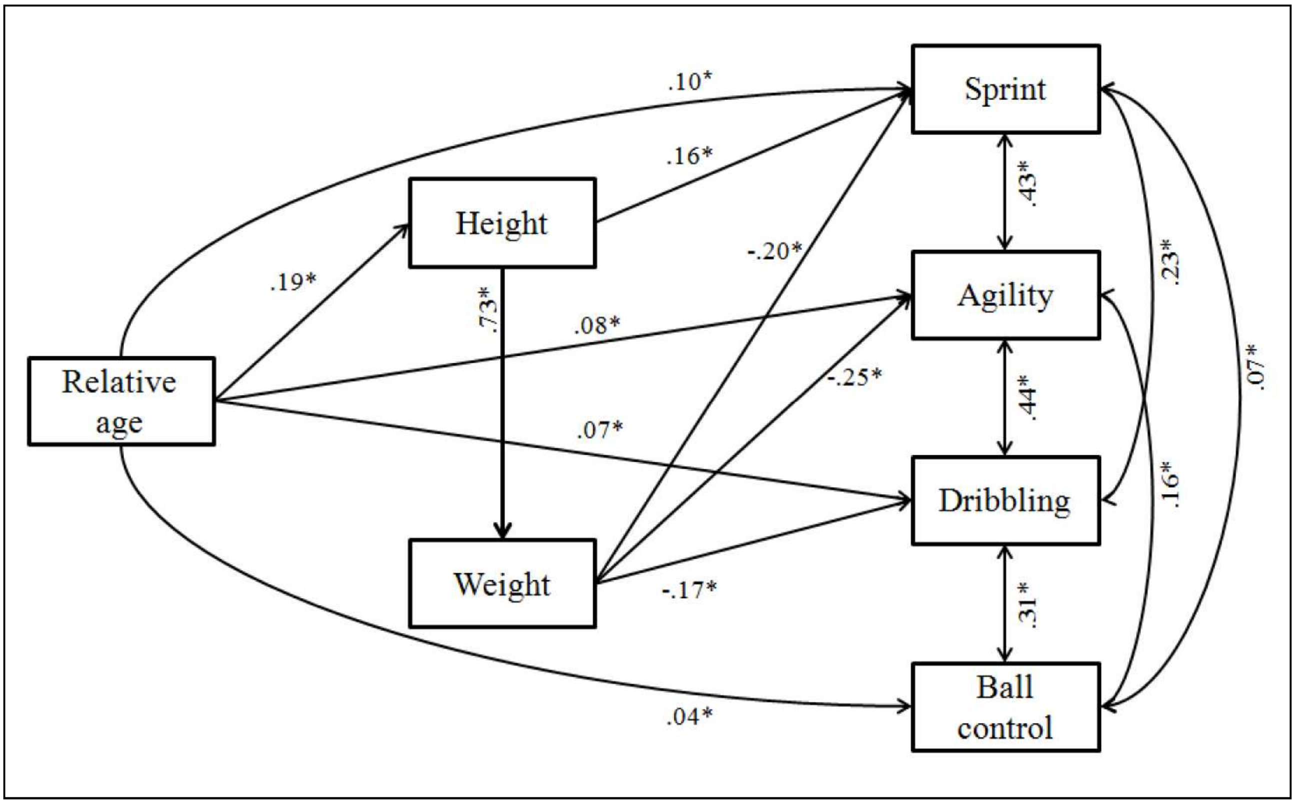

*Figure 12: Representative path model for age group U12 with standardised path coefficients estimated with the entire sample for relative age, sprint, agility, dribbling, ball control, shooting. The signs of the coefficients were reversed because lower times indicate better performances, *p<.05.*

The exploratory path analysis resulted in one model for each age group (Figure 12), exemplary for U12). Cross-validating the covariance structure of these models with the second half of the sample did not result in any significant differences (2.45≤χ^2≤10.45, *p*>.05). Finally, the calculated path models that were based on the whole sample showed acceptable model fit (4.41≤χ^2≤57.32, *CFI/TLI*>.95, *RMSEA*<.05, *SRMR*<.05).

Table 4 presents the resulting direct and indirect effects of relative age on individual motor performance tests. Relative age positively affected the sprint (U12, U14), agility (U12), dribbling (U12) and ball control (U12) performance. Furthermore, relative age had indirect positive effects on sprint (U12-U14) and dribbling (U13), mediated by height. No indirect effects via height existed for agility, ball control and shooting. Indirect effects via weight were mediated by differences in height in most cases. Indirectly via height and weight, relative age negatively affected the results of sprint (U12-U13), agility (U12-U15), dribbling (U12, U14-U15) and positively affected sprint in U15. Only two indirect effects via weight were found for ball control. Additionally, one out of two of these did not prove to be significant.

Table 4: Results of Path Analysis: Standardised Direct and Indirect Effects of Relative Age (RA) on Motor Performance

Variables		Effects			
Dependent	Independent	U12	U13	U14	U15
Height	RA	.19*	.20*	.21*	.21*
Weight	RA	--	--	.03*	--
	Height	.73*	.79*	.82*	.85*
Sprint	RA	.10*	--	.07*	--
	Height	.16*	.10*	.21*	--
	Weight	-.20*	-.12*	--	.31*
	RA via Height	.03*	.02*	.04*	--
	RA via Weight	--	--	--	--
	RA via Height & Weight	-.03*	--	--	.06*
Agility	RA	.08*	--	--	--
	Height	--	--	--	--
	Weight	-.25*	-.21*	-.18*	-.15*
	RA via Height	--	--	--	--
	RA via Weight	--	--	-.01*	--
	RA via Height & Weight	-.03*	-.03*	-.03*	-.03*
Dribbling	RA	.07*	--	--	-.03
	Height	--	-.12*	--	--
	Weight	-.17*	--	-.19*	-.21*
	RA via Height	--	-.02*	--	--
	RA via Weight	--	--	-.01*	--
	RA via Height & Weight	-.02*	--	-.03*	-.04*
Ball Control	RA	.04*	--	--	--
	Height	--	--	--	--
	Weight	--	--	-.08*	--
	RA via Height	--	--	--	--
	RA via Weight	--	--	.00	--
	RA via Height & Weight	--	--	--	--

Note. The signs of the coefficients were reversed because lower times indicate better performances. *p<.05.

Discussion

The birth rate of football players in the age groups U12 to U15 that were selected for the competence centres of the German TID programme shows a *significant RAE*: Approximately 61% of the players were born in the first half of the year (Lames et al., 2008 for similar results). Although in practice, a relevant percentage of players leaves the TID programme or is newly selected into the programme each year, the birth distributions of the four age groups were quite similar. This means, that the overall birth distribution does not change between the seasons, whereas the sub-groups of players leaving the TID programme, staying in the programme or being newly selected into the TID programme between seasons likely differ in their RAE extent.

The extent of RAE in the TID programme can be regarded as low to moderate. The RAE is considerably smaller than that in other German talent development institutions, such as the elite youth academies of professional clubs, selected regional association teams (68.2%, respectively 73.3%, data obtained by internal request from DFB, 21-10-2011), or youth national teams (78.1%; Höner, 2010). To explain the moderating function of selection level, the *transition rate* – the percentage of eligible players who were selected for the relevant sample – can be used as an indicator of the level of competition between players during the selection process, which was assumed to be a risk factor for a RAE by Musch und Grondin (2001). The transition rate for selection into the competence centres of approximately 3.3% of the players is considerably higher than the rate for elite youth academies, regional association teams (U11-U19, 0.40%; U15-U18, 0.16%) and youth national teams (U15-U19, 0.02%) and thereby confirms the preceding assumptions.

Another risk factor for RAEs is a *selection strategy* of coaches, focusing on short-term success (Jimenez & Pain, 2008). In contrast to regional associations and youth national teams, training groups at competence centres do not regularly participate in competitions. As a consequence, the *pressure to succeed in competition* for competence centre coaches is lower, implying another explanation for the moderate RAE extent. Despite advantageous circumstances during the selection process the existing bias underlines the necessity of considering the influence of relative age on performance variables during talent identification.

The analysis of *relative age bias in motor performance diagnostics* highlights the importance for considering normal development curves within groups of selected players. The subsequent revision of the motor score resulted in accelerated motor performance values for relatively younger and retarded performance for relatively older players. Because the results were also controlled for physical development, relatively younger players can be regarded as particularly skilful concerning their motor capability.

Indicators of the higher potential of the selected relatively younger players have already been shown (Baker & Logan, 2007; Wattie et al., 2007) and can be explained in two ways: to raise their chances for selection, relatively younger players must compensate for their developmental disadvantage with greater football talent. Once selected, the relatively younger players benefit from adapting their performance level to the superior performance of relatively older players within their training group. The results of the most complex tests of dribbling and ball control in this study are most likely to be related to global match performance and might therefore demonstrate performance adaptations of the relatively younger players. For isolated performance tests without a ball, such as for sprint and agility, performance adaptations appear to be unlikely. Generally, performance adaptations should be small because of the low number of additional training sessions (one per week) within the competence centres. In their club team, relatively older and relatively younger competence centre players are often both key players; therefore, further adaptation effects are most likely small.

As indicators for physical development, height and weight, adapted to the exact relative age of players, were used. Unlike skeletal age, these variables are not direct indicators of biological maturation. Above-average values for height with respect to the birthday of a player can result from either early maturation or high final height in adulthood. However, this study showed that above-average performance scores of relatively younger players were not caused by advantages in physical development status.

The overall small effects in the analysis of the *mechanisms underlying relative age-related biases in motor performance* can be explained by using a sample of players who were already chosen respecting a relatively high selection criteria (Carling et al., 2009) and by the small age range of one year for each age group used, in contrast to other studies (Figueiredo et al., 2011).

The results showed the advantage of relatively older and physically advanced players, especially in tests with high physiological demands, such as sprint and agility. This bias appears to be problematic because although physiological variables are inaccurate in predicting later success in adulthood (Le Gall et al., 2010), actual differences in global performance as well as success during selections of youth players mainly depend on these physiological variables (Coelho e Silva et al., 2010; Figueiredo et al., 2009a; Vaeyens et al., 2006). The direct effects of relative age on sprint, agility and dribbling can be explained by the physiological advantages of relatively older players as for example higher explosive power, which does not lead to changes in height and weight. Additionally, the direct effects might have been caused by a better training environment with more positive feedback and support form coaches and parents for relatively older players (Baker, Schorer, et al., 2010). The indirect effect via height on sprint most likely showed the advantage of a having a larger step length in producing better results in linear sprint. Higher weight, caused by higher height, negatively affects the performance of relatively older players in tests that require agility, such as running agility and dribbling. The direct effects of relative age on agility, dribbling and ball control in U12 that do not exist in U13 to U15 most likely reflect the increasing performance homogeneity within training groups. Performance homogeneity can be explained by adaption processes between players and by higher selection criteria in older age groups, displayed in the decrease in the sample height from U12 to U15.

Similar to tests in previous studies that were solely technically demanding (e.g. Figueiredo et al., 2009b), the ball control test showed hardly any impact from relative age. The few indirect effects on this test were small and often not significant.

In general, the results of the path analysis may partially be affected by the reliability of the tests which might have contributed to the low percentages of the explained variance. The different numbers of significant effects between agility, dribbling and ball control, however, are presumably not related to their reliability.

Despite the lower test reliability, technical skill tests separate players of different performance levels and possess prognostic validity for the selection of youth national teams (Höner, 2010) as well as for the transition from youth to elite adult football (Huijgen et al., 2009). These tests might therefore be a useful supplement to reduce the relative age-related bias in talent identification procedures.

The stepwise path model procedure meets the originally confirmatory characteristic of path analysis. However, the large sample sizes in conjunction with small effect sizes might have caused random effects in the model structure and can therefore be mentioned critically. Otherwise, only huge sample sizes enable the use of multicausal statistical procedures for an adequate analysis of the complex relationships among relative age, anthropometric measurements and several motor performance variables.

Conclusion

After the first official selection, the moderate extent of the RAE in combination with the enormous width of the DFB TID programme still facilitate developmental support for approximately 2,000 competence centre players born between October and December. Hence, the risk for overlooking relatively younger talented players (unfairness and reduced effectiveness of TID) is small. Nevertheless, selected relatively older players might not be sufficiently talented for further support (reduced efficiency of TID). When grading the extent of RAE, it has to be considered that initially being selected as a competence centre player is only the first step in a series of progressing selection levels. Small RAEs might increase during subsequent selections and lead to huge RAEs at higher selection levels. Interventional studies are required to evaluate the practicability of already intensively discussed theory-based approaches (Baker, Schorer, et al., 2010 for a review) for reducing RAEs in the future.

The direct and indirect effects of relative age on the results of single motor tests depend on the physiological and technical demands of the tests. Technical skill tests tend to be less affected by relative age in groups of selected players.

Revising relative age biases in the motor performance diagnostics shows that despite their age disadvantages, the selected relatively younger players show particularly high performance. Hence, these players must be protected during further selection processes against age-related discrimination until their developmental disadvantages disappear with time. Adapting individual data to relative age differences with normal growth curves might be utilised as a method for coaches to consider the influence of relative age on performance diagnostics during talent identification processes.

3.3 Analyse der zeitlichen Entwicklungsbedingungen Selektionsniveau und Altersklasse

3.3.1 Studie 2: RAE-Änderungen zwischen Selektionsniveaus und Altersklassen

This is the authors accepted manuscript of an article published in Sportwissenschaft [German Journal of Exercise and Sport Research]. The original article is available at https://link.springer.com/article/10.1007/s12662-017-0457-0. The manuscript is used as part of this dissertation with the permission of Springer.

Figure 13: Titel Page of the manuscript submitted to the German Journal of Exercise and Sport Research

Abstract

Relative age effects (RAEs) describe an overrepresentation of youths born early within annual age cohorts. An understanding of how talent selection procedures cause RAE emergence in talent development programmes facilitates specific advice for their reduction. This cross-sectional and longitudinal study investigated the location of RAE differences between consecutive age categories and competition levels and RAE emergence through talent selection procedures. The sample comprised 35,390 male youth football players from the German talent development programme from three seasons (2010/11-2012/13). Cross-sectional analyses showed a consistent increase of RAEs over four ascending competition levels and slightly increasing RAEs from age categories U12 to U15, with a subsequent decrease until U19. The longitudinal analyses of talent selection procedures revealed an RAE increase for players newly selected for higher competition levels and no change in RAE extent for players retained across consecutive age categories at the same competition level. Findings were used to specify common suggestions to reduce RAEs in talent development programmes.

Keywords: reduction interventions, selection processes, talent development, youth soccer

Zusammenfassung

Ein relativer Alterseffekt (RAE) liegt bei einer auf einen Stichtag bezogenen Überrepräsentation relativ Älterer in Jahreskohorten vor. Für fundierte Vorschläge zu einer Reduktion des RAEs ist es notwendig zu verstehen, wie Talentauswahlprozesse zur Entstehung des RAE in Talentförderprogrammen beitragen. Diese Studie untersucht querschnittlich und längsschnittlich, wo Unterschiede im RAE-Ausmaß zwischen aufeinanderfolgenden Wettkampfniveaus und Altersklassen auftreten und durch welche Talentauswahlprozesse eine Veränderung des RAE-Ausmaßes verursacht wird. Die Studienstichprobe enthält 35.390 Jugendfußballspieler des deutschen Talentförderprogrammes aus drei Spielzeiten (2010/11-2012/13). Die querschnittlichen Analysen ergaben eine gleichmäßige Zunahme des RAE-Ausmaßes über vier aufsteigende Wettkampfniveaus und geringfügig ansteigende RAEs zwischen den Altersklassen U12 bis U15 mit einem anschließenden Rückgang bis zur U19. Die Längsschnittanalyse der Talentauswahlprozesse zeigte eine Zunahme des RAE-Ausmaßes bei der Auswahl neuer Spieler auf höhere Wettkampfniveaus und keine RAE-Änderungen für Spieler, die auf demselben Wettkampfniveau in die nächsthöhere Altersklasse übernommen wurden. Aufbauend auf den Ergebnissen werden gängige Vorschläge für eine RAE-Reduktion spezifiziert.

Schlüsselwörter: Auswahlprozesse, Fußball, Reduktionsmaßnahmen, Talentförderung

Introduction

Annual age-grouping with fixed cut-off dates in youth sports often leads to an overrepresentation of children born early in relation to the cut-off date. This issue has been discussed for the past three decades as *relative age effects* (RAEs) (Baker, Schorer, et al., 2010; Barnsley et al., 1985). Particularly in male football, existing RAEs have been extensively reported in youth and adult players (Cobley, Baker, et al., 2009; Meylan et al., 2010; Musch & Grondin, 2001). The effect is widespread across European talent development programmes and well documented amongst currently successful youth football nations like France, Germany, Spain and Switzerland (Carling et al., 2009; Grossmann & Lames, 2013; Jimenez & Pain, 2008; Romann & Fuchslocher, 2011b). However, the causes of RAE development are still remarkably unclear (Roberts, 2014), and a noticeable reduction of RAEs in the last decade has not been achieved (Helsen et al., 2012). Therefore, research should focus on the factors that facilitate RAE emergence in talent development programmes to enable specific advice for practitioners about where and how to apply effective RAE reduction interventions in talent development programmes.

RAE emergence in talent development programmes is directly linked to *talent selection procedures (*i.e., the process of choosing some players from a larger group of youth players organised in annual age cohorts). These systematic selection procedures are meant to focus the limited promotion resources (e.g., high-level coaching) on the most promising players (Cobley et al., 2012; Delorme, Boiché, et al., 2010a; Vaeyens et al., 2008) and are to be distinguished from non-systematic exchanges of players between amateur clubs.

Environmental factors, like promotion resources, have been assigned a decisive role in talent models for the development of natural giftedness into systematic talent (Gagné, 2009; Ward et al., 2007). Consequently, a more frequent selection of relatively older players is considered unfair and inefficient (Dixon et al., 2011; Edgar & O'Donoghue, 2005). Furthermore, promoted players have a higher probability of being continuously selected at higher competition levels of talent development programmes, resulting in a “vicious circle” (Helsen et al., 2005, S. 630). This feedback loop explains the persistence of RAEs throughout talent development programmes and into adulthood (Lames et al., 2008). For this reason, studies should examine the role of selection procedures in promoting RAE emergence within talent development programmes.

The multi-tiered selection procedures in talent development programmes take place over several consecutive competition levels and age categories. This assumption applies to all football associations that conduct a systematically organised multi-layered talent development programme. The selection procedures in these programmes basically are of two different types: players selected for the first time from lower to higher competition levels (hereinafter called "newly selected") and players remaining at a certain competition level across consecutive age categories ("retained"), if coaches decide that they are worthy of further promotion (B.C. Huijgen, M.T. Elferink-Gemser, K.A. Lemmink & C. Visscher, 2014).

A means to locate selection procedures that lead to greater RAEs in talent development programmes is to find differences in the RAE extent between groups from consecutive competition levels and age categories. Previous studies' data with respect to this issue lack consistency (irrespective of the studies' original research purpose), thus underlining the need for further research. For example, the data from a comprehensive review by Cobley, Baker, et al. (2009), which aimed to find moderators of RAE extent, showed larger RAEs in older compared to younger age categories. On the other hand, subsequent studies found no RAE differences between age categories (Diaz Del Campo et al., 2010; Votteler & Höner, 2014). In addition to the study-specific explanations for the results, a methodological aspect may be responsible. Most of these studies compared groups that simultaneously differed in their respective competition levels and age categories (Jimenez & Pain, 2008; Romann & Fuchslocher, 2011b). For example, in a complex analysis of several influencing factors, Schorer et al. (2009) examined a subsample of 13- to 16-year-old regional representative players and a subsample of 16- to 19-year-old youth national players in team handball. Since the variables competition level and age category were confounded, their effect on RAE differences cannot be considered in isolation. Hence, for a definite location of RAE differences, a study's design should ensure that the respective groups only differ in either their age category or their competition level.

The foremost cross-sectional studies on RAE differences have located where in talent development programmes changes in the extent of RAE occur, but they do not reveal exactly which selection procedures cause RAEs. In this respect, one exceptional longitudinal study by Till, Cobley, Wattie, et al. (2010) in UK Rugby examined the RAE extent of players re-selected into representative teams in consecutive age categories. It showed that the retention of players through consecutive age categories was a structural feature of the Rugby talent development programme that facilitated RAE persistence across the age categories U13 to U15.

Noticeably, the longitudinal design made it possible to consider that youth players in talent development programmes are often chosen from previously selected groups ("selection within the selection", Jimenez & Pain, 2008, S. 999). This aspect is important because even a random selection of players from a preselected group with an existing RAE bias results in the maintenance of the RAE. So far, it is unclear whether the findings from Till, Cobley, Wattie, et al. (2010) are applicable to youth football, because the talent development system in UK Rugby, with each player starting again at the lowest level of competition in the next age category, differs from the structure of talent development programmes in European football (B.C. Huijgen et al., 2014; Jimenez & Pain, 2008; Romann & Fuchslocher, 2011b). Thus, a similar longitudinal study investigating the effect of different selection procedures on the emergence of RAEs in football is warranted.

The present study focuses on the talent development programme of the German Football Association (DFB), (arguably) the largest talent development programme in football worldwide (Schott, 2010). The programme includes four ascending competition levels (competence centre, youth academy, regional association and youth national team) and extends across the age categories U12 to U19. The study investigates the emergence of the RAE across these competition levels and age categories with two methodological approaches. First, cross-sectional RAE differences between consecutive competition levels and age categories are separately analysed to locate where exactly in the talent development programme changes in RAE extent occur *(objective I).* Secondly, longitudinal analyses investigate how selection procedures influence the emergence of RAEs by choosing newly selected players for higher competition levels and retaining players across consecutive age categories (*objective II*).

Methods

Sample and Design

In the German talent development programme, basic talent promotion at the lowest competition level, the competence centre, includes four age categories from U12 to U15, roughly covering early adolescence. Starting with U12, the (more) elite promotion of players to youth academies continues during middle adolescence until the age category U19. At the next competition level, regional associations play official nationwide tournaments in the four age categories U15 to U18. At the highest competition level, the youth national teams are assembled in the age categories U15 to U19. Therefore, the study design included 21 groups, each with a different competition level × age category combination, to strictly differentiate competition levels and age categories (Figure 14).

With respect to the analyses of the two types of selection procedures (objective II), Figure 14 schematically models the most important selection pathways for newly selected players (from lower to higher competition levels) and for retained players (across consecutive age categories) in the DFB talent development programme.

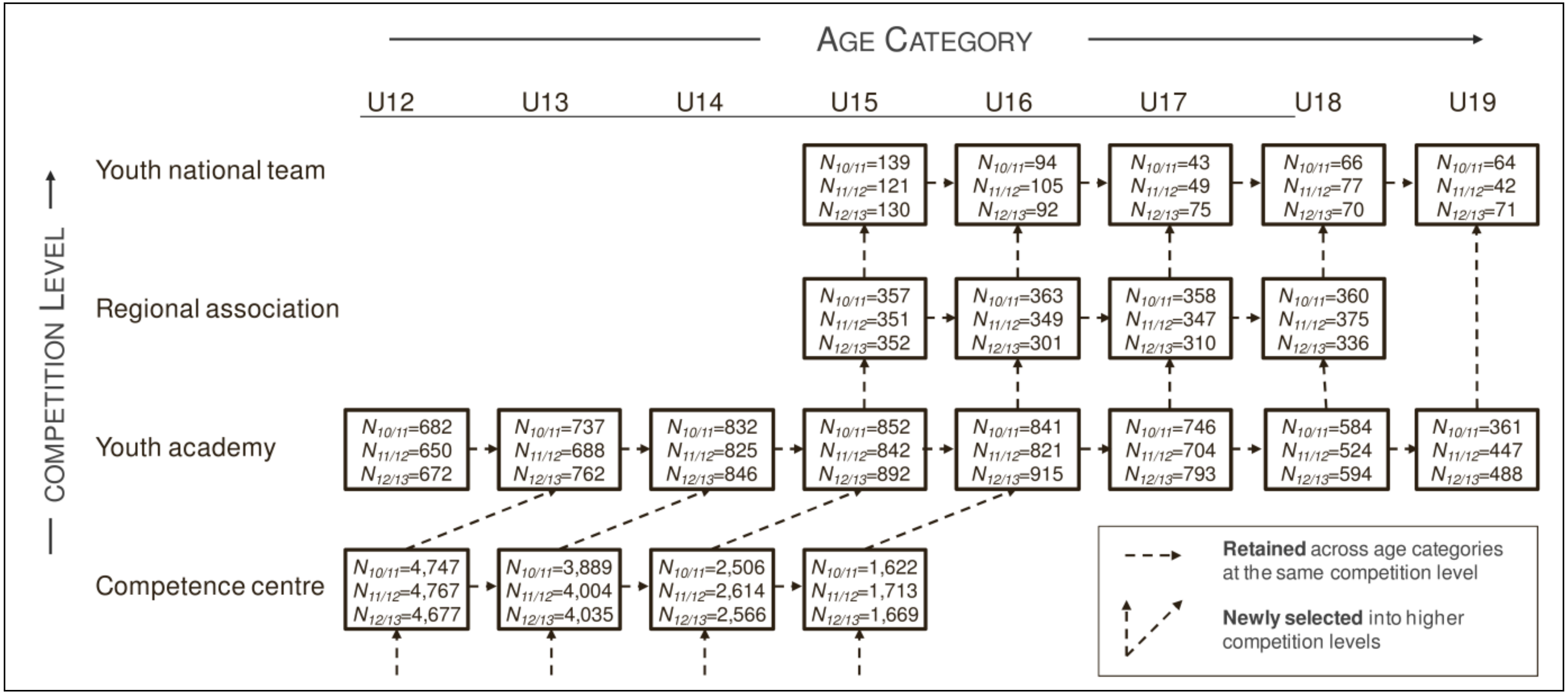

Figure 14: Structure of the German Talent Development Programme with Number of Selected Players per Season (Based on the Sample Used in this Study) and Selection Pathways Examined in this Study

The comprehensive study sample consisted of 35,390 different male players in the age categories U12 to U19 who had been selected at least once during three seasons (2010/11, 2011/12 and 2012/13) for one of the 366 competence centres, 45 youth academies, 21 regional associations teams or the youth national team. The corresponding squad lists, including players' names, birthdays, age categories and club names, have been provided by the German Football Association. The ethics department of the Faculty of Economics and Social Sciences at the University of Tübingen and the scientific board of the DFB approved the implementation of this study.

Procedure and statistical analysis

Based on players' date of birth, the independent variable relative age was defined as the chronological age of a player within his age category with January 1st as the cut-off date. Temporal resolutions of relative age in birth months, birth quarters (Q1: January-March, Q2: April-June, Q3: July-September, Q4: October-December) and birth half-years (H1: January-June; H2: July-December) were used. The temporal resolution of birth months was applied to show the relationship between relative age and observed birth frequencies while maintaining as much information about the actual distribution of players' relative age as possible (Loffing, 2016).

For both objectives, players from all three seasons were included to gain reliable results. This procedure is consistent with similar studies that analysed the RAE at high competition levels with typically small sample sizes (Romann & Fuchslocher, 2011b; Till, Cobley, Wattie, et al., 2010). Thus, the sample sizes of the U15 to U19 youth national team, for example, correspond to the number of players selected at least once for the corresponding team during the three examined seasons. Since the analyses focused on the structural influence of selection procedures on RAE development, we thereby accepted that, for instance, a player considered for the age category U15 in the season 2010/11 was repeatedly included in the analysis of the age category U16 in the following season.

Furthermore, some players are promoted at different selection levels within one season (e.g., youth academy players can play regional association tournaments and youth national team matches in the same season). We accepted that these players were simultaneously included in the sub-samples of different selection levels within one age category to evaluate the practice in the status quo. The resulting number of cases per group and the corresponding birth distribution is shown in Table 5.

Statistical analyses were conducted with SPSS 21 (IBM) and Excel 2007 (Microsoft). The level of significance was fixed at $\alpha = 0.05$ for all significance tests. As a preliminary analysis to show the relationship between relative age and observed birth frequencies, a Spearman rank correlation coefficient between month of birth and the respective birth frequency was calculated. A chi-squared test (goodness-of-fit) examined the existence of a RAE. To prevent an increased Type I risk in the goodness-of-fit test, the test compared the birth distributions in birth quarters of all examined groups with the expected birth distributions of all eligible German youth players from the corresponding birth years (Delorme, Boiché, et al., 2010b; Delorme & Champely, 2015). A chi-squared test against a hypothetical equal distribution would result in considerable deviation in the chi-squared values (difference of 0.4 to 136.9 points), without changing the main results of the significance tests however. The expected birth distributions were extracted from extended member statistics provided by the DFB (internal data request from 13-03-2011, data available as supplementary online material).

For the analyses of *cross-sectional RAE differences* between consecutive competition levels and age categories (objective I), odds-ratios (ORs) with 95%-confidence intervals were calculated as effect sizes for the RAE extent in all groups (Cobley, Baker, et al., 2009). The applied $OR_{(H1:H2)}$ displays the relative changes of being selected for players born in the first half of the year as compared to players born in the second half of the year. Therefore, the odds of players from the first half of the year (e.g., number of U12 competence centre players born in the first half year divided by the number of all eligible German U12 youth players born in the first half year) were divided by the odds of players from the second half of the year. ORs of 1.44, 2.48, and 4.27 were interpreted as small, medium and large effects, respectively, applying a transformation of commonly used limits for Cohen's d (Borenstein et al., 2011; Cohen, 1988). Significant RAE differences between consecutive competition levels or age categories were indicated by an OR outside the confidence interval limits of the lower competition level or previous age category, respectively.

For the longitudinal analyses of *newly selected and retained players* (objective II), the players' selection pathways during the three examined seasons were tracked by re-identifying their name, birth date and club name on all examined squad lists. For the horizontal and diagonal selection pathways between two consecutive seasons, the data of two selection cycles between 2010/11 and 2011/12 as well as between 2011/12 and 2012/13 were combined. For the vertical selection pathways within one season, the two selection cycles within the season 2011/12 and within the season 2012/13 were summarized.

Figure 15 shows that one group of retained players from the former age category (e.g., players retained from U12 youth academy to U13 youth academy) and one group of newly selected players from a lower competition level (e.g., newly selected from U12 competence centre to U13 youth academy) are combined into one resulting group (e.g., U13 youth academy). Retained youth academy players and players newly selected from the competence centres were examined over two selection cycles. The resulting group additionally includes a residual number of players from alternative (not examined) selection procedures.

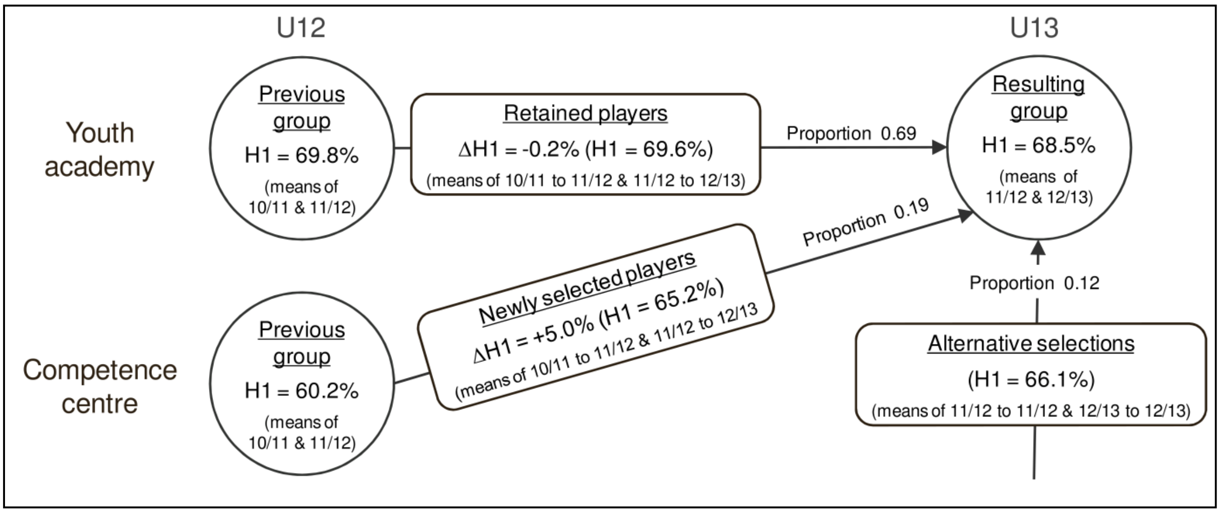

Figure 15: Exemplary Design and Results for the Longitudinal Analysis in Objective II: Players Selected into the U13 Youth Academy (YA). Proportions of Selection Procedures within the Resulting Group and Change in RAE Extent of Selected Players Compared with their Previous Competition Level or their Former Age Category. (H1: Percentage of Births in First Half-year)

First, we analysed the proportion of retained and selected players within the resulting group to determine to which degree RAE emergence in the resulting group was affected by a change in RAE extent of retained players and by a change in RAE extent of newly selected players compared to their previous competition level. Together with an additional proportion of players from alternative selections, the proportions of retained and newly selected players sum up to 1.0.

Subsequently, to investigate a change in RAE through both selection procedures, we compared the RAE extent of the retained players with the RAE extent in their previous age category and the RAE extent of newly selected players with that of their previous competition level. As a descriptive single value for the RAE extent we used the percentage of births in the first half-year (H1). As a value for the change in RAE extent for selected players, we calculated the difference ΔH1 between the RAE extent of the selected players and the RAE extent in the players' previous group.

For additional significance testing, chi-squared (goodness-of-fit) tests revealed whether the birth distribution of the selected players (in half-years) differed significantly from the birth distribution of the players' former groups. Small effects between these subsamples were to be expected because the former groups consisted of talent development programme players with an already existing RAE. In order to test these small effects with an appropriate test power of $1-\beta = .90$, large samples sizes of $N = 1,000$ would be necessary (Faul, Erdfelder, Lang & Buchner, 2007). The examined subgroups of selected players, however, were particularly small at high competition levels. Therefore, irrespective of the significance tests' results, a difference of at least 5% in the percentage of births in the first half of the year (e.g., 55% in the former total group vs. 60% in the players selected from the former group) was considered a relevant change in RAE extent. Such a difference corresponds to a small effect of $w = .10$ in the chi-squared test (Cohen, 1988).

Results

Table 5 shows the birth distribution for all examined groups. The preliminary analysis demonstrated existing RAEs in all examined groups. The Spearman rank correlation coefficient showed a clear, negative relationship between the month of birth and the birth frequency in each month ($-.99 \leq \rho \leq -.90$, $p < .01$ each). Accordingly, the relative birth frequency per birth quarter steadily decreased from birth quarter one to birth quarter four (with values ranging from Q1: 34.2-53.1%, Q2: 23.7-28.2%, Q3: 15.6-24.1% to Q4: 6.6-15.6%) and significantly differed from the expected birth distribution of all eligible German youth players ($47.23 \leq \chi^2 \leq 869.70$, $p < .05$ each). The examined groups consisted of 60-77% relatively older players with birth dates between January and June, translating into RAEs with effect sizes ranging from small to medium-large ($1.53 \leq OR_{(H1:H2)} \leq 3.52$) in all groups.

Table 5: Number of Cases, Relationship of Birth Month and Birth Frequency, Birth Distribution in Birth Quarters and Extent of Relative Age Effects for Each Group

Competition level	Age category	*N*	Birth distribution: Relationship birth month × birth frequency (Spearman-ρ)	Percentage in birth quarters (%): 1 (Jan-Mar)	2 (Apr-Jun)	3 (Jul-Sep)	4 (Oct-Dec)	χ^2	RAE extent: $OR_{(\text{half-years 1 vs. 2})}$ [95%-CI]
Competence centre	U12	14,191	-.99**	34.2	26.4	23.9	15.5	869.70**	1.53 [1.48; 1.59]
	U13	11,928	-.98**	34.2	26.1	24.1	15.6	734.47**	1.53 [1.47; 1.59]
	U14	7,686	-.98**	34.5	26.6	24.0	14.9	516.08**	1.57 [1.49; 1.64]
	U15	5,004	-.97**	35.3	26.4	23.5	14.8	416.24**	1.65 [1.56; 1.75]
Youth academy	U12	2,004	-.99**	41.4	27.2	19.9	11.4	367.95**	2.19 [1.99; 2.40]
	U13	2,187	-.99**	40.8	27.7	19.2	12.3	381.11**	2.19 [2.00; 2.39]
	U14	2,503	-.99**	43.3	26.5	18.7	11.4	541.64**	2.31 [2.12; 2.52]
	U15	2,586	-.99**	43.9	26.8	18.7	10.6	615.10**	2.47 [2.27; 2.69]
	U16	2,577	-.99**	44.5	26.2	18.9	10.5	650.35**	2.50 [2.30; 2.72]
	U17	2,243	-.99**	43.6	25.9	19.1	11.4	524.77**	2.38 [2.18; 2.61]
	U18	1,702	-.98**	42.2	26.5	20.1	11.2	359.36**	2.24 [2.02; 2.48]
	U19	1,296	-.97**	40.0	24.6	21.1	14.3	184.43**	1.83 [1.63; 2.05]
Regional association	U15	1,060	-.97**	47.5	26.4	16.5	9.5	342.02**	2.91 [2.54; 3.34]
	U16	1,013	-.98**	48.9	23.8	19.1	8.3	352.00**	2.76 [2.40; 3.17]
	U17	1,015	-.99**	46.8	26.1	17.8	9.3	316.84**	2.81 [2.45; 3.23]
	U18	1,071	-.97**	42.6	26.9	19.2	11.3	233.59**	2.32 [2.03; 2.64]
Youth national team	U15	390	-.95**	53.1	24.4	15.6	6.9	183.99**	3.52 [2.78; 4.47]
	U16	291	-.91**	52.2	23.7	17.2	6.9	129.34**	3.28 [2.50; 4.29]
	U17	167	-.92**	47.9	26.9	18.6	6.6	59.85**	3.11 [2.19; 4.42]
	U18	213	-.94**	47.4	28.2	16.4	8.0	75.24**	3.15 [2.31; 4.31]
	U19	177	-.90**	45.2	26.0	17.5	11.3	47.23**	2.47 [1.79; 3.42]

Note. ** $p<.01$

Cross-sectional RAE differences (objective I)

Overall, the differences in RAE extent between consecutive *competition levels* in Figure 16 revealed a stepwise increase of RAE effect sizes in the corresponding order of competition levels with similar increase rates for all three steps. The RAE at the (higher) competition level youth academy ($2.19 \leq OR_{(H1:H2)} \leq 2.47$) was distinctly larger than at the competence centre level ($1.53 \leq OR_{(H1:H2)} \leq 1.65$) in each of the age categories U12 to U15. Similarly, in each age category U15 to U19, the RAEs increased from the youth academies ($1.83 \leq OR_{(H1:H2)} \leq 2.50$) to the regional associations ($2.32 \leq OR_{(H1:H2)} \leq 2.91$) and again to the youth national teams ($2.47 \leq OR_{(H1:H2)} \leq 3.52$). These differences in the extent of RAE between consecutive competition levels were significant with few exceptions. Only the ORs of the U18 regional association and the U17 youth national team lay within and not above the confidence interval limits of the ORs at the previous competition level.

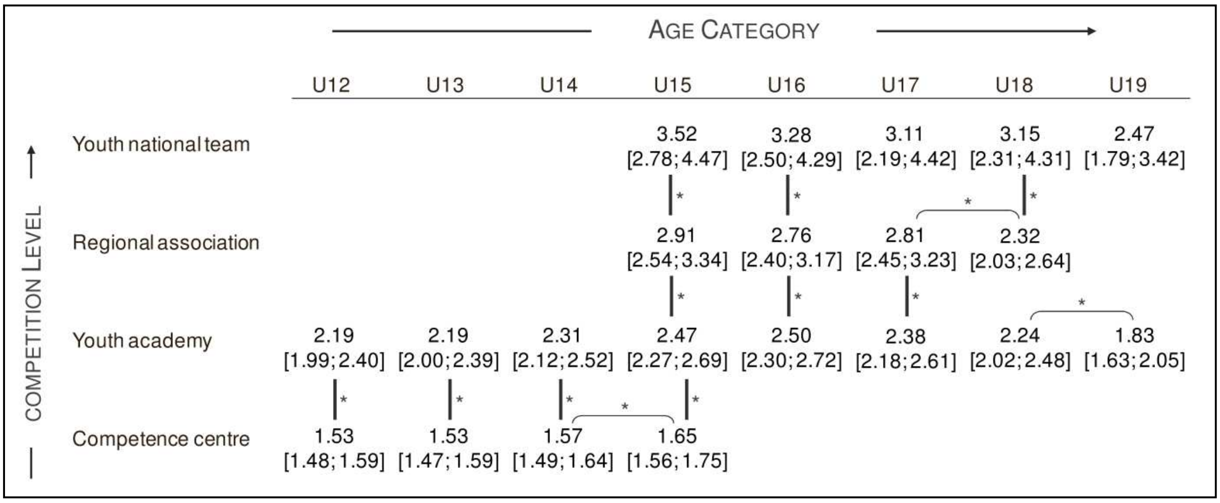

*Figure 16: Cross-sectional Differences in RAE Extent (OR with 95%-Confidence Intervals) Between Consecutive Age Categories and Competition Levels. *p<.05*

Altogether, the differences in RAE extent *between consecutive age categories* were considerably smaller and mostly non-significant. Nevertheless, a visible trend of a slight increase between consecutive age categories from U12 to U15 at the competence centres and youth academies and a decrease from U15 to U19 at the youth academies (from U16 to U19), regional associations and youth national teams was observed. The clearest RAE decreases were found between the second-oldest and oldest age categories at each competition level above the competence centres, reaching significance in two of three cases (decreasing RAE from U18 to U19 youth academies and from U17 to U18 regional associations).

Longitudinal analyses of newly selected and retained players (objective II)

To explain the complex pattern of results for objective II, Figure 15 gives an illustrative example for the age category U13 at the youth academy competition level. The U13 youth academy group was assembled from 69% (proportion of 0.69) of players retained from the previous age category (U12 youth academy) and 19% newly selected players from the lower competition level (U12 competence centre), respectively. 12% of the players in the resulting group came from alternative, not examined selection pathways (e.g., from amateur clubs to youth academies).

Players retained across the age categories U12 to U13 at the youth academy level hardly changed their RAE extent compared to their previous age category ($\Delta H1 = -0.2\%$ of births in the first half of the year), However, newly selected players for the U13 youth academies from the U12 competence centre level showed a relevant RAE increase of $\Delta H1 = +5\%$ in players born in the first half-year, thereby contributing to the RAE increase between the competence centre level and the youth academies.

Table 6 shows the *proportions* of all newly selected and retained player groups. A major proportion of at least 56% to 82% of players in the resulting groups was retained from the former age category with only one exception (proportion of .47 in U18 youth national team). As a consequence, newly selected players from lower competition levels mostly represented smaller proportions (from 11% to 38%) of the resulting groups. Exceptions with higher proportions included the newly selected players for the age category U18 at the youth national team level (.53) and the newly selected players for the U12 competence centres, U15 regional associations and U15 youth national teams (1.00, .65 and 1.00, respectively), in which no additional players from previous age categories were retained, per design.

Considering the longitudinal *changes in RAE extent* of newly selected and retained players, overall, choosing newly selected players led to a relevant increase in RAE, whereas the RAE extent of retained players showed only minor changes. Among the *retained players*, the RAE extent did not change significantly compared to the previous age categories ($\chi^2 \leq 1.26$, $0.22 \leq p \leq 0.97$).

The analysis of *newly selected players* to higher competition levels resulted in an increase in RAE extent in 11 of 13 cases. In nine of these cases, the increase in percentages of players born in the first half-year was relevant (i.e., more than 5%). The underlying differences in the birth distribution compared with the former competition level were significant for the players newly selected for the age category U15 at the competition levels youth academy ($\chi^2 = 13.20$, $p = .000$) and regional association ($\chi^2 = 4.20$, $p = .040$).

Table 6: Proportion and Change in RAE Extent for Newly selected Players from Lower Competition levels and Players Retained across Age Categories

Resulting group (Seasons 2011/12 and 2012/13 combined)				Proportions of selected players within resulting group			Change in RAE extent for selected players (RAE extent H1 in %)		
Competition level	Age category	N	RAE extent (H1 in %)	Retained	Newly selected	Alternative selections	Retained	Newly selected	Alternative selections
Competence centre	U12	9,444	61.2		1.00			(61.2)	
	U13	8,039	60.9	0.80	0.20		+0.6 (60.8)	(61.1)	
	U14	5,180	61.3	0.82	0.18		+1.2 (60.7)	(64.1)	
	U15	3,382	61.5	0.80	0.20		+0.1 (61.1)	(63.2)	
Youth academy	U12	1,322	68.8			1.00			(68.8)
	U13	1,450	68.5	0.69	0.19	0.12	-0.2 (69.6)	**+5.0** (65.2)	(66.1)
	U14	1,671	68.5	0.63	0.21	0.16	+0.5 (68.6)	**+6.0** (65.5)	(72.3)
	U15	1,734	71.6	0.68	0.15	0.17	+2.0 (72.7)	**+15.5**** (76.5)	(64.8)
	U16	1,736	70.5	0.71	0.11	0.18	+0.9 (71.0)	**+7.2** (68.7)	(69.4)
	U17	1,497	68.8	0.75		0.25	+0.4 (70.0)		(65.3)
	U18	1,118	68.9	0.79		0.21	+0.5 (70.6)		(62.3)
	U19	935	65.1	0.76		0.24	-1.3 (67.3)		(58.3)
Regional association	U15	703	76.5		0.65	0.35		**+6.1*** (77.7)	(74.3)
	U16	650	74.3	0.63	0.21	0.16	+2.8 (75.7)	+4.8 (75.3)	(67.8)
	U17	657	73.2	0.66	0.23	0.11	+1.4 (72.2)	**+7.4** (76.2)	(72.5)
	U18	711	67.9	0.56	0.25	0.19	+0.6 (73.0)	**-8.6** (60.3)	(62.7)
Youth national team	U15	251	81.0		1.00			+4.5 (81.0)	
	U16	197	76.7	0.62	0.38		+4.8 (82.5)	**-7.2** (67.1)	
	U17	124	75.7	0.77	0.23		+0.2 (72.1)	**+14.4** (87.6)	
	U18	147	75.6	0.47	0.53		+1.8 (78.3)	**+5.3** (73.2)	
	U19	113	71.7	0.79	0.18[a]	0.03	-2.8 (72.0)	**+5.9** (71.0)	(69.7)

Note. *p<.05, **p<.01 for the chi-squared (goodness-of-fit) test comparing the birth distribution of the selected players (in half-years) with the expected birth distribution in the previous group. H1: percentages of birth in the first half-year. In boldface: Change in RAE extent (H1) of at least 5%, whereby a 5%-difference corresponds to a small effect in the chi-squared test (Cohen, 1988). [a]Selection pathway from U19 youth academy to U19 youth national team, because U19 regional association does not exist.

Discussion

Given the pervasiveness of RAEs in youth football and the need to understand the causes of RAE development to derive specific and feasible reduction interventions, the current study focused on RAE development driven by selection procedures between consecutive competition levels and age categories within the German football talent development programme. Moving the state of current knowledge forward, the study presented results for the exact location of relevant changes in RAE extent. It revealed a significant stepwise increase in RAE extent between ascending competition levels. Overall, minor changes in RAE extent between consecutive age categories still revealed a systematic trend, with the exception of a decrease in the oldest age categories (objective I). Longitudinal analyses of the underlying selection procedures showed that newly selected players from lower to higher competition levels yielded an increase in the RAE extent of selected players, whereas the retention of players did not result in a change in RAE extent (objective II).

Cross-sectional RAE differences (objective I)

Considering the cross-sectional RAE differences *between competition levels* (in objective I), samples from other highly regarded football talent development programmes in England, Spain, France and Switzerland (Carling et al., 2009; Diaz Del Campo et al., 2010; Jimenez & Pain, 2008; Lovell et al., 2015; Romann & Fuchslocher, 2011b) revealed similar RAE differences between youth national teams and youth academies. In addition to these findings, the current study's strict separation of several competition levels and age categories showed that relevant changes in RAE extent take place between each of the consecutive competition levels in a similar amount and irrespective of age category.

With respect to the smaller and mostly non-significant cross-sectional RAE differences *between age categories*, other youth football studies showed similarly small differences for the age categories U11 to U18 (Diaz Del Campo et al., 2010; Helsen, Starkes & Van Winckel, 1998). Despite the small differences, a trend of increasing RAEs from U12 to U15 and decreasing RAEs in the higher age categories was still visible at each competition level. Furthermore, the study design allowed for an unambiguous assignment of differences in RAE extent. Thus, the resulting trend across age categories is more reliable than in studies where, due to other research purposes, some confounding occurred (Cobley, Baker, et al., 2009).

The most noticeable decrease in RAEs in this study between U18 and U19, was even more pronounced in another study examining the youth national teams participating in the UEFA championships in the year 2000 (U16: birth percentages in first half-year H1 = 73.2%, U18: 60.4%, U21:

49.7%) (Helsen et al., 2005). The study of Helsen et al. (2005), however, did not discuss whether the change in cut-off dates for some participating nations three years before the UEFA tournament, with a subsequent overlap of two different RAEs (Helsen, Starkes, & Van Winckel, 2000; Ostapczuk & Musch, 2013), contributed to the more pronounced RAE decrease between the U16 and U21 national teams.

Irrespective of differences in the degree of the RAE decrease, the attenuation of RAEs in older age categories found in youth football studies is in line with smaller but still existing RAEs (H1=57%) in all European professional football leagues in adulthood (Besson et al., 2013). An attenuation of RAEs in older age categories and a higher probability of already selected relatively younger players of becoming professionals in adulthood has already been observed in other studies (Carling et al., 2009; Schorer et al., 2009). The results of these studies indicate that after reaching high competition levels in talent development programmes, relatively younger players have better long-term career chances than relatively older players. Competing against superior, relatively older opponents may provide relatively younger players with a beneficial training environment (Baker, Schorer, et al., 2010), resulting, for example, in the development of superior technical skills (Votteler & Höner, 2014). An additional benefit for relatively younger players may be the development of an advantageous psychological disposition (McCarthy et al., 2016). Nevertheless, these assumptions are rather speculative and should be more closely addressed in future research.

Longitudinal analyses of newly selected and retained players (objective II)

Research designs that longitudinally track players' selection pathways to detect changes in RAE extent were not applied in previous RAE studies in youth football. The longitudinal analyses showed that *newly selected players* increased the extent of RAE compared to the lower competition level. In combination with the cross-sectional RAE differences between competition levels (objective I), the current study showed that RAE emergence in talent development programmes is an additive effect of tiered selection procedures irrespective of the examined age category.

Although the RAE increase between competition levels was of comparable extent, different mechanisms within each selection procedure may be responsible. The initial preference for relatively older players during selection from amateur levels has been frequently attributed to maturity-related performance advantages of relatively older players (Baker, Schorer, et al., 2010; Furley & Memmert, 2016; Meylan et al., 2010). These performance differences, however, become considerably smaller within the increasingly homogeneous group of already selected players in talent development programmes (Carling et al., 2009; Skorski, Skorski, Faude, Hammes & Meyer, 2016; Votteler & Höner, 2014). Therefore, an additional increase of RAEs during consecutive selections should have further underlying mechanisms, such as an increased focus on contemporary performance differences caused by greater pressure to succeed in team competition at higher competition levels (Hill & Sotiriadou, 2016; Jimenez & Pain, 2008). Consistent with this assumption, relatively older teams playing in the highest German youth league are more successful compared with relatively younger teams (Augste & Lames, 2011; Grossmann & Lames, 2013).

The longitudinal analyses of *retained players* revealed major proportions of retained players with minor changes in the RAE extent This result can easily be connected to the small RAE differences across age categories at each competition level found for objective I and is nearly identical to the results from Till, Cobley, Wattie, et al. (2010) in UK rugby. Therefore, the rugby study's conclusion that retention is a main mechanism of the persistence of RAE (Till, Cobley, Wattie, et al., 2010) can be extended to youth football in the examined age categories U12 to U19 and at all competition levels. The persistent RAEs of retained players may reflect coaches' increased awareness of already selected players or their self-confident opinion, having already selected the most talented players (Sherar et al., 2007).

A different theoretical explanation can be derived from Gagné's theoretical model of talent development (Gagné, 2009), in which developmental support (e.g., top-level coaching) is an important aspect of systematically developing natural (football) giftedness into talent. In Gagné's terms, additional talent promotion for groups with an existing RAE transforms a former uniform distribution of giftedness into a skewed distribution of talent (with more talented relatively older players). Thus, the retention of more relatively older players in consecutive age categories for all competition levels may simply reflect the actual distribution of talent at the corresponding competition level.

Consequences for RAE reduction interventions

According to the preceding theoretical explanation, reduction interventions should aim at an early prevention of RAE emergence. Furthermore, the findings of this study point out that reduction measures should focus on newly selected players from lower competition levels in all age categories.

A common reduction proposition is to implement quotas for the birth distribution of selected players (Barnsley & Thompson, 1988). However, the results of the current study stress that a player quota aiming at a uniform distribution of selected players' birth months is too simplistic and may have unintended negative consequences (Wattie, 2013).

With respect to the assumption of an already skewed distribution of talent (with more talented relatively older players) at higher competition levels, player quotas should consider the extent of RAE bias already present at the previous competition level. For example, at the competence centre level the existing RAE of about 60% of births in the first half-year should be regarded as the actual distribution of talent. Thus, quotas for the selection of new players from competence centres to youth academies should consider this RAE extent of 60% as a baseline. A deterministic baseline, however, does not fit well with the rather probabilistic disadvantage (i.e., some relatively younger players are promoted at higher competition levels) of relatively younger players (Wattie, 2013). Therefore, feasible quotas for practice should include enough freedom to consider that the birth distribution of gifted players in small groups does not necessarily follow the theoretical uniform distribution of giftedness.

Additionally, the group of selectable players gets even smaller when coaches have to select players, like goalkeepers, according to their playing position. Since coaches' willingness to apply player quotas can be outweighed by various pressures to select certain players (Hill & Sotiriadou, 2016), quotas should consider the underlying conditions for the selecting coach (in clubs or associations).

Given that an already existing RAE and its probabilistic nature are considered, and recognizing positional constraints for player selection as well as other factors influencing coaches' selection strategy, the implementation of players quotas provides a feasible and effective solution for reducing the extent of RAEs. If the conditions for player quotas are not satisfactory (e.g., small number of selectable players), "human solutions" (Wattie, 2013, S. 13) to increase coaches' awareness of players' relative age, for example age-ordered numbering of players' shirts (Mann & van Ginneken, 2016), should be preferred.

Furthermore, from a sports association's perspective, some unfairness and inefficient distribution of talent promotion resources due to an existing RAE does not automatically translate into a less effective talent development programme. Indeed, recent international youth and adult successes demonstrated the talent development programmes of France, Germany, Spain and Switzerland to be effective in producing highly-qualified youth players for the professional level despite an existing RAE (Carling et al., 2009; Jimenez & Pain, 2008; Romann & Fuchslocher, 2011b).

In Germany, the enormous breadth of the programme guarantees developmental support for a high number of relatively younger players (e.g., approximately 2,000 players from the fourth birth quarter in the U12 to U15 competence centres) and thereby reduces the risk of overlooking highly talented relatively younger players at that level (Votteler & Höner, 2014). Nevertheless, a reduction of RAEs should be considered with regard to further optimization of the distribution of financial and personal resources in talent development programmes. For example, an appropriate distribution of training time and well-educated coaches not for the relatively older but rather for the most gifted players may increase the efficiency of talent promotion at lower competition levels.

Strengths and limitations

Overall *strengths* of the present study lie in its comprehensive, representative data set, and its examination of the whole German soccer developmental system. The results of the study were highly consistent and can be regarded as reliable and representative because the sample of 35,390 players is close to a total survey of all German talent development programme players from three seasons.

Limitations of this study derive from deviations between the examined structure of selection procedures and actual selection pathways in practice. The study examined only the most important and nationally representative selection pathways of systematic selections in the German talent development programme. Therefore, some pathways within the programme as well as non-systematic selections between amateur clubs could not be considered. Most important may be the fact that the study design did not include the selection procedures between amateur clubs and the competence centres. However, these selection procedures covering the initial entrance into the talent development programme comprise several regional peculiarities (e.g., preceding selections for local district teams) and are therefore difficult to include in a consistent research design. Future research should more closely address the selection procedures between amateur clubs and the first stages of talent development programmes to understand how RAEs initially emerge.

Conclusion

This study is part of the ongoing process to extend RAE research beyond the initial proof of its existence to an explanation of its underlying causes. Despite three decades of RAE research, RAEs remain as persistent as ever (Helsen et al., 2012). Therefore, further knowledge about the causes of RAE development is necessary to provide specific and feasible scientific advice for a reduction of RAEs in practice. In this light, the current study assumed that selection processes between consecutive age categories and competition levels have an important role in the development of relative age effects in talent development programmes in youth football. Under this assumption, the study identified where relevant changes in RAE extent occur between consecutive competition levels and age categories within the German talent development programme. Furthermore, it showed how talent selection processes cause longitudinal changes in RAE extent.

Key findings of the study's cross-sectional part were a stepwise increase in the extent of RAE across consecutive competition levels irrespective of the examined age category and minor changes between consecutive age categories at all competition levels. The study's longitudinal analyses revealed that the choice of newly selected players for higher competition levels caused an increase in RAE extent whereas the retention of players from former age categories did not change the RAE extent. Overall, the study showed that the occurrence of RAEs in the German football talent development programme spans all age categories and competition levels and is caused by multiple tiered selection processes over time. These results were used to specify the suggestion of player quotas as a possible intervention to reduce RAEs in talent development programmes.

4 Fazit und Ausblick

Trotz der langjährigen Forschung zum RAE und der mehrfach geäußerten öffentlichen Kritik an seinen negativen Folgen gelten die Mechanismen der RAE-Entstehung immer noch als relativ unklar und bleibt seine Verbreitung in der Praxis seit Jahrzehnten unverändert (Helsen et al., 2012; Roberts, 2014). Ziel der vorliegenden Arbeit war es daher, den Forschungsprozess zum RAE über den Nachweis seiner Existenz hinaus zu einer Erklärung seiner Entwicklungsursachen fortzuführen. Dazu sollten die Ursachen der RAE-Entstehung im Nachwuchsfördersystem des Deutschen Fußball-Bunds erforscht werden, um darauf aufbauend gezielte und realisierbare Interventionsmaßnahmen für die Praxis abzuleiten. Vor dem theoretischen Hintergrund eines Modells zu individuellen Bedingungen sowie Aufgaben- und Umweltbedingungen der RAE-Entstehung von Wattie et al. (2015) wurden zwei empirische Studien zum RAE im DFB-Nachwuchsfördersystem durchgeführt.

4.1 Zusammenfassung der empirischen Studien

Zentrales Ergebnis der ersten Studie zum RAE ist, dass die bereits selektierten Nachwuchstalente nahezu keine motorischen Leistungsunterschiede zwischen relativ Älteren und relativ Jüngeren aufweisen. Auf Amateurniveau fanden andere Studien hingegen die erwarteten Leistungsvorteile relativ Älterer und biologisch reiferer Nachwuchsfußballer vor (Bliss & Brickley, 2011; Carvalho, Eisenmann & Malina, 2012; Gastin & Bennett, 2013; Gil et al., 2014). Damit bestätigt das Ergebnis der Studie die theoretische Modellannahme, dass der Zusammenhang zwischen den individuellen RAE-Bedingungen relatives Alter, körperliche Reife und motorische Leistungsfähigkeit von der zeitlichen Entwicklungsbedingung Selektionsniveau beeinflusst wird.

Ein weiteres zentrales Ergebnis der Studie ist, dass die motorische Leistungsfähigkeit über mehrere Altersklassen hinweg den Verlauf einer „Treppenfunktion" mit geringen Leistungsunterschieden innerhalb der Altersklassen und großen Leistungssprüngen zwischen den Altersklassen zeigt. Der Vergleich dieser Treppenfunktion mit einer zu erwartenden Entwicklungskurve motorischer Leistungsfähigkeit über die Altersklassen U12 bis U15 verdeutlicht, dass die um relative Altersunterschiede statistisch bereinigte motorische Leistung relativ Jüngerer durchschnittlich höher einzustufen ist als die relativ Älterer. Da die Studie auch ausschließt, dass relativ Jüngere ihren Altersnachteil innerhalb der Stichprobe durch eine körperliche Frühentwicklung kompensieren, ist der Schluss zulässig, dass relativ Jüngere motorisch besonders talentiert sein müssen, um beim ersten Selektionsprozess zur Aufnahme in das DFB-Talentförderprogramm berücksichtigt zu werden. Aus diesem Ergebnis lässt sich die Vermutung ableiten, dass relativ Jüngere, die es schaffen, trotz ihres Altersnachteils bei Selektionsmaßnahmen berücksichtigt zu werden, besonders gute Chancen für ihre langfristige Karriereentwicklung haben (Baker, Schorer, et al., 2010). Empirische Unterstützung erhält diese Annahme durch die Feststellung höhere relativer Übergangsquoten relativ Jüngerer vom Jugendbereich in den Erwachsenenbereich (Le Gall et al., 2010; McCarthy et al., 2016; Skorski et al., 2016), höhere Einstufungen auf Draft-Listen[1] (Coutts, Kempton & Vaeyens, 2014; Deaner, Lowen & Cobley, 2013), höhere Gehälter (Ashworth & Heyndels, 2007) sowie durch bessere und längere Karrieren relativ Jüngerer (Ford & Williams, 2011; Schorer et al., 2009). Eine Erklärung für die langfristig besseren Karrierechancen selektierter relativ Jüngerer ist, dass sie um im Konkurrenzkampf mit den körperlich bevorteilten relativ Älteren zu bestehen, langfristig wertvolle technische und taktische Fähigkeiten sowie besondere psychologische Persönlichkeitseigenschaften entwickeln (Baker, Schorer, et al., 2010). Eine empirische Analyse dieser Vermutung steht jedoch noch aus.

Die zweite Studie zum RAE untersuchte den Einfluss der im theoretischen Modell als zeitliche Entwicklungsbedingungen integrierten Merkmale Selektionsniveau und Altersklasse bei der RAE-Entstehung. Grundannahme der Studie war, dass die für die RAE-Entstehung relevanten Talentselektionsprozesse jeweils zwischen aufeinanderfolgenden Selektionsniveaus und Altersklassen stattfinden. Als zentrale Talentselektionsprozesse wurden die Selektion neuer Spieler von einem tieferem auf ein höheres Selektionsniveau und die Übernahme von Spielern zwischen Altersklassen desselben Selektionsniveaus untersucht. Eine querschnittliche Analyse ergab eine gleichmäßige Zunahme des RAE über vier aufsteigende Selektionsniveaus. Die verschiedenen Selektionsniveaus zeigten ein mit anderen Fußballverbänden vergleichbares RAE-Ausmaß (Anteil von Nachwuchsspielern aus der ersten Geburtsjahreshälfte: Stützpunktprogramm ≈60%, Leistungszentrum ≈69%, Verbandsauswahlmanschaften ≈72% und Jugendnationalmannschaften ≈75%). Die deutlich kleineren RAE-Unterschiede zwischen aufeinanderfolgenden Altersklassen zeigten einen dennoch zuverlässigen Trend der RAE-Zunahme von der Altersklasse U12 bis zur U15 mit einem anschließenden Rückgang bis zur höchsten Altersklasse U18 bzw. U19 auf jedem Selektionsniveau. Vor dem Hintergrund eines relativ inkonsistenten Forschungsstands, zeigen die stabilen Ergebnisse der Studie mit einer repräsentativen Stichprobe auf, wie die RAE-Entwicklung alle Altersklassen und Selektionsniveaus eines Nachwuchsfördersystems umspannt und dass sie ein sich verstärkender Effekt eines mehrfach gestuften Selektions- und Förderprozesses ist.

[1] College-Spieler werden in Nord-Amerika vor einer Verpflichtung durch Profi-Teams von Experten bezüglich ihres sportlichen Wertes auf sogenannten Draft-Lists geordnet.

Die Längsschnittanalyse der Talentauswahlprozesse zeigte auf allen Selektionsniveaus eine Zunahme des RAE-Ausmaßes bei der erstmaligen Auswahl neuer Spieler auf höhere Selektionsniveaus und keine RAE-Änderungen für Spieler, die auf demselben Selektionsniveau in die nächsthöhere Altersklasse übernommen wurden. Da nach den Ergebnissen der ersten empirischen Studie keine motorischen Leistungsunterschiede zwischen relativ jüngeren und älteren Spielern nach der ersten Selektion in die DFB-Stützpunkte mehr bestehen (Votteler & Höner, 2014), müssen für die weitere Zunahme des RAE bei Talentselektionsmaßnahmen für höhere Selektionsniveaus andere Bedingungen verantwortlich sein. Mögliche Annahmen hierzu, wie z. B. ein zunehmender Erfolgsdruck für Trainer, sind aktuell noch spekulativ und müssen in zukünftigen empirischen Studien geprüft werden.

Als Erklärung für die Beständigkeit des RAE-Ausmaßes bei der Übernahme von Spielern in die nächsthöhere Altersklasse wird in der zweiten Studie diskutiert, dass das bestehende RAE-Ausmaß in der vorherigen Altersklasse die tatsächliche Verteilung des fußballerischen Talents wiederspiegelt (Votteler & Höner, 2016). Dies wird damit begründet, dass die ursprüngliche Gleichverteilung sportlicher Begabung durch die Förderung von Spielergruppen mit vorhandenem RAE bereits in eine schiefe Verteilung sportlichen Talents mit mehr talentierten relativ älteren Nachwuchsspielern transformiert wurde. Eine Interventionsmaßnahme zur Reduktion der bestehenden Schiefe in der Geburtenverteilung stände demnach im Widerspruch zur hypothetischen Verteilung des Talents bei Spielergruppen mit vorhandenem RAE. Vielmehr sollten Interventionsmaßnahmen darauf abzielen, bei der erstmaligen Selektion von Spielern auf höhere Selektionsniveaus eine Zunahme des RAE-Ausmaßes zu vermeiden.

4.2 Ausblick auf zukünftige RAE-Forschung

Bei der Konkretisierung des theoretischen Modells von Wattie et al. (2015) für die empirischen Studien dieser Dissertation wurden Einschränkungen auf die Sportart Fußball, männliche Nachwuchsspieler und das DFB-Nachwuchsfördersystem vorgenommen (vgl. Abschnitt 2). Die Ergebnisse der empirischen Studien besitzen damit Geltung für Nachwuchsfördersysteme aus Sportarten mit ähnlichem Anforderungsprofil, ähnlicher Popularität und vergleichbarer Ausbildungsstruktur wie Fußball in Deutschland. In Frage kommen dafür beispielsweise andere große europäische Fußballverbände wie Spanien oder Frankreich sowie ähnliche physisch-körperbetonte Sportarten mit großer nationaler Popularität wie Rugby in England. Bei Transfers in andere Bereiche muss eine eingeschränkte Gültigkeit der Erkenntnisse in Kauf genommen werden. Beispielsweise werden im deutschen Handball, anders als bei den Jahreskohorten im Fußball, in einer Altersklasse immer die

Spieler zweier Jahrgänge zusammengefasst. Eine Studie von Schorer, Wattie und Baker (2013) konnte zeigen, dass es aufgrund dieser Altersklasseneinteilung zusätzlich zum RAE auch einen „constant year effect“ im deutschen Jugendhandball gibt, bei dem der ältere Jahrgang einer Altersklasse überrepräsentiert ist. Obwohl die Spielsportarten Fußball und Handball viele gemeinsame Bedingungen aufweisen, sind die Ergebnisse der vorliegenden Arbeit nicht universell auf das deutsche Nachwuchsfördersystem im Handball übertragbar. Damit zeigt sich generell, dass die gezielte Variation einzelner individueller, Aufgaben- und Umweltbedingungen der RAE-Entstehung als Ausgangspunkt für zukünftige RAE-Forschung verwendet werden kann.

Die zeitlichen Entwicklungsbedingungen Altersklasse und Selektionsniveau wurden in den empirischen Studien ebenfalls eingeschränkt auf den Jugendbereich mit den Altersklassen U12 bis U19 und die Selektionsniveaus oberhalb des Amateurlevels. Eine Ausweitung der Bedingungen auf die Übergangsphase in den Erwachsenenbereich bietet neue Forschungsansätze. Hochinteressant ist beispielsweise die Fragestellung, warum relativ jüngeren Nachwuchsathleten, die bei den Talentselektionsmaßnahmen im Jugendbereich berücksichtigt wurden, mit relativ größerer Häufigkeit den Sprung in den Profibereich schaffen als relativ Ältere (Le Gall et al., 2010; McCarthy & Collins, 2014; Skorski et al., 2016). Ein möglicher Mechanismus dieser Umkehr des RAE ist, dass relativ Jüngere durch die ständige Herausforderung mit relativ Älteren zu konkurrieren, langfristig vorteilhafte psychische Dispositionen ("mental toughness", McCarthy et al., 2016, S. 1464) erwerben.

Ein weiterer Ansatzpunkt für Studien sind die RAE-Bedingungen, die im Rahmen dieser Dissertation nicht untersucht wurden. Im Bereich individueller Bedingungen gilt der Einfluss von Selektionsprozessen auf die psychologischen Persönlichkeitseigenschaften selektierter oder nicht selektierter Nachwuchsathleten als wichtiger Mechanismus der langfristigen RAE-Entwicklung (Hancock, Adler, et al., 2013). Im Bereich der Umweltbedingungen sind der Einfluss der Selektionsstrategie des Trainers und Möglichkeiten zur Manipulation dieser Selektionsstrategie bisher unzureichend erforscht. Die Ergebnisse einer ersten Studie deuten an, dass eine direkt auf den Trainer abzielende Interventionsmaßnahme, z. B. eine Aufklärung über die Existenz des RAE und seiner negativen Folgen, wirkungslos ist, wenn die Selektionsstrategie des Trainers von anderen Umweltbedingungen, wie einem hohen kurzfristigen Erfolgsdruck in der jeweiligen Talentförderinstitution, beeinflusst wird (Hill & Sotiriadou, 2016). Damit wird zugleich ersichtlich, dass bei der Evaluation möglicher Maßnahmen zur Reduktion des RAE neben deren Machbarkeit und Effektivität dieser Maßnahmen auch unerwünschte Interaktionen mit anderen RAE-Bedingungen Beachtung finden müssen (vgl. Wattie, 2013).

Eine weitere Forschungsperspektive sehen Wattie et al. (2015) in der Anwendung anderer statistischer Ansätze auf die RAE-Problematik. Vorhersagen zur Wirkung von Entwicklungsbedingungen auf die RAE-Entstehung für den Einzelfall sind, ähnlich wie bei der Vorhersage zukünftigen sportlichen Erfolgs über die Ergebnisse motorischer Tests (Höner & Votteler, 2016), immer probabilistischer Natur. Insofern erscheint es notwendig, die bisher zumeist lineare statistische Modellierung der Zusammenhänge bei der RAE-Entstehung um probabilistische Ansätze zu erweitern. Der sogenannte „personenorientierte“ Ansatz bietet als Kombination einer Cluster-Analyse ähnlicher Merkmalstypen mit anschließender logistischer Regression eine multivariate probabilistische Methode (Bergman & Trost, 2006; von Eye & Bogat, 2006) und hat sich in der Talentforschung bereits bewährt (Zibung & Conzelmann, 2012).

4.3 Interventionsmaßnahmen zur Reduktion des RAE

Kategorien von Interventionsmaßnahmen in der wissenschaftlichen Diskussion

Die in bisherigen Studien publizierten Vorschläge für Interventionen zur Reduktion des RAE zielen auf die Umweltbedingungen Altersklasseneinteilung anhand eines Stichtags, strukturelle Rahmenbedingungen der Talentselektion und den Trainer als Verantwortlichen für die Talentselektion ab (Andronikos, Elumaro, Westbury & Martindale, 2016; Baker, Schorer, et al., 2010).

Vorschläge zur Änderung der *Altersklasseneinteilung* anhand eines Stichtags sind verschiedene Varianten rotierender Stichtage (Spieler sind im Verlauf ihrer Nachwuchskarriere zeitweise relativ älter und zeitweise relativ jünger) oder eine Einteilung der Nachwuchsathleten nach dem biologischen Entwicklungsstand (Hurley, Lior & Tracze, 2001; Musch & Grondin, 2001). Der logistische Aufwand dieser Vorschläge stellt die für ihre Umsetzung verantwortlichen Nachwuchsfördersysteme jedoch vor sehr große Herausforderungen (Baker, Schorer, et al., 2010). Eine weniger drastische Änderung der Altersklasseneinteilung ist die im Schweizer Amateurfußball eingeführte „Carte Blanche“ (Schweizerischer Fußballverband, 2016). Die Regelung erlaubt, dass ein im Entwicklungsstand deutlich zurückliegender Nachwuchsspieler für ein Jahr in die darunterliegende Altersklasse zurückgestuft werden kann. Allerdings besteht diese Option nur für die Ebene Amateurverein und nicht für die höheren Selektionsniveaus des Nachwuchsfördersystems.

Als Interventionsmaßnahme für die *Struktur eines Nachwuchsfördersystems* wurde vorgeschlagen, die ersten Talentselektionen in den Zeitraum nach der Pubertät zu verlagern (Dawid & Muehlheusser, 2015; Güllich, 2014; Güllich & Emrich, 2012). Diese Maßnahme hat das Ziel, den Trend einer frühzeitigen systematischen Talentselektion umzukehren. Damit würde eine RAE-Entstehung während des aufgrund großer biologischer Entwicklungsunterschiede riskanten Zeitraums Pubertät verhindert werden. Gleichzeitig könnte man damit einen frühzeitiger Sportartenaustritt von Nachwuchsathleten, die nicht bei Talentselektionsmaßnahmen berücksichtigt wurden, vermeiden (Baker, Schorer, et al., 2010). Aufgrund der großen Anzahl an Nachwuchsspielern im (deutschen) Fußball erscheint eine frühzeitige systematische Talentselektion jedoch notwendig, um talentierte Nachwuchsspieler mit ausreichend guten Förderbedingungen auf die stetig steigenden Leistungsanforderungen im Erwachsenenbereich vorzubereiten und sie national und international konkurrenzfähig zu machen.

Eine weitere Möglichkeit des strukturellen Eingriffs in den Talentselektionsprozess ist die Vorgabe von *Quoten* für die Geburtenverteilung der selektierten Spieler (Barnsley & Thompson, 1988). Bei der Vorgabe einer Gleichverteilung über die Geburtsquartale müssten Trainer beispielsweise darauf achten, für jedes Geburtsquartal den gleichen Spieleranteil auszuwählen. Ähnlich wie bei dem Vorschlag rotierender Stichtage ist eine Quotenregelung mit logistischem Aufwand verbunden und benötigt daher Akzeptanz und Unterstützung von der verantwortlichen Talentförderinstitution.

Die Umweltbedingung *Trainer* ist ein weiterer Ansatzpunkt für Reduktionsmaßnahmen. Trainer verwenden aus pragmatischen Gründen die aktuelle Leistungsfähigkeit eines Spielers als Kennzeichen seines Talentpotentials und tragen somit zur RAE-Entstehung bei (Dixon et al., 2011; Emrich et al., 2008). Eine aktuelle Studie zu Mechanismen der RAE-Entstehung bei Selektionsprozessen zeigte darüber hinaus, dass Fußballtrainer ungeachtet tatsächlicher Leistungsunterschiede groß gewachsene Spieler mit hoher Leistungsfähigkeit assoziieren (Furley & Memmert, 2016). Eine mögliche Intervention besteht darin, die Ausbildung der Trainer für die Talentselektion zu verbessern und sie durch Zusatzinformationen bei der Talentselektion zu unterstützen (Cobley, Baker, et al., 2009). Eine aktuelle Studie konnte zeigen, dass das relative Alter als Zusatzinformation nur dann zu einer Reduktion des RAE-Risikos führt, wenn sie dem Trainer in adäquater Form zur Verfügung steht (Mann & van Ginneken, 2016). Während die alleinige Kenntnis des relativen Alters nicht zur Vermeidung eines RAE bei der Talentselektion führte, entstand bei Spieler, die während der Sichtungsmaßnahme ihr relatives Alter als Nummer auf dem Markierungsleibchen präsentierten, kein relativer Alterseffekt mehr. Als weitere Zusatzinformationen schlagen Romann und Cobley (2015) vor, den Trainern um relative Altersunterschiede bereinigte Leistungskennwerte bereitzustellen. Die Effektivität zusätzlicher Informationen bei der RAE-Reduktion ist allerdings nicht selbstverständlich. So zeigte eine Interventionsstudie, dass sich die Selektionsstrategie eines Trainers nicht zwangsläufig ändert, wenn ihm das relative Alter seiner Spieler und das Phänomen RAE bekannt ist (Hill & Sotiriadou, 2016). Als Grund gaben die betroffenen Trainer in Interviews an, dass ihre Selektionsentscheidungen vom kurzfristigen Erfolgsdruck für ihre Trainerkarriere und dem Einfluss der Eltern mitbestimmt werden. Damit wird deutlich, dass bei der Konzeption effektiver Reduktionsmaßnahmen für die Selektionsstrategie des Trainers, der Einfluss der Umweltbedingung Talentförderinstitution beachtet werden muss.

Trotz der vielen in der Forschung diskutierten Ansätze zur Reduktion des RAE, erscheint ihre Umsetzung in der Praxis schwierig. Zumindest wurden bisher keine Änderungen des RAE-Ausmaßes im Fußball nachgewiesen (Helsen et al., 2012) und mangelt es an Studien zu erfolgreichen Interventionsmaßnahmen. Um in den verantwortlichen Nachwuchsförderinstitutionen Akzeptanz und Unterstützung zu erfahren, sollten Reduktionsmaßnahmen neben aktuellen Erkenntnissen zur RAE-Entstehung das spezifische Gefüge der Umweltbedingungen eines Nachwuchsfördersystems berücksichtigen (Wattie, 2013).

Interventionsmaßnahmen im DFB-Nachwuchsfördersystem

Als übergeordnete Maßnahme zur Reduktion des RAE wurde das *Bewusstsein und Verständnis* zum Phänomen RAE bei den Verantwortlichen in der Praxis erhöht. Dazu wurden die Ergebnisse der empirischen Studien der Dissertation sowie die hier im Folgenden in der Synopsis vorgestellten Vorschläge zu einer Reduktion des RAE im DFB-Nachwuchsfördersystem im Sinne eines Wissenstransfers bei mehreren zentralen Tagungen den hauptamtlichen Trainer und Funktionären des DFB-Nachwuchsfördersystems vorgestellt und gemeinsam diskutiert (z. B. Verbandssportlehrertagung Kamen-Kaiserau 2014). Zudem wurde die Problematik RAE bei nachfolgenden dezentralen Trainerfortbildungen im DFB-Stützpunktprogramm thematisiert.

Aus Sicht des Projekts „sportwissenschaftliche Begleitung des DFB-Talentförderprogramms" sind insbesondere die *DFB-Stützpunkte* und die *Verbandsauswahlmannschaften* Förderstufen, bei denen durch zentral vorgegebene Regulierungen der DFB-Verantwortlichen, Einfluss auf die Entstehung des RAE genommen werden kann. Bei den Leistungszentren der Profivereine und den DFB-Jugendnationalmannschaften scheint dies zwar grundsätzlich auch möglich, aufgrund des hohen Erfolgsdrucks der Trainer bei nationalen und internationalen Meisterschaften aber schwerer umsetzbar zu sein. Daher werden hier nur für die beiden Selektionsniveaus DFB-Stützpunktprogramm und Verbandsauwahlmannschaften spezifische Reduktionsmaßnahmen unter Berücksichtigung struktureller Besonderheiten der jeweiligen Ebene vorgeschlagen. Gleichzeitig werden jedoch die Ergebnisse der zweiten empirischen Studie zum RAE berücksichtigt, die gezeigt haben, dass die RAE-Entwicklung das zusammenhängende System aller Selektionsniveaus und Altersklassen umspannt (Votteler & Höner, 2016). Weiterhin zeigten die Ergebnisse der Studie, dass insbesondere die erstmalige Selektion neuer Spieler für höhere Selektionsniveaus zur Erhöhung des RAE-Ausmaßes bei-trägt. Daher konzentrieren sich die Reduktionsmaßnahmen auf eine Vermeidung der RAE-Entstehung in diesen Selektionsprozessen.

DFB-Stützpunktprogramm

Generell sind die bestehenden Umweltbedingungen an den DFB-Stützpunkten (u. a. sehr breite Förderung mit verhältnismäßig wenig Konkurrenzdruck bei Talentselektionsmaßnahmen, einheitliche, vorgeschriebene Selektionsstrategie, geringerer Druck auf den Trainer für mannschaftlichen Erfolg) günstig für Interventionen zur Reduktion des RAE. Da die Selektion in die Stützpunkte der Beginn der systematischen Talentselektion im DFB ist, können Interventionsmaßnahmen frühzeitig eine RAE-Entstehung vermeiden. Die Entscheidung fiel auf die Einführung einer *Quotenregelung* mit der Vorgabe einer Gleichverteilung der Geburtenhäufigkeit über die Geburtshalbjahre. Diese Quotenregelung muss jedoch berücksichtigen, dass, aufgrund der probabilistischen Natur des Phänomens RAE (Wattie, 2013), zufällige Schwankungen in der Geburtenverteilung der talentiertesten Spieler möglich sind. Daher gilt die Quotenregelung nicht als deterministische Vorgabe, sondern als Orientierungsgrundlage für den sichtenden Trainer, von der er im Einzelfall abweichen kann.

Aufgrund der zufälligen Schwankungen in der Geburtenverteilung talentierter Spieler ist eine Quotenkontrolle für Geburtshalbjahregeeigneter als für Geburtsquartale, da sie dem Trainer mehr individuellen Entscheidungsspielraum lässt. Allerdings sollte beachtet werden, dass solche „technischen Lösungen" (Wattie, 2013, S. 13) zu ungewünschten Nebenwirkungen führen können. Beispielsweise kann eine Halbjahresquote im Sinne eines doppelten Stichtags 1. Januar und 1. Juli zu Beginn jeden Halbjahres dazu führen, dass Spieler aus dem ersten Geburtsquartal (Januar bis März) und für das zweite Halbjahr Spieler aus den dritten Geburtsquartal (Juli bis September) bevorzugt selektiert werden. Um diese unerwünschte Nebenwirkung zu verhindern, wurden die Trainer im DFB-Stützpunktprogramm angewiesen, auch die Verteilung über die Geburtsquartale im Auge zu behalten.

Die Quotenregelung einer Gleichverteilung für beide Geburtshalbjahre ist nur dann geeignet, wenn auf Vereinsniveau eine Gleichverteilung der Geburtenhäufigkeit gegeben ist. Um zu verhindern, dass aufgrund möglicher Vorsichtungen im Verein bereits bei den zur Talentselektion antretenden Vereinsspielern ein RAE besteht, werden Vereinstrainer in der Regel angewiesen, die gleiche Anzahl an Spielern aus dem ersten und zweiten Geburtshalbjahr zur Sichtung mitzubringen.

Nachdem ein Spieler ins DFB-Stützpunktprogramm aufgenommen wurde, könnten dem Stützpunkttrainer für die Entscheidung, welche Nachwuchstalente weiter förderungswürdig sind, altersbereinigte Leistungskennwerte als *Zusatzinformation* zur Verfügung gestellt werden (Romann &

Cobley, 2015). Wie in der ersten empirischen Studie angedeutet, besteht dafür die Möglichkeit, die Ergebnisse der Spieler in der halbjährlichen technomotorischen Diagnostik statistisch um den Einfluss relativer Altersunterschiede zu bereinigen (Votteler & Höner, 2014)[2].

Die höhere körperliche Reife relativ älterer Spieler gilt als Ursache für deren häufigere Selektion als Talent. Daher ist die Bereitstellung von *Informationen über den Reifestand* seiner Spieler für den Trainer hilfreich zur Reduktion des RAE. Vor diesem Hintergrund wurde im Rahmen dieser Arbeit eine Pilotstudie mit *N*=404 DFB-Stützpunktspielern der Altersklassen U11 bis U14 durchgeführt. In der Pilotstudie wurde die testtheoretische Güte des „maturity-offset“-Verfahrens zur Erfassung der somatischen Reife von Mirwald, Baxter-Jones, Bailey und Beunen (2002) an zwei Messzeitpunkten (Zeitabstand fünf Monate) längsschnittlich analysiert (Votteler, Murr & Höner, 2014). Gegenüber den im medizinischen Kontext häufig verwendeten Methoden zur Erfassung des biologischen Alters über das Skelettalter und über die Ausprägung sekundärer Geschlechtsmerkmale (Baxter-Jones, Eisenmann & Sherar, 2005), hat das ohnehin ökonomischere Verfahren den zusätzlichen Vorteil, dass keine Belastung mit Röntgenstrahlung oder ein Eindringen in die Privatsphäre des Nachwuchssportlers notwendig ist (Malina et al., 2012). Für die Berechnung des maturity-offsets (Zeitabstand vom aktuellen chronologischen Alter zum Alter des größten Wachstumsschubs) müssen lediglich die Körpergröße, das Körpergewicht und die Sitzhöhe eines Probanden erfasst werden. Obwohl die Methode bereits intensiv in der Talentforschung im Sport (Matthys, Fransen, Vaeyens, Lenoir & Philippaerts, 2013; Till, Cobley, O' Hara, Cooke & Chapman, 2014) und in der Sportpraxis (Fuchslocher, Romann, Rüdisüli, Birrer & Hollenstein, 2011) eingesetzt wird, ist die für die Zuverlässigkeit und Genauigkeit der Ergebnisse relevante testtheoretische Güte des Verfahrens bisher nur in Einzelaspekten untersucht worden (Malina, 2012). Die Pilotstudie zeigte signifikante Unterschiede im Ergebnis der Methode zwischen dem ersten und dem zweiten Messzeitpunkt in den Altersklassen U11 bis U13 und konnte somit zeitgleich mit einer anderen Studie (Malina & Kozieł, 2014) nachweisen, dass das Messergebnis vom Alter der untersuchten Person abhängt. Zudem konnten mit der vorgeschlagenen Kategorisierung der Messergebnisse nur 3,2% der Spieler reliabel als früh- oder spätreif klassifiziert werden. Damit war die Methode nur für Extremfälle im begrenzten Altersbereich der Altersklasse U14 anwendbar und somit insgesamt für eine flächendeckende Diagnostik im DFB-Stützpunktprogramm ungünstig (Votteler et al., 2014).

[2] Dieser Vorschlag wurde aufgrund der ohnehin hohen Komplexität der Leistungsrückmeldungen an die Trainer bisher nicht umgesetzt.

Verbandsauswahlmannschaften

Für die Verbandsauswahlmannschaften wurden relative Alterseffekte mit einem Anteil von 69,5% bis 73,9% in der ersten Jahreshälfte geborener Spieler festgestellt. Im Vergleich zum vorherigen Selektionsniveau Leistungszentrum nahm der RAE bei der Selektion für die Verbandsauswahlmannschaften in jeder Altersstufe jeweils um circa 3% zu. Als möglichst ökonomische Regelung, die eine Reduktion des RAE bewirkt und zugleich den ambitionierten Zielen der Landesverbände Rechnung trägt, möglichst gute Platzierungen bei den DFB-Sichtungsturnieren zu erzielen, wird eine *gemäßigte Quotenregelung* vorgeschlagen. Für die genaue Spezifikation der Quotenregelung wäre es denkbar, die Anzahl der Spieler aus der ersten Jahreshälfte im 16er Kader auf beispielsweise höchstens elf Spieler (68,8% Spieleranteil erste Jahreshälfte) zu beschränken. Somit würde berücksichtigt werden, dass die Spieler häufig aus Leistungszentren selektiert werden, in denen bereits ein RAE von etwa 69% in der ersten Jahreshälfte geborener Spieler vorliegt und die Selektion der Verbandsauswahlspieler somit nur ein weiterer Selektionsschritt im zusammenhängenden System der RAE-Entstehung im DFB-Nachwuchsfördersystem ist (Votteler & Höner, 2016). Damit würde ebenso Berücksichtigung finden, dass aus der ursprünglich anzunehmenden Gleichverteilung sportlicher Begabung auf Amateurniveau über die systematische Förderung in den Leistungszentren (mit vorhandenem RAE) eine schiefe Verteilung sportlichen Talents mit mehr relativ älteren Talenten geworden ist (Votteler & Höner, 2016). Zusätzlich könnte bei der Quotenregelung beachtet werden, dass die bei der Sichtung zur Verfügung stehende Anzahl potentieller Verbandsauswahlspieler geringer wird, weil Trainer beispielsweise die Torhüter zwangsläufig nach ihrer Spielposition auswählen müssen. Die Quote könnte sich somit auf die übrigen 14 Feldspieler beziehen.

Eine solche Quotenregelung hätte keine nachhaltig negativen Auswirkungen auf die Sichtung der DFB-Jugendnationalmannschaften, da ein Trainer bei zu vielen Spielern aus der ersten Jahreshälfte in der Konsequenz lediglich seine „Nr. 12" aus dem Spielerkader streichen müsste. Diese „Nr. 12" ist jedoch in den meisten Fällen kein ernsthafter Kandidat für die Jugendnationalmannschaft. Exemplarisch wären von der Quotenregelung bei den Sichtungsturnieren im Jahr 2012, 46 der 84 Mannschaften (21 Landesverbände in vier Sichtungsturnieren) betroffen gewesen[3]. Diese 46 betroffenen Mannschaften hätten im Schnitt zwei Spieler (maximal fünf) aus der ersten Jahreshälfte streichen müssen. Damit hätten pro Sichtungsturnier durchschnittlich 23 Spieler mehr aus der zweiten Jahreshälfte teilgenommen und der Spieleranteil aus der ersten Jahreshälfte wäre insgesamt von 73,0% auf 65,4% reduziert worden.

[3] Daten dieser Auswertung stammen aus Studie 2 (Votteler & Höner, 2016).

Um die von Sportverbandsseite zögerliche Reaktion auf Vorschläge zur Reduktion des RAE zu verstehen, muss man berücksichtigen, dass ein gewisses Maß an Unfairness und geringer Effizienz aufgrund eines vorhandenen RAE nicht automatisch eine geringe Effektivität des betroffenen Nachwuchsfördersystems mit sich bringt. Tatsächlich zeigen die aktuellen Erfolge der Nationen Deutschland, Frankreich, Spanien und Schweiz im Jugend- und Erwachsenenbereich, dass Nachwuchsfördersysteme trotz eines existierenden RAE effektiv darin sein können, hochqualifizierte Jugendspieler für den Profibereich auszubilden (Carling et al., 2009; Jimenez & Pain, 2008; Romann & Fuchslocher, 2011b).

Die enorme Breite des DFB-Nachwuchsfördersystems hat den zusätzlichen Vorteil, dass auch eine sehr hohe Anzahl relativ jüngerer Spieler gefördert wird (z. B. werden ungefähr 2.000 Nachwuchsspieler des vierten Geburtsquartals in der Altersklasse U12 bis U15 an den DFB-Stützpunkten trainiert). Da die Selektionsniveaus einen großen Teil der Altersklassen im Jugendbereich umspannen und pro Jahr in jeder Altersklasse und auf jedem Selektionsniveau etwa 20% der Spieler neu gesichtet werden (Votteler & Höner, 2016), haben auch Talente, die aufgrund ihrer Entwicklung erst verhältnismäßig spät überdurchschnittliche Leistungen zeigen, noch in höheren Altersklassen die Möglichkeit gesichtet zu werden. Das Risiko hochtalentierte relativ jüngere Nachwuchsspieler zu übersehen ist daher sehr gering. Trotzdem sollte eine Reduktion des RAE in Betracht gezogen werden, um die Verteilung der Förderressourcen auf die begabtesten Spieler effizienter zu gestalten.

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Eidesstattliche Erklärung

Meine Dissertation ist gemäß § 6 (2) der Promotionsordnung Teil mehrerer Gemeinschaftsarbeiten. Folgende vier Publikationen wurden für die kumulative Dissertation eingereicht:

(1) Höner, O., Votteler, A., Schmid, M., Schultz, F., & Roth, K. (2015). Psychometric properties of the motor diagnostics in the German football talent identification and development programme. *Journal of Sports Sciences, 33*, 145-159.

(2) Höner, O. & Votteler, A. (2016). Prognostic relevance of motor talent predictors in early adolescence: a group- and individual-based evaluation considering different levels of achievement in youth football. *Journal of Sports Sciences,* 34, 2269-2278.

(3) Votteler, A., & Höner, O. (2014). The relative age effect in the German Football TID Programme: Biases in motor performance diagnostics and effects on single motor abilities and skills in groups of selected players. *European Journal of Sport Science, 14,* 433-442.

(4) Votteler, A., & Höner, O. (2017). Cross-sectional and longitudinal analyses of the relative age effect in German youth football. German Journal of Exercise and Sport Research. doi: 10.1007/s12662-017-0457-0.

In den ersten beiden Publikationen wurde vor allem das vorherige Datenmanagement, die statistischen Analysen und deren Beschreibung im Methoden- und Ergebnisteil des Manuskript von mir, Andreas Votteler (AV), in Zusammenarbeit mit dem Leiter des Forschungsprojekts Prof. Dr. Oliver Höner (OH) durchgeführt. Die Publikationen (3) und (4) wurden von mir erstellt und der Entstehungsprozess von Prof. Dr. Oliver Höner mit mehrfachen kritischen Rückmeldungen und Verbesserungsvorschlägen unterstützt. Um die individuellen Beiträge der Autoren zu veranschaulichen, soll im Folgenden der Anteil an den einzelnen Publikationen anhand von Prozentzahlen verdeutlicht werden: Artikel 1 (OH: 65%, AV: 20%, weitere Mitautoren: 15%); Artikel 2 (OH: 60%, AV: 40%); Artikel 3 (AV: 60%, OH: 40%), Artikel 4 (AV: 80%, OH: 20%).

Ich erkläre hiermit, dass ich meinen Anteil an der mit diesem Zulassungsantrag zur Promotion eingereichten Arbeit selbständig verfasst, nur die angegebenen Quellen und Hilfsmittel benutzt und wörtlich oder inhaltlich übernommene Stellen als solche gekennzeichnet habe. Ich versichere an Eides statt, dass diese Angaben wahr sind und dass ich nichts verschwiegen habe. Mir ist bekannt, dass die falsche Abgabe einer Versicherung an Eides statt mit Freiheitsstrafe bis zu drei Jahren oder mit Geldstrafe bestraft wird.

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Anhang 1

Originalmanuskript vor Publikation von

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Anhang 1

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Running head: Diagnostics in the German Football TID-Programme

Psychometric Properties of the Motor Diagnostics in the German Football Talent Identification and Development Programme

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Anhang 1

Title: Psychometric Properties of the Motor Diagnostics in the German Football Talent Identification and Development Programme

Abstract

The utilisation of motor performance tests for talent identification in youth sports is discussed intensively in talent research. This article examines the reliability, differential stability and validity of the motor diagnostics conducted nationwide by the German football talent identification and development programme and provides reference values for a standardised interpretation of the diagnostics results. Highly selected players (the top 4% of their age groups, U12-U15) took part in the diagnostics at 17 measurement points between spring 2004 and spring 2012 (*N*=68,158). The heterogeneous test battery measured speed abilities and football-specific technical skills (sprint, agility, dribbling, ball control, shooting, juggling). For all measurement points, the overall score and the speed tests showed high internal consistency, high test-retest reliability and satisfying differential stability. The diagnostics demonstrated satisfying factorial-related validity with plausible and stable loadings on the two empirical factors “speed” and “technical skills”. The score, and the technical skills dribbling and juggling, differentiated the most among players of different performance levels and thus showed the highest criterion-related validity. Satisfactory psychometric properties for the diagnostics are an important prerequisite for a scientifically sound rating of players’ actual motor performance and for the future examination of the prognostic validity for success in adulthood.

Keywords: soccer, tests, reliability, validity, reference values

1. Introduction

The exploration of young athletes' potential for sporting excellence in adulthood, and the optimisation of support for these young athletes on their way to superior performance, i.e., the processes of talent identification and talent development (TID, Williams & Drust, 2012), is an expanding field of practice and research (Cobley, Schorer, & Baker, 2012, p. 1). To support the TID process, current research addresses the search for relevant talent predictors in diagnostics. The general prerequisites for the prognostic power of diagnostics are the appropriate selection of predictors and a scientifically sound assessment of the selected characteristics (Nolting & Paulus, 2009).

The *selection* of relevant talent characteristics is itself challenging. Based on a multidimensional and dynamic approach, the range of predictors should not only contain several (physical, physiological and psychological) personal characteristics and environmental factors (Williams & Reilly, 2000) but should also exceed the measurement of actual performance in order to reveal athletes' development potential (Abbott, Button, Pepping, & Collins, 2005; Abbott & Collins, 2004; Hohmann, 2009; Pankhurst & Collins, 2013; Renshaw, Davids, Phillips, & Kerhervé, 2012). Another problematic area is the use of cross-sectional designs for data assessment without considering potential confounders such as relative age or maturity (Unnithan, White, Georgiou, Iga, & Drust, 2012; Vaeyens, Coelho e Silva, Visscher, Philippaerts, & Williams, 2013; Votteler & Höner, 2013).

Problems such as these are far from resolved and many studies are thus forced to focus on a smaller range of predictors. For this reason, TID programmes in many countries have been accompanied by scientific studies using motor diagnostics in the last several years, even though the use of such "physical skill tests" for talent identification remains disputed (e.g. Lidor, Côté, & Hackfort, 2009). Comprehensive studies have been conducted, particularly for football, in countries such as Portugal, Belgium, the Netherlands and Switzerland. These studies examined some of the problems related to the selection of talent predictors such as the influence of biological maturity on different motor skills and abilities (Figueiredo, Coelho e Silva, & Malina, 2011), the age dependent diagnostic power of different motor tests (Vaeyens et al., 2006), dynamic aspects of performance development in motor skills (Huijgen, Elferink-Gemser, Ali, & Visscher, 2013) or the function of psychological characteristics for motor development (Zuber & Conzelmann, 2013).

With respect to the *assessment* of talent predictors such as motor skills or abilities, psychometric properties are a critical issue in talent research. Sufficient reliability and differential stability can provide essential information about the accuracy of the measurement instrument as well as development-related fluctuations in the assessed characteristics. Nevertheless, for many (particularly football-specific) diagnostics, either no evaluations or only insufficient evaluations of these properties have been reported (Ali, 2011; O'Reilly & Wong, 2012). Additionally, the variables' differential stability is an under-documented property even though this is a prerequisite for a variable being considered as a talent predictor during athletes' adolescence (Abbott & Collins, 2002; Hohmann, 2009) – a period in which high inter- and intra-individual fluctuations in motor development can be expected (Malina, Bouchard, & Bar-Or, 2004).

Furthermore, the meaningful interpretation of test results requires validity and standardised reference values for the diagnostics (Kline, 2000). One criticism concerning validity is that at present time mainly physiological, or isolated football-specific skills tests of low external validity, are used to acquire information regarding the actual and future global match performance in football (Unnithan et al., 2012). A further concern is the scientifically sound application of diagnostics. The standardisation of tests is essential, especially for large-scale diagnostics conducted nationwide. Beyond standardising test execution, reference values for the test results are necessary for providing meaningful interpretation, particularly when tests are used for making decisions about individuals or for screening purposes (Kline, 2000, p. 49) such as in talent diagnostics.

As a prerequisite for talent research intending to investigate the long-term prognostic relevance of motor diagnostics, this study aims to analyse the psychometric properties of a diagnostics conducted nationwide by one of the world's largest sport-specific TID programmes – a programme started in 2002 by the German Football Association (Deutscher Fußball-Bund, DFB). The DFB promotes 14,000 talented youth players in the age groups Under12 to Under15 (U12 to U15), i. e. approximately the top 4% players in each age group, at one of the DFB's 366 regional competence centres, given that they have not already been selected for the youth academy of a professional club. The main aim of the competence centres is to improve youth players' football-specific (technical) skills and speed abilities (Schott, 2010). To monitor players' motor performance development, the football-specific skills and speed abilities of all selected competence centre players are tested twice a year using a heterogeneous test battery implemented in 2004 (Lottermann, Laudenklos, & Friedrich, 2003). In detail, this study comprises four objectives concerning the motor performance diagnostics of this TID programme:

I. the reliability of the diagnostics in terms of *internal consistency* and *test-retest reliability*,
II. the *differential stability* of the assessed characteristics in order to consider not only measurement-related but also developmentally based fluctuations in the diagnostics results,
III. the *factorial-* and *criterion-related validity* of the diagnostics (Do the heterogeneous diagnostics reflect the targeted technical skills and speed abilities? Do the diagnostics results differentiate between players of different performance levels?),
IV. *standardised reference values* for a scientifically sound and nationally standardised interpretation of the diagnostics results.

2. Methods

2.1. Study Sample and Design

Table 1 describes the sub-samples for each of the four objectives, including the number of completed test procedures and players' mean anthropometric characteristics. The main sample comprised 68,158 male competence centre players in the age groups U12 to U15 who participated in the semi-annually conducted motor diagnostics between spring 2004 (T1) and spring 2012 (T17). Each competence centre player completed at least one single test of the heterogeneous test battery on at least one measurement point. For various reasons (e.g., injuries), a random group of players (≈7%) did not complete the entire testing procedure.

Table 1

Because data for juggling were available only beginning with T14, the results of measurement points T14 to T17 were used to examine the validity of the test battery. The analysis of criterion-related validity was carried out by investigating the results of an additional sample of 2,288 youth academy players (U12 to U15). Because professional clubs aim to promote the most talented players in their youth academies, these players can be expected to have, on average, higher performance levels than competence centre players.

All players' parents provided informed consent for the recording of data and its scientific use. The ethics department of the Faculty of Behavioural and Cultural Studies at the Ruprecht-Karls University of Heidelberg and the scientific board of the DFB approved the implementation of this study.

2.2. Measures and Procedure

The motor performance diagnostics is conducted by the responsible coaches at all competence centres in the first half (autumn diagnostics) and the second half of each season (spring diagnostics) during a nationwide, predetermined time frame of nine weeks and is carried out according to a standardised test manual (DFB, 2013). To control the standardised procedure, trained student research assistants regularly monitored the test execution at selected competence centres.

*** Figure 1***

The test battery (Figure 1) comprised six tests (Lottermann et al., 2003). The times for *sprint*, *agility* and *dribbling* were measured by light barrier systems. The times for *ball control* and *juggling* were registered with stopwatches. For each test, the better of two attempts counted. Merely for the *shooting test*, the precision (shot on target field meant a hit) and shot speed (subjective rating on a three-stage scale) of all eight shots were combined. The results of five single tests were combined into a global score using the following formula (juggling was not included in the score, because it was not implemented until autumn 2010):

$$\text{Score}=10{,}000*[(17.29*\text{sprint})+(9.43*\text{agility})+(4.11*\text{dribbling})+(2.41*\text{ball control})+\text{shooting}]^{-1}$$

The weighting factors display the ratio of the shooting test's standard deviations with all other tests from measurement point one (T1). Consequently, the product of standard deviation and the weighting factor is equal for all included tests (Lottermann et al., 2003).

2.3. Statistical analysis

Statistical analyses were performed using SPSS 21 and Mplus 5.2.1. For the analysis of reliability, the *internal consistency* of each single test (consistency of the two attempts, consistency of the eight shots for shooting) and the score (first attempts with second attempts) was calculated with Cronbach's alpha. Cronbach's alpha was used as the common measure for internal consistency rather than calculating the Pearson correlation because the Pearson coefficient underestimates the true reliability of the test with two attempts (Eisinga, Grotenhuis, & Pelzer, 2012). For the *test-retest reliability* of each test, the relation between the autumn and spring diagnostics within each season (average timespan 5 months) was analysed using the

Pearson correlation coefficient. The consistency and test-retest reliability were analysed for all 17 measurement points separately, and the mean estimates as well as the 95% confidence intervals for the average internal consistency and test-retest reliability were calculated.

The *differential stability* of the diagnostics spanned a total period of approximately three years from U12 to U15. The season performance for each age group was calculated using the mean value of the autumn and spring diagnostics for players who completed both tests within the corresponding season. The results in U12 for each player were correlated with the results of the sequential diagnostics in U13 to U15 to estimate the 1-, 2- respectively 3-year stabilities.

For the *factorial-related validity*, factor analyses of all six single tests were conducted for each age group. In step one, an exploratory factor analysis (EFA) with oblique promax-rotation was calculated with autumn diagnostics results using a randomly selected first half of the sample. The number of factors was determined using Kaiser-Guttmann-criterion, Scree-Test and a sequential analysis of the resulting factor-loading structure (Thompson, 2008). In a second step, the factorial structure and factor loadings were cross-validated using confirmatory factor analysis (CFA) with fixed factor loadings and fixed factor correlations with the second half of the autumn sample. For a restrictive model estimation, all irrelevant EFA loadings with no values >.30 in the other age groups were excluded from the CFA measurement models. Similarly, the stability of the factorial structure was examined with the data of the following spring diagnostics. For the analysis of the model fit, the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR) as well as the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI) were used as common indicators (acceptable fit for values close to .05 for RMSEA/SRMR and close to .95 for CFI/TLI, Schumacker & Lomax, 2010).

The *criterion-related validity* of the diagnostics was analysed with mean differences between competence centre and youth academy players' performance using t-tests for independent samples. These t-tests were calculated for each of the eight age group diagnostics (U12 autumn, U12 spring, …, U15 autumn, U15 spring) for all single tests and the score. As effect sizes, Cohen's d and the percentile rank (PR) for the mean performance of youth academy players within the results of all competence centre players were calculated. Because of a possible α-cumulation during multiple significance testing for eight age group diagnostics, α was Bonferroni-adjusted (α_i=.05/8=.006).

Standardised reference values for each age group and each test were obtained separately for competence centre and youth academy players by calculating PRs for all test results from autumn and spring diagnostics (T1 to T17). The test performance of each player from U12 to U15 was graded as category A (PR>70), B (30≤PR≤70) or C (PR<30), implying a rating of the performances as above-average, average or below-average Germany-wide.

3. Results

3.1. Reliability

Table 2 presents the means and 95% confidence intervals for the internal consistency and the test-retest reliability as estimates of the general reliability upon the 17 measurement points. The small range of the confidence intervals demonstrates the robustness of the estimators (for internal consistency and for test-retest reliability).

Table 2

The global score as well as sprint and agility results display high *internal consistencies* for the entire sample (α≥.89) that only decrease slightly in the age-specific analyses (.84≤α_i≤.85). The juggling test has acceptable internal consistency when regarding both the entire sample and the individual age groups (.72≤α_i≤.75). The consistencies of the technical skills tests, dribbling and ball control, are questionable (α=.61 and .68, respectively), and even smaller within each age group (.53≤α_i≤.57 and .61≤α_i≤.64, respectively). The consistency of shooting must be classified as critical for the entire sample (α=.41) as well as for each age group (.37≤α_i≤.40).

The *test-retest reliabilities* for the entire sample with higher performance heterogeneity are approximately 0.1 points higher than for separate age groups. Considering all age groups together, the score demonstrates satisfying test-retest reliability with *r*=.74. The same applies for sprint (*r*=.76) and nearly for juggling (*r*=.69). With respect to agility (*r*=.60), dribbling (*r*=.56) and ball control (*r*=.50), moderate results were observed. As before, the shooting test presents the most critical value (*r*=.31).

3.2. Differential Stability

The *differential stabilities* decrease in an approximately parallel manner with longer time intervals for all tests (Figure 2) so that the order of the tests' stability remains nearly constant for longer periods. Thus, for all time intervals, the score and sprint test possess the highest stability (and juggling, for which only the 1-year stability was available). The stability of these tests steadily decreases from the 1-year stability in U13 ($r_{U12/U13}$≈.71) to the 3-year stability ($r_{U12/U15}$≈.51). Agility and dribbling tests show stabilities from $r_{U12/U13}$≈.63 to $r_{U12/U15}$≈.50. Moreover, ball control and shooting clearly show the lowest stability over all periods. While the stability of ball control decreases from $r_{U12/U13}$=.49 to $r_{U12/U15}$=.35 from the 1-year to the 3-year interval – and thus shows substantial correlations between the test results in U12 and the results in the following age groups – the shooting test only shows minor correlations between different seasons (e.g., $r_{U12/U15}$=.21).

Figure 2

3.3. Validity

Table 3 shows the results for the *factorial-related validity* including EFA statistics exploring the factorial structure of the motor diagnostics (with the first half of the autumn sample) as well as the results of the CFAs confirming these structures by cross validation (with the second half of the autumn sample). Further on, the analysis of the stability of the factorial structure (spring sample) is presented. The EFA resulted in solutions with two oblique factors for each age group, of which each solution had moderate correlations ($.43 \leq r_i \leq .50$) between both factors and each factor solely explained approximately 20% of variance. Sprint and agility showed substantial loadings on the first factor, which can be associated to the „speed“-related demands within the diagnostics. Ball control, shooting and juggling loaded on the second factor, representing the “technical skills”. The dribbling test possessed substantial loadings on both factors, which tended to higher loadings on the factor “technical skills” in the higher age groups. Figure 3 presents the resulting measurement models with the highly significant path coefficients (p<.01).

The cross validation of these measurement models confirmed the factorial structure for all age groups. The four models showed acceptable model fit (CFI/TLI>.93, RMSEA/SRMR≤.05 each). Further on, the measurement models remained stable after nearly half a year because the CFA statistics for the spring sample reconfirmed the model (CFI/TLI>.95, RMSEA/SRMR≤.05 for each age group; Table 3).

Table 3

Figure 3

Table 4 compares the statistics of competence centre and youth academy players’ performances in the diagnostics with regard to the *criterion-related validity*. The comparison of shooting test results showed a trend toward better performances for youth academy players in all age groups, which reached significance in only four cases (U12 autumn, U13 spring, U15 autumn and U15 spring). Consistent with small effect sizes ($.08 \leq d_i \leq .34$), the youth academy players' performances in shooting were, with one exception ($PR_{U15\text{-}autumn}$≈67), only slightly above average ($52 \leq PR_i \leq 60$). All the other dependent variables in each age group showed highly significant and relevant differences in favour of youth academy players. Mean youth academy performances corresponded to $PR_i > 60$ in all age groups (with one exception in sprint: $PR_{U12\text{-}autumn}$≈56). Particularly the score ($70 \leq PR_i \leq 79$), dribbling ($71 \leq PR_i \leq 78$) and juggling ($75 \leq PR_i \leq 92$) were shown to be diagnostically valid with middle to high effects sizes ($.51 \leq d_{i(score)} \leq .76$, $.59 \leq d_{i(dribbling)} \leq .74$ and $.46 \leq d_{i(juggling)} \leq .90$). Agility ($.42 \leq d_i \leq .57$) and ball control ($.38 \leq d_i \leq .67$) showed middle effect sizes. Low to middle performance advantages for youth academy players were observed for sprint ($.20 \leq d_i \leq .49$).

Table 4

3.4. Reference values

Table 5 contains the *reference values* separated for male competence centre and youth academy players for all tests of the motor diagnostics for spring and autumn tests in all age groups U12 to U15. These reference values enable a standardised interpretation of the motor diagnostics results. They show that as age increases higher performances are necessary in order to be rated in the A category. In addition, higher reference values for the youth academy players serve as another confirmation of the criterion-related validity of the test battery. For example, in the autumn diagnostics a U12 player at the youth academy level must perform the dribbling test in under 10.51 seconds to be categorised as "above average" (A) whereas the reference value for categorisation as an A player at the competence centre level is 11.15 seconds.

Table 5

4. Discussion

Although psychometric properties of diagnostics are fundamental to scientifically sound feedback for practice and potential talent prognosis, such properties are seldom reported for football skill performance tests (Ali, 2011). When interpreting the presented psychometric properties, it should be considered that, unlike other studies (Ali et al., 2007; Figueiredo, Gonçalves, Coelho e Silva, & Malina, 2009), this study examined a homogeneous sample with regard to performance level and age (the top 4% of youth football players in Germany). While focussing the evaluation of a diagnostics on elite players of the same age corresponds to the practical demands of talent selection for higher selection levels, the consequently small variances led to relatively conservative reliability estimates and relatively small group differences (Traub & Rowley, 1991, p. 43).

Considering the reliability of the motor diagnostics, the score possesses acceptable *internal consistency* and acceptable *test-retest reliability* across all 17 measurement points. Sprint and agility ($\alpha_i \geq .89$) show similar reliability to tests in other studies (Hulse et al., 2013; Kutlu, Yapıcı, Yoncalık, & Çelik, 2012; Mirkov, Nedeljkovic, Kukolj, Ugarkovic, & Jaric, 2008; Rumpf, Cronin, Oliver, & Hughes, 2011; Sporis, Jukic, Milanovic, & Vucetic, 2010). The reliability of the technical skills tests is lower, in particular for shooting, and moderate for the other tests. This tendency confirms the findings of Ali et al. (2007). However, other studies also showed high reliability values for technical skills tests (Figueiredo et al., 2009; Kutlu et al., 2012), which might be caused by other types of reliability, statistical assessment or examined samples. For dribbling and ball control strategic considerations by the players may have led to lower consistency estimates because some players complete a "safety trial" on their first attempt before they take a greater risk on the second attempt. The reliability of the shooting test must be classified as critical, and the results should be interpreted cautiously.

As may be expected, the *differential stability* of all variables nearly linearly decreases with longer time spans (a nearly parallel trend for all examined variables). Particularly for a time period (U12-U15) that is relevant to development and sensitive to fluctuations (Malina, 2004), the score shows satisfying stability (3-year stability: r=.5). With this stability, the score – and the sprint, agility, dribbling (and ball juggling) tests – can be classified as potentially relevant for talent prediction. More definite interpretations of the stability values are difficult because only a few studies with hardly comparable sample characteristics (higher performance heterogeneity) and different stability periods exist. Other studies also show a tendency to decreasing stability over longer periods, to higher stability values for anthropometric and physiological characteristics (r_{tt}>.70) compared to technical skills as well as to lower stabilities during puberty (Hohmann, 2009; Joch, 2001).

The *factorial structure* of the diagnostics is plausible in terms of content. The EFA led to a two-factor measurement model assigning the tests according to their demands to either „speed“ or „technical skill“, whereas dribbling was determined by both factors. Cross-validating the factorial structure with quite restrictive models confirmed the stability of the factorial structure within each age group. The correlation between the two factors most likely results from an underlying general motor capability and thereby justifies using the score as a representative motor performance index of the heterogeneous test battery. Slightly increasing loadings of dribbling on the technical skills factor with older age groups most likely display a change in the demands of the tests with increasing chronological age, which should be considered when older age groups are examined.

Whereas in other studies partly the examined technical skills and speed characteristics differentiated only between groups with huge differences in performance level (Vaeyens et al., 2006) or partly did not show any differences (Coelho e Silva et al., 2010), the *criterion-related validity* is shown here even on an already highly selective performance level. In all age groups, youth academy players demonstrated significant superior performance in all variables (except shooting). In addition to the score, mainly the technical skill tests for juggling, dribbling (PR_i≥74) and ball control (PR_i≥67) were shown to be diagnostically valid in all age groups. Although the speed tests sprint and agility had higher reliability values, they showed lower differences in competence centre and youth academy players' performance concerning their criterion-related validity. Because physically demanding speed tests are, in general, likely more affected by maturation than technical skill tests (Figueiredo et al., 2009; Malina et al., 2005; Votteler & Höner, 2013), the already small performance advantages of youth academy players in these tests may additionally be caused by their greater maturation (cf. height and weight in Table 1).

In this study, the analysis of the psychometric properties was intentionally conducted in the context of a practice-oriented evaluation. This includes the (partially problematic) conditions under which such a nationwide diagnostics can be performed. With respect to this, further scientific criteria gain relevance. The diagnostics is challenging but also satisfying regarding the *test economy* (concerning costs, time, test leaders, e.g. Ali, 2011) and the *standardisation of the test execution* (see Figure 1). In addition, when positioning the advantages of objective tests against subjective ratings (Unnithan et al., 2012), the reference values provide an important contribution to the *standardised interpretation* of the diagnostics results. The subjectively perceived *usefulness* may be considered as an additional criterion for a diagnostics. This can be shown by the increased number of youth academies who have voluntarily participated in the diagnostics (since 2009, an average of 16 youth academies per half year).

The confirmation of scientifically sound psychometric properties in this practice-oriented evaluation of the motor diagnostics in the TID programme is an important prerequisite for future examinations of the prognostic validity for predicting sporting success in adulthood. With regard to the predictive potential of talent diagnostics, it should be noted that the specification of fixed cut-off values will always remain illusionary (Lidor et al., 2009). Nevertheless, attempts to predict talent should not end with the proclamation that "talent prediction is impossible", because, indeed, coaches are often forced to make such predictions during daily, routine practices. It is the task of scientific talent research to demonstrate the extent to which diagnostics can provide support for the predictions required in coaches' daily routines. Therefore, it will be necessary in the future to extend the range of examined players' characteristics to other factors; for example, psychological characteristics (Macnamara & Collins, 2013; Van Yperen, 2009) and more valid measures for analysing complex game performance (Unnithan et al., 2012). Likewise, longitudinal research designs and adequate statistical procedures, e.g., complex neuronal network analysis (Hohmann, 2009) and person-oriented approaches (Zibung & Conzelmann, 2012), should be used to provide scientifically sound data for the practice.

5. Conclusion

This article presented the scientifically sound psychometric properties of the motor diagnostics in the German TID programme and the differential stability of its score as an important prerequisite for future examinations of the prognostic validity for predicting sporting success in adulthood. The psychometric properties were intentionally analysed in the manner of a practice-oriented evaluation in order to consider the partly problematic circumstances in which such diagnostics are typically conducted in nationwide TID programmes. Despite these circumstances, taken together the diagnostics offered satisfying psychometric properties. Concerning the single tests, the speed tests showed higher reliability values than the technical skill tests. On the other hand, most skill tests proved, on average, higher criterion-related validity than the speed tests in discriminating between different levels of performance. The test manual and the proposed reference values enable a standardised execution and interpretation of diagnostics results within the nationwide German TID programme. Additionally, they enable researchers from other countries to repeat the tests and compare their results with the average motor performance of two important selection levels in the German TID programme.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Anhang 1

Table 1.

Number of Examined Competence Centre (CC) Players and Youth Academy (YA) Players and Average Anthropometric Characteristics for Each Age Group

Objectives (Measurement Points)	Performance Level	Autumn[b]				Spring[b]			
		Age Group	N[a] Total	Height (cm)	Weight (kg)	Age Group	N[a] Total	Height (cm)	Weight (kg)
I (Reliability), II (Stability), IV (Reference Values) (T2, T4, ... T16 for autumn 2004-11 resp. T1, T3, ... T17 for spring 2004-12)	CC	U12	35,293	148.6	38.0	U12	37,639	150.8	39.7
		U13	29,135	154.3	42.1	U13	32,188	157.1	44.6
		U14	19,973	161.6	48.1	U14	20,567	164.7	51.5
		U15	12,927	169.1	55.7	U15	13,284	172.0	59.2
		Total	**97,328**			**Total**	**103,678**		
	YA	U12	617	148.9	38.2	U12	639	151.2	40.0
		U13	744	155.4	42.6	U13	720	158.9	45.4
		U14	721	163.4	50.1	U14	726	167.1	54.1
		U15	655	170.7	58.3	U15	624	173.0	60.8
		Total	**2,737**			**Total**	**2,709**		
III (Validity) (T14 + T16 for autumn 2010-11 resp. T15 + T17 for spring 2011-12)[c]	CC	U12	8,449	148.8	38.0	U12	8,143	150.7	39.5
		U13	6,880	154.4	42.1	U13	6,688	157.0	44.3
		U14	4,487	161.2	47.8	U14	4,050	164.2	50.7
		U15	2,800	169.1	55.4	U15	2,446	171.8	58.5
		Total	**22,616**			**Total**	**21,327**		
	YA	U12	402	149.2	38.3	U12	389	151.3	39.7
		U13	450	155.5	42.6	U13	401	158.3	45.2
		U14	456	163.7	50.2	U14	409	166.7	53.8
		U15	420	171.3	58.8	U15	380	173.1	60.9
		Total	**1,728**			**Total**	**1,579**		

Note. [a]Players counted,who completed at least one of the six single tests at the corresponding measurement point. [b]Autumn diagnostics is the first measurement point, spring diagnostics the second measurement point in each season. [c]Because the new juggling test was deployed from T14 onwards, data from T14 to T17 were used.

Table 2.

Internal Consistencies and Test-Retest Reliabilities (5 months) of All Motor Tests (Means and 95% Confidence Intervals (CIs) resp. Range for Means of Age-Specific Estimations of Reliability) Based on 17 Measurement Points (T1 to T17, respectively, Spring 2004 to Spring 2012)

Variable	Items	Alpha Cronbach		r_{tt}[b]	
		U12-U15 (overall)	U12, U13, U14, U15 (age-specific)	U12-U15 (overall)	U12, U13, U14, U15 (age-specific)
		M [95%-CI]	M_{Min} - M_{Max}	*M* [95%-CI]	M_{Min} - M_{Max}
Score	2	.89 [.89; .90]	.84 - .85	.74 [.73; .75]	.60 - .64
Sprint	2	.95 [.95; .95]	.92 - .93	.76 [.75; .78]	.64 - .69
Agility	2	.91 [.91; .91]	.90 - .90	.60 [.59; .62]	.55 - .57
Dribbling	2	.61 [.60; .61]	.53 - .57	.56 [.54; .57]	.47 - .50
Ball Control	2	.68 [.67; .70]	.61 - .64	.50 [.48; .51]	.40 - .42
Shooting	8	.41 [.38; .43]	.37 - .40	.31 [.29; .33]	.27 - .30
Juggling[a]	2	.77	.72 - .75	.69	.59 - .65

Note. [a]The juggling test was implemented at measurement point T14. Hence, not enough data exist to calculate reliable CIs. [b]Correlations between autumn and spring diagnostics within each season.

Table 3.

Results of EFA and CFA for the Construct Validity of Motor Tests for the Age Groups U12 to U15 (T14 to T17, respectively, Autumn 2010 to Spring 2012)

		Results EFA (First Half of Sample Autumn 2011 & 2012)									Fit-Indices CFA[a] (Second Half Autumn Sample)				Fit-Indices CFA[a] (Sample of Spring 2011 & 2012)			
		EFA Loadings (pattern matrix)																
Age group	Factors and Communality	Sprint	Agility	Dribbling	Ball Control	Shooting	Juggling	Eigen-value be-fore rota-tion	Explained variance after rota-tion (%)	r_{xy} factors	CFI	TLI	RMSEA [90% CI]	SRMR	CFI	TLI	RMSEA [90% CI]	SRMR
	Speed	**.50**	**.92**	**.35**	-.04	-.02	-.02	2.12	23.87	0.50								
U12	Technical Skill	-.01	-.07	**.35**	**.58**	**.33**	**.49**	1.11	18.81		.97	.97	.04 [.03; .05]	.03	.98	.98	.03 [.03; .04]	.03
	h^2	.25	.78	.37	.31	.10	.23											
	Speed	**.41**	**.98**	**.38**	.04	-.02	-.06	2,09	24.42	0.45								
U13	Technical Skill	.03	-.11	**.36**	**.54**	**.31**	**.52**	1.12	18.07		.97	.97	.03 [.03; .04]	.04	.98	.98	.03 [.03; .04]	.03
	h^2	.18	.88	.40	.31	.09	.25											
	Speed	**.36**	**.97**	**.22**	-.05	-.01	-.10	2.04	22.55	0.49								
U14	Technical Skill	-.04	-.03	**.48**	**.54**	**.34**	**.57**	1.12	20.35		.93	.93	.05 [.04; .06]	.05	.95	.95	.05 [.04; .05]	.04
	h^2	.12	.92	.38	.27	.11	.28											
	Speed	**.33**	**.99**	**.26**	-.06	-.02	-.15	1.92	21.72	0.43								
U15	Technical skill	-.09	-.02	**.45**	**.54**	**.27**	**.63**	1.19	18.97		.97	.97	.04 [.02; .05]	.04	.95	.95	.05 [.04; .06]	.05
	h^2	.09	.96	.37	.27	.07	.34											

Note. Factor loadings used in the CFA measurement model are in boldface. [a]Irrelevant EFA loadings with no values >.30 in all age groups (loadings <.15) were excluded. Retained factor loadings and factor correlations were used as fixed coefficients for the CFA models. [b]Algebraic sign was reversed because higher values mean higher performance.

Anhang 1

Table 4.

Differences in Motor Performance between Competence Centre (CC) Players and Youth Academy (YA) Players (T14 to T17, respectively, Autumn 2010 to Spring 2012): Means, T-test[b] with Effect Size Cohen's d, Percentile Rank (PR) of Mean YA Player Performance Among CC Players.

		U12		U13		U14		U15	
		Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
Score	*M±SD* (CC)	42.38 ± 2.08	43.39 ± 2.1	43.94 ± 2.09	44.75 ± 2.08	45.27 ± 2.08	45.89 ± 2.08	46.39 ± 2.14	46.98 ± 2.14
	M±SD (YA)	43.85 ± 2.34	44.68 ± 2.01	45.56 ± 2.19	46.25 ± 2.15	46.7 ± 2.05	47.18 ± 2.14	48.02 ± 2.08	48.08 ± 2.08
	t	9.51**	7.83**	12.13**	9.22**	9.84**	8.06**	10.48**	6.16**
	df	246.72[a]	7,346	6,277	5,972	4,071	3,582	2,480	2,135
	d	0.7	0.61	0.76	0.72	0.68	0.62	0.75	0.51
	$PR_{CC}(M_{YA})$	76.66	72.57	78.61	76.44	75.48	73.39	77.28	70.24
Sprint	*M±SD* (CC)	3.69 ± 0.18	3.65 ± 0.17	3.59 ± 0.17	3.55 ± 0.17	3.46 ± 0.17	3.42 ± 0.18	3.34 ± 0.17	3.29 ± 0.17
	M±SD (YA)	3.66 ± 0.17	3.58 ± 0.15	3.54 ± 0.16	3.47 ± 0.15	3.41 ± 0.16	3.33 ± 0.14	3.3 ± 0.16	3.23 ± 0.14
	t	3.83**	8.40**	6.64**	9.73**	6.85**	11.10**	4.27**	7.50**
	df	8,556	423.57[a]	6,985	453.56[a]	551.43[a]	524.64[a]	2,996	550.26[a]
	d	0.2	0.41	0.32	0.45	0.32	0.49	0.23	0.37
	$PR_{CC}(M_{YA})$	56.73	65.09	61.25	67.92	62.42	69.23	57.39	62.13
Agilty	*M±SD* (CC)	8.5 ± 0.44	8.38 ± 0.43	8.31 ± 0.42	8.23 ± 0.41	8.18 ± 0.4	8.13 ± 0.39	8.08 ± 0.41	8.05 ± 0.4
	M±SD (YA)	8.32 ± 0.44	8.19 ± 0.4	8.11 ± 0.39	8.01 ± 0.37	7.95 ± 0.36	7.91 ± 0.38	7.88 ± 0.4	7.87 ± 0.38
	t	8.20**	8.69**	9.47**	11.08**	11.47**	10.42**	9.33**	7.90**
	df	8,499	421.61[a]	6,951	436.14[a]	4,664	4,117	2,987	2,559
	d	0.42	0.43	0.46	0.54	0.57	0.55	0.49	0.45
	$PR_{CC}(M_{YA})$	63.77	64.3	65.92	68.72	70.86	70.41	68.2	65.35
Dribbling	*M±SD* (CC)	11.61 ± 1	11.28 ± 0.9	11.12 ± 0.87	10.91 ± 0.82	10.78 ± 0.78	10.68 ± 0.76	10.63 ± 0.81	10.5 ± 0.71
	M±SD (YA)	10.94 ± 0.88	10.65 ± 0.74	10.47 ± 0.75	10.31 ± 0.81	10.31 ± 0.77	10.16 ± 0.73	10.13 ± 0.68	10.07 ± 0.64
	t	14.94**	15.99**	17.42**	14.15**	12.14**	12.78**	13.18**	11.44**
	df	449.61[a]	434.50[a]	521.69	427.56[a]	4,652	4,099	572.66[a]	508.22[a]
	d	0.67	0.7	0.74	0.73	0.6	0.67	0.62	0.59
	$PR_{CC}(M_{YA})$	74.21	75.98	78.38	78.25	71.94	75.46	71.64	70.9
Ball control	*M±SD* (CC)	11.58 ± 1.71	10.83 ± 1.52	10.66 ± 1.49	10.14 ± 1.36	10.06 ± 1.37	9.66 ± 1.26	9.69 ± 1.33	9.32 ± 1.29
	M±SD (YA)	10.68 ± 1.64	10.14 ± 1.4	9.66 ± 1.25	9.43 ± 1.25	9.23 ± 1.22	9.1 ± 1.32	8.82 ± 1.08	8.84 ± 1.17

	t	10.12**	8.51**	16.00**	10.59**	13.20**	8.16**	14.31**	6.58**
	df	8,404	8,029	521.70[a]	424.53[a]	542.19[a]	4,079	574.05[a]	2,517
	d	0.52	0.45	0.67	0.52	0.6	0.44	0.66	0.38
	$PR_{CC}(M_{YA})$	67.07	63.89	74.27	67.67	71.45	64.01	73.82	60.43
Shooting	*M±SD* (CC)	17.1 ± 3.63	16.7 ± 3.79	16.28 ± 3.84	15.9 ± 3.89	15.82 ± 3.99	15.45 ± 3.9	15.26 ± 4.01	14.98 ± 3.97
	M±SD (YA)	16.12 ± 3.63	16.05 ± 3.57	15.95 ± 3.48	15.07 ± 3.68	15.25 ± 3.72	15.13 ± 3.94	13.89 ± 4.01	14.44 ± 4.01
	t	4,16**	2.25	1.38	2,78*	2.14	1.13	4,89**	1,70**
	df	8,291	7,878	6,753	6,477	4,418	3,960	2,756	2,419
	d	0.27	0.17	0.09	0.21	0.14	0.08	0.34	0.14
	$PR_{CC}(M_{YA})$	58.73	54.75	59.76	55.64	54.89	51.55	67.39	55.24
Juggling	*M±SD* (CC)	1.32 ± 1.76	1.94 ± 2.4	2.54 ± 2.99	3.19 ± 3.54	3.81 ± 3.96	4.66 ± 4.54	5.12 ± 4.75	5.92 ± 5.24
	M±SD (YA)	3.03 ± 3.9	3.56 ± 3.8	3.93 ± 4.06	5.85 ± 5.05	6.02 ± 5.02	7.42 ± 5.54	7.71 ± 5.68	8.78 ± 6.17
	t	7.66**	7.65**	6.22**	9.44**	7.72**	8.65**	7.47**	7.59**
	df	311.82[a]	338.24[a]	353.06[a]	346.23[a]	349.74[a]	356.59[a]	335.77[a]	352.51[a]
	d	0.9	0.65	0.46	0.72	0.54	0.59	0.53	0.53
	$PR_{CC}(M_{YA})$	92.43	85.88	77.97	83.25	81.93	79.38	75.01	77.08

Note. The algebraic sign of Cohen's d was inverted for Juggling and Score because higher points mean higher performances. [a]Variances not homogenious, [b]Relevant deviations from normal distribution for the t-tests were denied by repeating each test with the non-parametric Mann-Whitney-U-Test, which confirmed all inferential test results. **highly significant (P<.01/8), *significant (P<.05/8), α Bonferroni-adjustiert with k=8.

Anhang 1

Table 5.

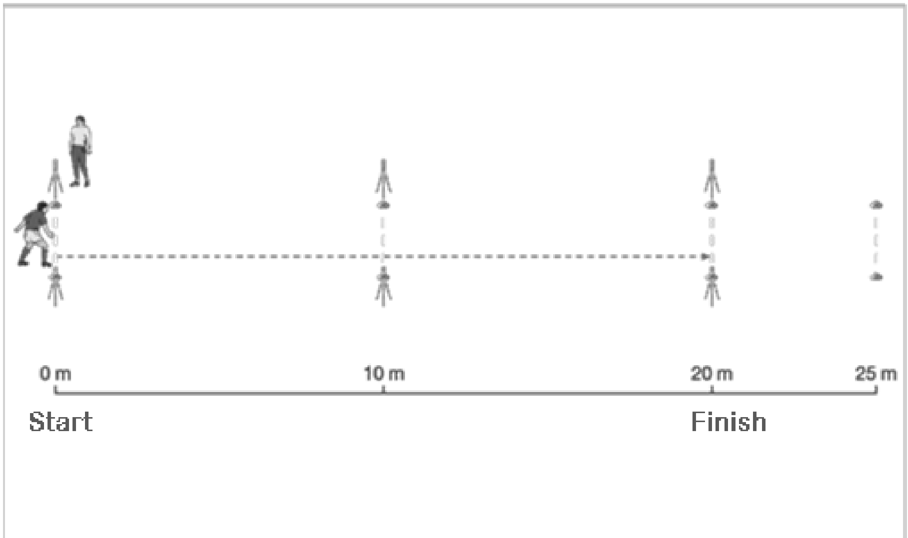
Reference Values for the Results of Competence Centre (CC) Players and Youth Academy (YA) *Players*[a] *Including All 17 Measurement Points Separated for the Age Groups U12 to U15 in the Autumn and Spring Diagnostics (Upper Limits Representing Percentile Rank (PR) 70 and Lower Limits for PR30 are used to Categorise Players as Category A (Above-average Performance), B (Average Performance) or C (Below-average Performance)).*

		U12		U13		U14		U15	
		Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
	Score	[41.05; 43.16]	[41.96; 44.09]	[42.60; 44.77]	[43.25; 45.42]	[43.93; 46.07]	[44.48; 46.61]	[44.99; 47.22]	[45.50; 47.72]
	[PR30; PR70]	(n=30,662)	(n=32,435)	(n=25,316)	(n=27,298)	(n=17,065)	(n=16,768	(n=10,621)	(n=10,443)
	Sprint	[3.78; 3.60]	[3.73; 3.56]	[3.68; 3.50]	[3.64; 3.47]	[3.56; 3.38]	[3.51; 3.32]	[3.43; 3.25]	[3.38; 3.20]
	[PR30; PR70]	(n=33,997)	(n=35,677)	(n=27,740)	(n=30,159)	(n=18,787)	(n=18,811)	(n=11,872)	(n=11,893)
	Agility	[8.73; 8.28]	[8.60; 8.17]	[8.52; 8.09]	[8.45; 8.02]	[8.38; 7.97]	[8.32; 7.92]	[8.28; 7.87]	[8.22; 7.83]
	[PR30; PR70]	(n=33,767)	(n=35,586)	(n=27,639)	(n=30,107)	(n=18,722)	(n=18,770)	(n=11,826)	(n=11,864)
CC	Dribbling	[12.09; 11.15]	[11.75; 10.90]	[11.55; 10.72]	[11.35; 10.57]	[11.17; 10.42]	[11.06; 10.33]	[10.97; 10.23]	[10.89; 10.18]
	[PR30; PR70]	(n=33,842)	(n=35,562)	(n=27,623)	(n=30,067)	(n=18,673)	(n=18,708)	(n=11,801)	(n=11,816)
	Ball Control	[12.41; 10.74]	[11.67; 10.16]	[11.40; 9.95]	[10.97; 9.59]	[10.75; 9.41]	[10.41; 9.14]	[10.30; 9.02]	[10.11; 8.85]
	[PR30; PR70]	(n=33,087)	(n=34,979)	(n=27,242)	(n=29,680)	(n=18,441)	(n=18,520)	(n=11,645)	(n=11,660)
	Shooting	[20.00; 16.00]	[19.00; 15.00]	[19.00; 15.00]	[19.00; 15.00]	[19.00; 14.00]	[18.00; 14.00]	[18.00; 14.00]	[18.00; 13.00]
	[PR30; PR70]	(n=33,261)	(n=35,003)	(n=27,394)	(n=29,664)	(n=18,694)	(n=18,749)	(n=11,985)	(n=12,032)
	Juggling	[0.00; 1.00]	[1.00; 2.00]	[1.00; 3.00]	[1.00; 3.00]	[1.00; 4.00]	[2.00; 5.00]	[2.00; 6.00]	[2.00; 7.00]
	[PR30; PR70]	(n=7,966)	(n=7,457)	(n=6,469)	(n=6,060)	(n=4,208)	(n=3,593)	(n=2,582)	(n=2,137)

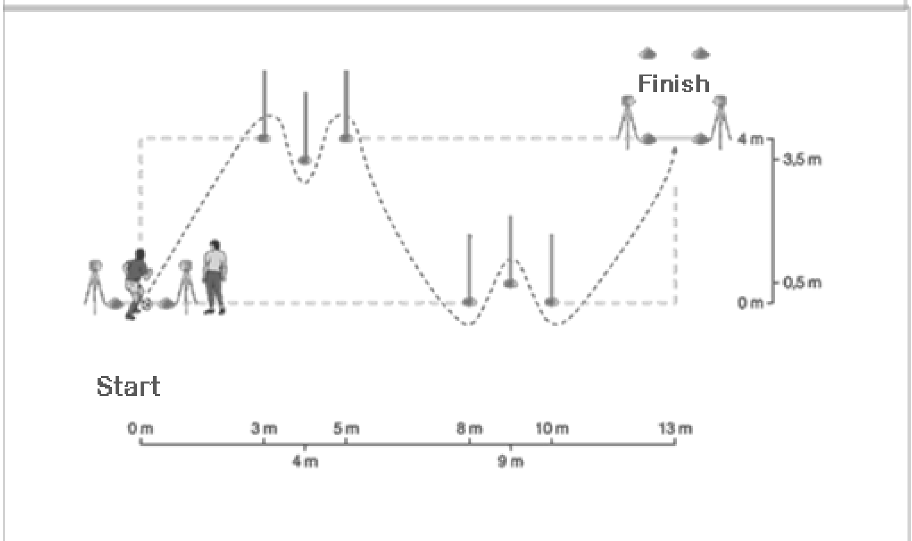
	Score [PR30; PR70]	[42.32; 45.00] (n=302)	[43.64; 45.67] (n=272)	[44.20; 46.34] (n=408)	[44.84; 46.60] (n=359)	[45.53; 47.72] (n=365)	[46.13; 48.16] (n=293)	[46.48; 48.32] (n=280)	[46.52; 48.65] (n=190)
	Sprint [PR30; PR70]	[3.76; 3.57] (n=613)	[3.68; 3.51] (n=650)	[3.62; 3.47] (n=735)	[3.57; 3.41] (n=743)	[3.49; 3.33] (n=713)	[3.44; 3.27] (n=684)	[3.38; 3.20] (n=638)	[3.31; 3.17] (n=550)
	Agility [PR30; PR70]	[8.53; 8.08] (n=608)	[8.36; 7.94] (n=633)	[8.28; 7.90] (n=732)	[8.20; 7.83] (n=729)	[8.13; 7.76] (n=714)	[8.12; 7.78] (n=690)	[8.04; 7.68] (n=633)	[8.08; 7.71] (n=552)
YA	Dribbling [PR30; PR70]	[11.34; 10.51] (n=610)	[10.92; 10.21] (n=650)	[10.82; 10.14] (n=728)	[10.56; 9.97] (n=746)	[10.57; 9.96] (n=708)	[10.44; 9.84] (n=680)	[10.93; 9.84] (n=598)	[10.38; 9.78] (n=535)
	Ball Control [PR30; PR70]	[11.37; 9.93] (n=588)	[10.66; 9.44] (n=640)	[10.38; 9.10] (n=709)	[9.92; 8.93] (n=718)	[9.79; 8.64] (n=679)	[9.55; 8.45] (n=644)	[9.43; 8.40] (n=583)	[9.41; 8.28] (n=523)
	Shooting [PR30; PR70]	[19.00; 14.00] (n=314)	[19.00; 15.00] (n=287)	[18.00; 14.00] (n=427)	[19.00; 14.00] (n=375)	[18.00; 13.00] (n=389)	[17.00; 13.00] (n=327)	[17.00; 13.00] (n=299)	[17.00; 13.00] (n=207)
	Juggling [PR30; PR70]	[1.00; 3.00] (n=236)	[1.00; 3.00] (n=218)	[1.00; 4.00] (n=271)	[2.00; 7.00] (n=249)	[2.00; 7.00] (n=260)	[3.00; 8.00] (n=211)	[3.00; 9.00] (n=244)	[4.00; 10.00] (n=200)

Note. For Juggling and Score, higher points indicate higher performance; for the other tests, lower times (in seconds) mean lower performances. [a]Competence centre and youth academy players.

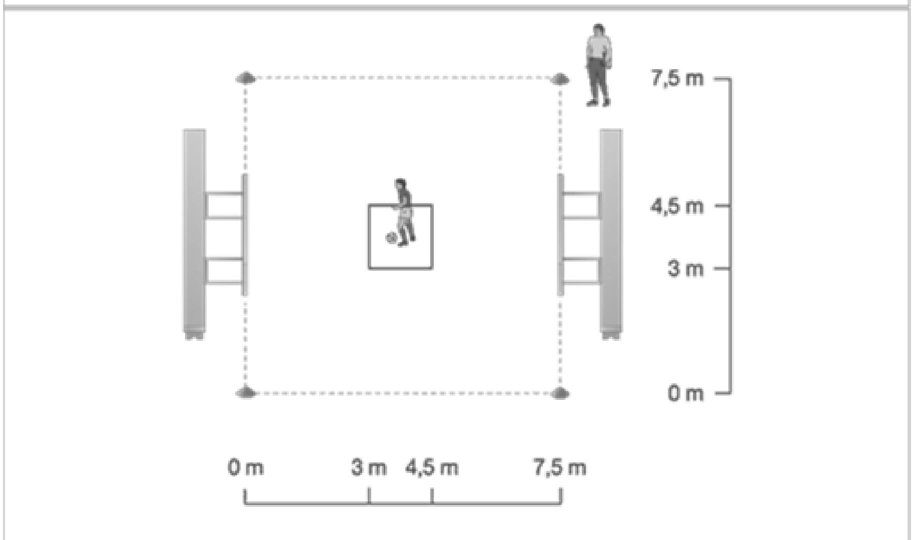
Figure 1.
Description of the Six Single Motor Tests in the Motor Diagnostics (DFB, 2013).



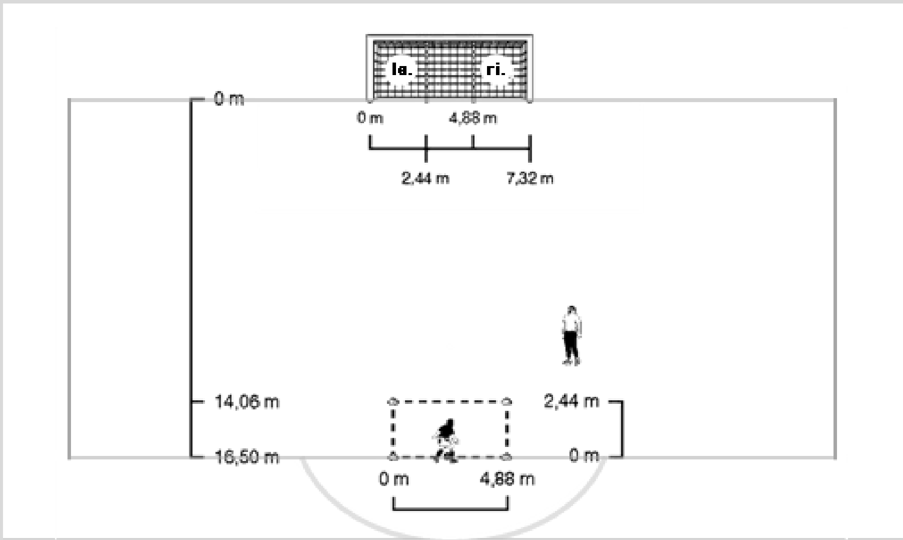
Sprint
Start from step position without any signal and run through a 20m linear course as fast as possible.



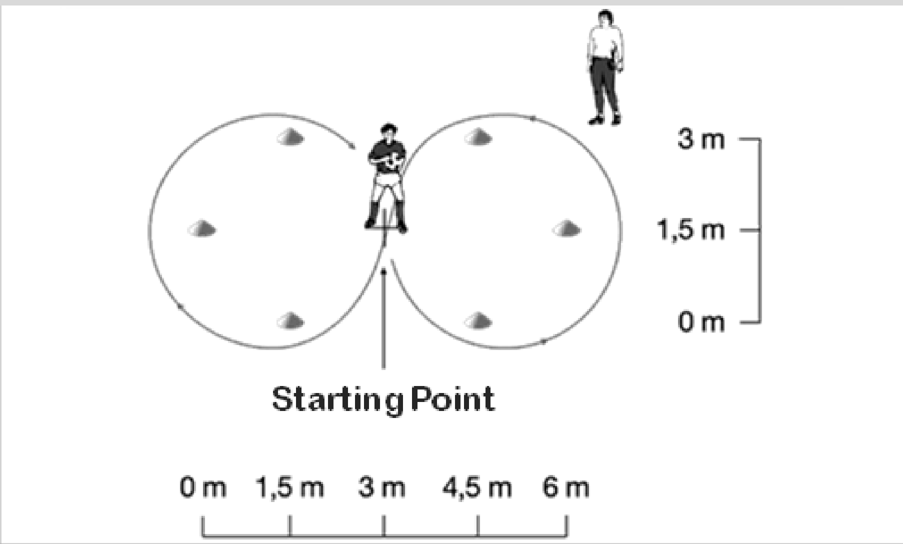
Agility / Dribbling
Start from step position without any signal and run through a slalom course as fast as possible. (Conduct without ball for agility, with ball for dribbling.)



Ball Control
Play six passes as fast as possible alternately against the two opposing impact walls. (Passes from the central passing field with at least two ball contacts. Time is measured from the first pass through the sixth ball receiving with the sole of the foot.)



Shooting
Shoot the ball from the shooting field primarily into the coach-ordered target field and secondarily with high speed. (Before shooting, the ball is set up into the shooting field with one contact. The coach rates precision and speed of 8 (2 targets * 2 feet * 2 attempts) shots.)



Juggling
Juggle the ball alternately and only with the left and right foot, through as many subsections of the eight-course as possible without ground contact. (The attempt is terminated in case of rule violation or after 45 seconds. Successfully passed subsections correspond to the number of points.)

Figure 2.

Stability of Motor Performance Results for All Competence Centre Players (T1 to T17, respectively, Spring 2004 to Spring 2012). Correlations Between the U12-Results and the Results in the U13-, U14- and U15-Seasons .

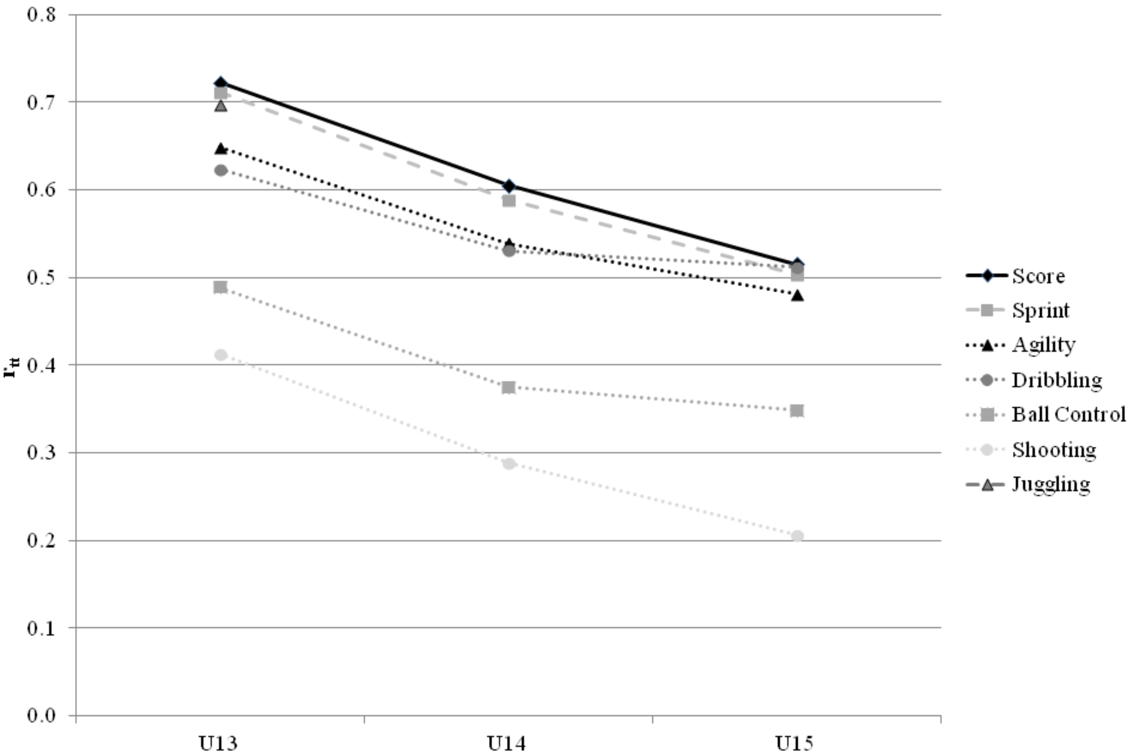
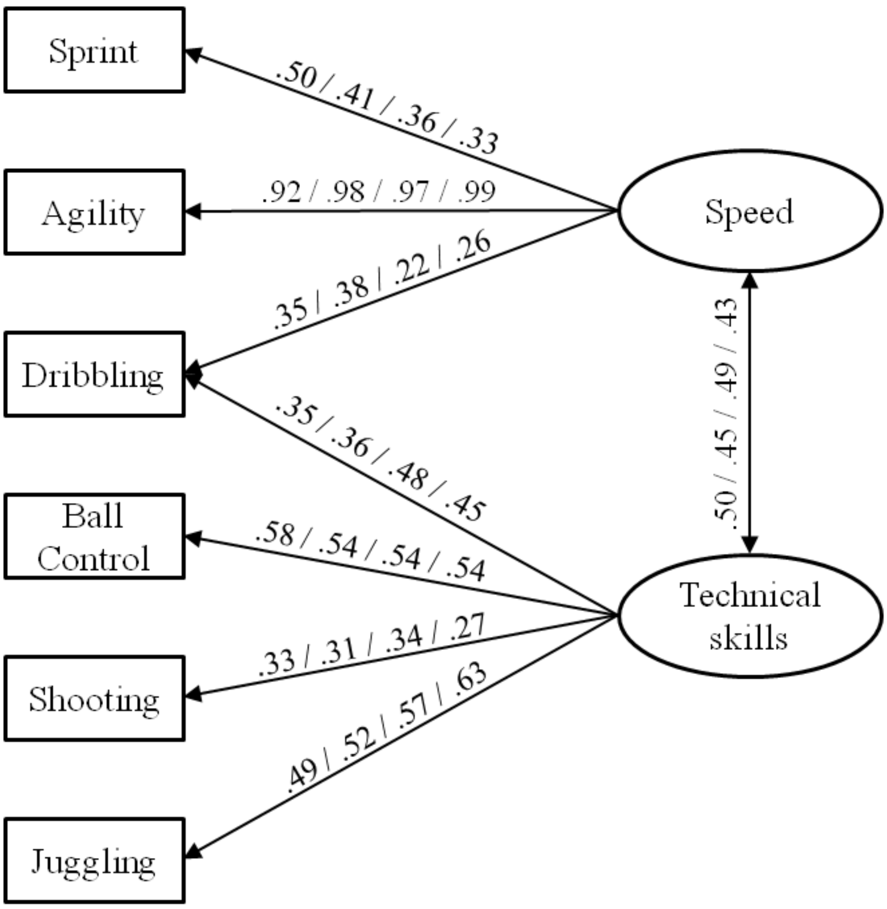


Figure 3.

Measurement Model for the Confirmatory Factor Analysis With Two Correlated Latent Factors, "Speed" and "Technical Skills", and Their Loadings on the Six Single Motor Tests for the Age Groups U12 to U15 (β_{U12} / β_{U13} / β_{U14} / β_{U15}) *for* Competence Centre (CC) *Players (T14 to T17, respectively, Autumn 2010 to Spring 2012). All Loadings Were Highly Significant (p<.01).*



Höner, O., & Votteler, A. (2016). Prognostic relevance of motor talent predictors in early adolescence: A group- and individual-based evaluation considering different levels of achievement in youth football. This is the authors accepted manuscript of an article published as the version of record in Journal of Sports Sciences, 34, 2269-2278. The original article is available at http://www.tandfonline.com/doi/full/10.1080/02640414.2016.1177658. The manuscript is used as part of this dissertation with the permission of Taylor & Francis.

Title: Prognostic Relevance of Motor Talent Predictors in Early Adolescence: A Group- and Individual-Based Evaluation Considering Different Levels of Achievement in Youth Football

Keywords: motor diagnostics, sensitivity, soccer, specificity, talent prognosis

Abstract

In the debate about the usefulness of motor diagnostics in the talent identification process, the prognostic validity for tests conducted in early adolescence is of critical interest. Using a group- and individual-based statistical approach, this prospective cohort study evaluated a nationwide assessment of speed abilities and technical skills regarding its relevance for future achievement levels.

The sample consisted of 22,843 U12-players belonging to the top 4% in German football. The U12-results in five tests served as predictors for players' selection levels in U16-U19 (youth national team, regional association, youth academy, not selected).

Group-mean differences proved the prognostic relevance for all predictors. Low individual selection probabilities demonstrated limited predictive values, while excellent test results proved their particular prognostic relevance. Players scoring PR≥99 had a 12 times higher chance to become youth internationals than players scoring PR<99. Simulating increasing score cut-off values enhanced specificity (correctly identified non-talents) but also led to lower sensitivity (loss of talents).

Extending the current research, these different approaches revealed the ambiguity of the diagnostics' prognostic relevance, representing both the usefulness and several pitfalls of nationwide diagnostics. Therefore, the present diagnostics can support but not substitute for coaches' subjective decisions for talent identification, and multidisciplinary designs are required.

Introduction

Talent identification and development (TID) programmes must select talented individuals from a large population of youth athletes who are deemed to be potential future elite athletes (Cobley, Schorer, & Baker, 2012). Particularly in popular sports, this selection process is a huge challenge because of the high participation rate and the relatively low ratio of athletes who will be selected to play in top levels. Talent selection is commonly conducted by experienced talent coaches who rather subjectively evaluate youth players' potential (Christensen, 2009). To support coaches' decisions with additional objective information, several TID programmes have implemented diagnostics that measure motor performance factors (Unnithan, White, Georgiou, Iga, & Drust, 2012).

From a scientific view, the diagnostics' prognostic validity is of critical interest, and there is a debate about whether such motor tests are useful for the talent identification process in practice (Carling & Collins, 2014). Some researchers strongly question the predictive function of motor tests for future success because of the complex nature of performance in sports games and the high inter-individual differences in players' development (Ronnie Lidor, Côté, & Hackfort, 2009; Pankhurst & Collins, 2013). Conversely, some longitudinal studies from different sports games showed that motor performance tests can be used to discriminate between prospectively successful and less successful players (Falk, Lidor, Lander, & Lang, 2004; Gabbett, Georgieff, & Domrow, 2007; R. Lidor et al., 2005; Till et al., 2011). These studies measured general motor abilities (e.g., speed, strength, and endurance) as well as sport-specific technical skills (e.g., dribbling, passing and throwing) to predict players' future success.

With regard to the here-addressed sport of football, several studies proved that different motor abilities as well as technical skills possess a general prognostic relevance for players' future performance levels (Gonaus & Müller, 2012; Huijgen, Elferink-Gemser, Lemmink, & Visscher, 2014; Huijgen, Elferink-Gemser, Post, & Visscher, 2009; Le Gall, Carling, Williams, & Reilly, 2010). These studies usually examined the mean differences in motor variables between groups of selected and non-selected players and provided *group-based* insights, which are important for talent research and for the coaches' knowledge about relevant talent factors. However, the group-based perspective lacks information about the diagnostics' prognostic relevance at the *individual level*. This is particularly important for coaches (who must make selection decisions in individual cases) and for sports associations (who might want to optimise their TIDs concerning the selection rates for different developmental stages).

On an individual level, prognostic statements must be probabilistic (Ackerman, 2014), which also means that fixed cut-off values in diagnostics must not be applied deterministically to distinguish between talents and non-talents. Therefore, the statistical information provided by talent studies is a critical issue for the practical relevance of diagnostics. To our knowledge, there are no scientific studies in football that analyse the diagnostics' probabilistic potential to support the predictions that coaches must make in their everyday routines. Furthermore, even if the specification of fixed cut-off values will always remain illusionary (Ronnie Lidor et al., 2009), there is a need for information about the prognostic validity in terms of sensitivity and specificity (proportion of correctly selected talents and correctly deselected non-talents) when sports associations intend to use diagnostic results as a supportive talent-screening tool.

Further critical issues in the debate of prognostic validity are the *development phases* in which the predictors are assessed and the level of performance operationalized as the criterion. Roughly categorizing the development phases into early (11-14 years), middle (15-17 years), and late adolescence (18-21 years) (e.g., Greydanus & Bashe, 2003), most of the studies included prognostic periods from middle adolescence to late adolescence or adulthood. Only a few studies have assessed motor predictors in early adolescence to discriminate between selection levels (e.g. Figueiredo, Gonçalves, Coelho e Silva, & Malina, 2009), although systematic talent selection in football starts at the age of 11 or 12 years (Höner, Votteler, Schmid, Schultz, & Roth, 2015; Huijgen et al., 2014). Another problem is that the criterion variables in talent studies are quite difficult to compare because of different *performance levels* between countries. Further, the achieved level is most often only roughly classified with two widely separated stages: “selected vs. non selected” (Gonaus & Müller, 2012) or “professionals vs. amateurs” (Roescher, Elferink-Gemser, Huijgen, & Visscher, 2010). Because coaches in TID programmes must make more detailed decisions between already highly selected elite and near-elite players, the motor predictors’ discriminative power between slightly different higher selection levels in adolescence (e.g., youth academy, regional association or youth national teams) is of particular interest.

As an extension to previous research, this study covered the sparsely examined middle-term period from early adolescence to middle-to-late adolescence and distinguished four different selection levels. Aiming at ecological validity and practical relevance, the study was conducted within the football TID programme led by the German Football Association (Deutscher Fußball-Bund, DFB). To monitor the talents’ development based on nationwide reference values, a motor test battery (Lottermann, Laudenklos, & Friedrich, 2003) was implemented in all 366 DFB competence centres. The tests in this nationwide assessment were designed pragmatically due to economic constraints with a focus on the central aims of the TID programme in early adolescence, i.e., the promotion of talented players’ speed abilities (sprinting, agility) and technical skills (dribbling, ball control, shooting) (Deutscher Fußball Bund, 2009).

The prognostic relevance of this motor test battery was evaluated within three objectives on a group-based level (providing information on mean differences) as well as on an individual-based level (providing probabilistic information). From a mean group-based perspective, we investigated the *diagnostics’ prognostic relevance* for reaching different performance levels in middle-to-late adolescence (I.). In addition, from a more probabilistic perspective, we determined players’ *individual selection probabilities* for reaching higher selection levels depending on their diagnostic results in early adolescence (II.), and we quantified the effect of fictive cut-off values in terms of *diagnostic sensitivity and specificity* as a talent-screening tool (III.).

Materials and Methods

Study Design and Sample

The DFB promotes 5,000 U12 players nationwide from amateur clubs at competence centres (Schott, 2010). In middle-to-late adolescence (U16-U19), the players regarded as the most talented are selected in an elite promotion programme for the youth academy, regional association, or even youth national teams. This *prospective cohort study design* included motor test results in the U12 age group (early adolescence) as predictors and the selection success in the age groups U16-U19 (middle-to-late adolescence) as the criterion. The *study sample* was composed of 22,843 U12 competence centre players from the 1993-1997 birth cohorts who participated in the nationwide diagnostics. The selected players belonged to the top 4% of U12 players in Germany. The U12 players were, on average, 148.5 (± 6.7) cm tall, weighed 38.0 (± 5.7) kg and were 11.4 (± 0.3) years old. All players' parents provided informed consent for the recording and scientific use of the data. The ethics department of the Faculty of Economics and Social Sciences at the University of Tübingen and the scientific board of the DFB approved the implementation of this study.

Measures

The test battery was composed of five tests measuring speed abilities and football-specific technical skills, such as *sprinting* (time for a 20-m sprint), *agility* and *dribbling* (time in a slalom course without and with a ball), *ball control* (time for six passes against two opposing impact walls), and *shooting* (8 shots at different target fields, each shot is rated by the coach with regard to precision and speed). The results of these negatively coded tests (less time and fewer points indicated better performance) were combined in a positively coded *score* using the formula

$$score=10{,}000*[(17.29*sprint)+(9.43*agility)+(4.11*dribbling)+(2.41*ball\ control)+shooting]^{-1}$$

Thereby, the weighting factors displayed the ratio of the shooting test's standard deviations with the corresponding test at the origin measurement point in 2004 (Lottermann et al., 2003).

Höner et al. (2015) presented a detailed description of the single tests and a comprehensive analysis of their psychometric properties. The internal consistencies and test-retest reliabilities over a 5-month period proved to be sufficient for the diagnostic score (α=.89 and r_{tt}=.74) with some weaknesses in single tests. In particular, the reliability of the shooting test was critical (α=.41 and r_{tt}=.31), whereas the sprint test exhibited the best psychometric properties in terms of reliability (α=.95 and r_{tt}=.76). Regarding the concurrent validity, the motor diagnostics in the relevant age group U12 revealed significant differences in motor performance between competence centre (CC) players and youth academy (YA) players in the score and in all single tests.

The criterion variable was operationalized as the highest selection level the former U12 players reached four to seven years later in the U16-U19 age groups. Therefore, the DFB's squad lists from 48 German youth academies, 21 regional associations and the youth national teams in the 2010/11, 2011/12 and 2012/13 seasons were analysed for the players' names and birth days. With this procedure, those players from the U12 sample who reached a higher selection level in middle-to-late adolescence in the German elite promotion programme were identified. Each player was allocated to the highest selection level that he reached in the U16-U19 groups. Therefore, the former U12 players were assigned to the following group levels: *youth national team* (N=195; top 0.9% of players in the examined sample), *regional association* (N=731; top 1.0-4.1%), *youth academy* (N=1,025; top 4.2-8.5%), and *not further selected* (N=20,892; the remaining 91.5% of the sample).

Statistical analysis

Analyses were performed using SPSS version 21. With regard to the general *prognostic relevance* (objective I), we determined the significance of mean differences between future selection levels with one-way ANOVAs and subsequent post-hoc Tukey's tests and classified the effect sizes (η^2, Cohen's d) according to Cohen (1988). Because motor performance differences between selection levels may be affected by differences between cohorts (Elferink-Gemser, Huijgen, Coelho e Silva, Lemmink, & Visscher, 2012) or in relative age (Carling, le Gall, Reilly, &

Williams, 2009; Votteler & Höner, 2014), the influence of these variables on the diagnostic score was analysed with two-way ANOVAs (selection level x birth year, and selection level x quarter of birth, respectively). Both variables, the cohort ($F_{(12;\ 19,626)}$ =1.01, p=.44) and the quarter of birth ($F_{(9;\ 19,629)}$ =0.89, p=.54), did not show any significant interactions with the selection level regarding the score. Thus, they were not further considered as confounder variables.

The following objectives were assessed using the score. We conducted a multinomial logistic regression for determining *individual selection probabilities* (objective II) for all higher selection levels on the basis of a player's U12 score. The overall model fit was examined with the likelihood ratio chi-squared test. The score's regression coefficients as well as the odds ratios e^{β} and their 95% confidence intervals were calculated with reference to the selection level "not selected". The regression coefficients were then used to calculate the statistical selection probabilities for reaching higher selection levels.

Because pseudo r-squared statistics often underestimate the relevance of predictors (Hosmer, Lemeshow, & Sturdivant, 2013), we determined a pragmatic effect size on the basis of a dichotomised score. Therefore, we first transformed the score results into percentile ranks (PRs). Then, we chose the 99, 90 and 50 PRs as threshold values to dummy code the score (for example, PR99 distinguishes between the best 1% and the worst 99% of performances in the diagnostics). The thresholds were orientated on the selection rates within the sample for youth national team players (≈1%; see table 1) and for selected players in general (≈10%) as well as on the centroid of the results' distribution of the U12 diagnostics (=50%). Finally, we calculated the odds ratios (relative chances) for being selected in middle-to-late adolescence between group 1 (players with better score results than the chosen thresholds) in comparison to group 0 (players with worse results).

To analyse the *sensitivity and specificity* (objective III), we fictively categorised players as "talented" or "not talented" based on the U12 diagnostics. Therefore, we used varying cut-off score values (PR10, PR20, PR30, and so on) and categorised players with a score beneath these cut-off values as non-talented, whereas players with a score better than this cut-off value were categorised as talented (with regard to each selection level). Afterwards, the player's category was compared with their future selection success to determine the proportion of correctly identified talents and non-talents in terms of the diagnostic sensitivity and specificity (Altman & Bland, 1994).

Results

Prognostic relevance of the motor tests (objective I)

Table 1 shows the mean results in the U12 diagnostics for players reaching different selection levels in middle-to-late adolescence. All motor variables significantly discriminated between selection levels ($p<.01$). The level effect was small to medium for the score ($\eta^2=.03$) and small for the single tests ($.01\leq\eta^2\leq.02$).

Table 1

The results of the post-hoc tests (Figure 1) showed that players who were selected in middle-to-late adolescence achieved significantly better performances than the non-selected players in all motor tests in U12. The largest differences were found for all motor variables between youth national and non-selected players with medium to large effect sizes ($.30\leq d\leq.90$). The effect sizes distinguishing between players selected for regional associations or youth academies and non-selected players were smaller ($.24\leq d\leq.62$ and $.19\leq d\leq.52$, respectively).

Figure 1

Within the selected players, the score and the speed tests were sensitive enough to discriminate significantly between the highest level and the other selected levels. Youth national team players had significantly better results than regional association and youth academy players with low to medium effect sizes in the variables score (d=.29 and d=.38, respectively), sprint (d=.36, and d=.31, respectively), and agility (d=.23, and d=.22, respectively). Further, youth national team players achieved significantly better results than youth academy players but not than regional association players in ball control (d=.30). The differences between the regional association and youth academy levels were small. They did not reach significance except for ball control (d=.21) and shooting (d=.09), in which regional association players achieved better performance.

The sequence of variables' discriminating power depended in part on the specific selection level. The most discriminating motor variables between selected and non-selected players were the score (.52≤d≤.90), followed by sprint, dribbling and ball control (.38≤d≤.67, .45≤d≤.64, and .32≤d≤.59, respectively). The smallest differences were found for shooting (.19≤d≤.30). On the highest level, the score and the sprint test discriminated most between youth national players and the other selected players (.29≤d≤.38, and .31≤d≤.36, respectively). Remarkably, the sprint test discriminated better than the score between the highest selection levels. However, the difference between the two effect sizes failed to reach significance (the 95% confidence interval for the effect size ranged from 0.12 to 0.46 for the score).

Individual selection probabilities based on the diagnostics (objective II)

Including the U12 score results in a logistic regression model to predict players' selection levels led to a significantly better model fit compared to the null model (χ^2=582.19, df=3, p<.01). The logistic regression coefficients and the estimated selection probability values at the score thresholds are shown in Table 2. The *odds ratios* e^{β} from the logistic regression model indicated that a one standard deviation (SD_{Score}=2.07) higher score increased the chance of being selected by a factor of 1.69 (=$(e^{\beta})^{2.07}$=$1.29^{2.07}$) for youth academies, by 1.89 (=$1.36^{2.07}$) for regional associations and by 2.51 (=$1.56^{2.07}$) for the youth national teams. The corresponding 95% confidence intervals proved that the e^{β} significantly differed among each other.

Table 2

Figure 2

The curves of the individual *selection probabilities* are displayed for each selection level in Figure 2. The selection probabilities were higher for lower selection levels. For example, with a medium test result in the score (PR=50), the estimated probabilities (1% for youth national team, 3% for regional association, and 4% for youth academy) were more or less equal to the actual selection rates for each selection level in the examined sample. Demonstrating the prognostic validity, the selection probabilities increased with higher test results in the score, but not in a parallel manner for the selection levels, due to the significantly different $e^{ß}$. For youth academies and regional associations, the increase rate was rather small and constant until the median results were reached (PR50). Afterwards, the selection probabilities noticeably increased for players with very good score results (PR90), up to 7% and 8%, respectively, and again for players with outstanding score results (PR99), up to 12% and 14%, respectively. In comparison, the curve for youth national teams showed nearly no increase between poor and medium diagnostic results. Whereas the selection probability for players' with very good scores (PR90) was only slightly higher than for players with medium results (PR50) (2% vs. 1%), the selection probabilities considerably increased up to 6% for players with outstanding scores (PR99).

The *odds ratios* OR_{PRi} presented in Table 2 indicated the relative chances of being selected between the dummy coded score groups. The highest ORs were found in the youth national team level. The regional association and youth academy teams had similar ORs. The OR_{PR90}=4.53 was quite similar to OR_{PR50}=5.3 for the youth national team, whereas the PR99 threshold led to a distinctly higher OR. Hence, a U12 player with a score value PR≥99 had an OR_{PR99}=12.19 times higher odds of becoming a youth national team player than a U12 player who scored PR<99. With regard to the youth academy or regional association level, the odds ratios only slightly increased from a threshold of PR50 (OR_{PR50}=2.21 and OR_{PR50}=2.82, respectively) to PR99 (OR_{PR99}=4.02 and OR_{PR99}=3.74, respectively).

Diagnostic sensitivity and specificity (objective III)

The results for the sensitivity and specificity (Figure 3) demonstrated that higher cut-off values lead to a higher rate of correctly identified non-talents (*higher specificity*) but simultaneously to a higher rate of not correctly identified talents (*lower sensitivity*). For example, a fictive cut-off of PR=30 would cut off 31.0% of the players that would not be selected for the youth national team in the future. However, this would result in 10.1% of the future youth national team players being cut off as well. The figure also shows that despite equal specificity, the sensitivity for the youth national team was higher compared to the regional association and youth academy teams, especially at the cut-off values of PR40 to PR70. Another particularity was that even at the marginal PR categories, not all players were correctly identified as talents or non-talents. When using the score's PR10 as a cut-off value, for example, 1.1% of the future youth national team players (*N*=2) would not be identified as talented. Similarly, 0.7% of players (*N*=134) would be incorrectly classified as talented when using the score's PR99 as the cut-off value, although they were not selected in later adolescence.

Figure 3

Discussion

Conducted within a nationwide talent development programme, this study addressed the controversial debate regarding the “real-world utility and possible pitfalls” (Carling & Collins, 2014, p. 1207) of motor diagnostics providing nationwide reference values in elite youth football. Compared to former studies in this field (Meylan, Cronin, Oliver, & Hughes, 2010), this study benefitted from a large sample size, enabling different statistical approaches with nationwide representative results. Thereby, the highest selected group on the youth national level was large enough to detect even small effect sizes and to provide reliable estimations for individual selection probabilities or diagnostic sensitivity.

Furthermore, the study provided new insight concerning the sparsely examined middle-term prediction period between the beginning of systematic talent selection (early adolescence) and the three highest levels of youth development in German football (middle-to-late adolescence). Thereby, this prediction period might be regarded as a limitation of this study because some studies questioned juvenile success as an appropriate predictor for success in adulthood (Güllich & Emrich, 2014). However, being selected for the youth academies in middle-to-late adolescence seems to be strongly associated with success in adulthood in German football, as nearly 90% of players in the first and second German professional leagues played at least one season for a youth academy (Güllich, 2014).

For further interpretation of the results, it must be considered that in studies with already selected samples, the variance in the investigated predictor and criterion variables is limited (“restriction of range of talent”; Ackerman (2014, p. 13)). This diminishes the expectable statistical correlation between predictor and criterion. Thus, differences in the calculated prognostic relevance in empirical studies may be associated with a systematic variation of the selection level of the original study sample as well as with differences in the selection rates of the successful players within the sample. The present study examined already selected players belonging to the top 4% of Germany's U12 players. Only 8.5% of the players from this U12 sample were selected for higher selection levels in middle-to-late adolescence. Achieving at least the youth academy level, these "successful" players of this study belong (together with other youth players educated in the youth academies already in early adolescence) to the top 1% of Germany youth players in middle-to-late adolescence (Schott, 2010).

At this high level, the motor score proved to be prognostically valid in discriminating between *group means* of future selected and non-selected players with medium to high effect sizes and in accordance with the order of selection levels (d=.52, d=.62, and d=.90). At an even higher level, the score significantly differentiated between the future youth national team (top 0.9% of the examined sample) and the regional association (top 1.0-4.1%) as well as youth academy players (top 4.2-8.5%) with small effect sizes (d=.29 resp. d=.38). This means that the motor diagnostics assessed in a real-world setting are sensitive enough to discriminate between subgroups on a notably higher level over a mid-term prognostic period.

However, the score did not discriminate significantly between regional association and youth academy levels. This might be a limitation of our study in that both levels are not distinct enough in practice. On the one side, based on our categorisation of the players, it can be assumed that the performance level in the regional association is higher than in youth academy teams. This is also underlined by the score results' mean values and the significantly different odds ratios in the logistic regression. Nevertheless, the performance level of regional associations as well as the number and quality of youth academies within each association differs considerably across Germany. Therefore, in a few cases, the order of performance levels may actually reverse, comparing players from small regional associations with youth academy players from larger regional associations who are not nominated for their association because there were so many outstanding talents in their (e.g., more populous) region.

Compared to similar research, the effect sizes for the diagnostic score were higher in this study. The predictors in other studies often only discriminate with small to medium effect sizes between two levels of “selected” vs. “non-selected players” (Gonaus & Müller, 2012; Huijgen et al., 2014), or did not clearly discriminate between different levels of selected players (Figueiredo et al., 2009; Le Gall et al., 2010). Amongst others, these deviating results may be explained by the fact that these studies used either more highly selected players from youth academies (e.g., best 0.5% of players nationwide, Huijgen et al., 2014) or non-selected players from amateur clubs (Figueiredo et al., 2009). Additionally, the selection rates from the examined samples into the higher future selection levels were considerably higher in other studies examining the selection rates of youth academy players into professional leagues (41-44%) (Huijgen et al., 2009; Le Gall et al., 2010) than in the present study (8.5%).

Additionally, the *sequence of the single tests’ discriminative powers* seems to be rather sample- and design-specific. Even within the present study’s sample, the order of effect sizes varied between different selection levels. This is in line with the assumption that an increased homogeneity in some motor characteristics in already selected players may be responsible for a change in discriminating factors on higher selection levels (Baker, Schorer, & Cobley, 2012). Overall, the sprint, ball control and dribbling tests had the highest discriminative power on average. However, despite their average lower effect sizes, ball control and shooting were the only tests to discriminate between the regional association and youth academy players. Furthermore, the low effect sizes for the shooting test do not necessarily imply that the shooting skill is not a talent predictor because the motor characteristics’ prognostic validity also depends on their reliable assessment. For complex characteristics, reliable assessment is a huge challenge due to economic constraints in nationwide conducted diagnostics. The shooting test used in the German TID suffers low reliability (Höner et al., 2015), which has similarly been reported for other shooting tests in which the accuracy and speed of multiple shots with a rolling ball and alternating feet have been considered (Ali, 2011). In addition to the influence of psychometric properties, the discriminative power of motor tests also varies between different development stages (Gil, Ruiz, Irazusta, Gil, & Irazusta, 2007; Vaeyens et al., 2006). This may be explained by differences in the motor characteristics' timing and tempo of development. For example, development in sprinting might be faster compared to dribbling in middle adolescence (Huijgen, Elferink-Gemser, Post, & Visscher, 2010).

Overall, meaningful comparisons of diagnostics' prognostic relevance require similar research designs that consider the selection rates into and within the examined samples, the players' developmental stage, and the tests' reliabilities. The discriminative power of talent diagnostics and single tests must therefore be considered as rather specific for each TID programme. Because other sports deviate regarding the demand profiles, results from prospective studies in other sport games (e.g., Gabbett et al., 2007) provide comparable insights for football talent research only on a general level (e.g., recommendations for focussing on long-term development and on longitudinal designs), but not for specific details, such as the magnitude of predictors' effect sizes.

The established group-based analysis performed well in proving the general prognostic relevance of the motor test battery in this study. However, it must be questioned whether such diagnostics are sensitive enough to discriminate accurately between similar performing groups of highly selected players or even to predict the selection success of individuals (Carling & Collins, 2014; Meylan et al., 2010). The present study went beyond the commonly used group-based analysis and used the large dataset for a more *individual and probabilistic analysis* of the diagnostic score, i.e., the variable with the largest effect sizes. The analysis of the individual selection probabilities for reaching higher selection levels in middle-to-late adolescence demonstrated increased selection probabilities for higher score values. For a score performance that was one standard deviation better, the odds of being selected increased by a factor of 1.69 to 2.51, depending on the examined selection level. Nevertheless, especially for the youth national teams, the selection probabilities for high score values were still relatively low. Although this can be explained by the low average selection rate and may not necessarily indicate a low prognostic validity of the diagnostics (Ackerman, 2014), this makes the task of searching for future national team players similar to searching for a needle in a haystack. Noticeably, the probability curve increased more rapidly for higher score values. Thus, the odds ratios for being selected for the youth national teams were particularly high if the chosen threshold was high (e.g., players achieving a score with a PR≥99 had a 12 times higher chance than players with a score PR<99). In addition to the demonstrated general prognostic relevance, these results proved the diagnostics' particular prognostic relevance for top-level results.

The diagnostics' prognostic power to distinguish between the youth national team players and the other selection levels is of particular interest for the identification of highly talented players. Another aspect is the regulation of selection rates to optimise the distribution of available resources (training opportunities, and coaches) to the most talented players (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Sports associations might attempt to improve the efficiency of their TID programmes by reducing the number of supported players. The *sensitivity and specificity* of a fictive screening tool with simulated cut-off values provide further empirical information for optimising a TID programme in this sense. For example, using the score's PR50 as a fictive cut-off value would lead to a loss of less than 17% of the later youth national team players. Initially, this loss seems to be small compared to saving a substantial amount of promotion resources that might be used for a more intensive promotion of the remaining players. However, halving the number of promoted players would not directly lead to half the costs for the TID. Thus, using cut-off values for the diagnostics investigated in this study would still lead to a relevant loss of talent.

In summary, the statistical approaches in this study suggested that the answer to the fundamental question regarding the real-world usefulness of motor diagnostics in TID programmes is between a clear "yes" or "no." The results demonstrated that the motor test battery in the German TID provides coaches and associations with additional knowledge about empirically well-founded talent predictors discriminating even the highest future achievement levels (objective 1).

However, the results for objectives 2 and 3 showed also that this prediction works even for the score, i.e., the predictor with the highest prognostic relevance, only to a certain extent. These analyses provided further evidence that the motor tests' sensitivity is still insufficient for a deterministic use for individual selection decisions and that fixed cut-off values for talent-screening purposes remain illusionary (Lidor, Côté, & Hackfort, 2009). Therefore, on the side of the coaches, motor diagnostics can support selection decisions not as deterministic but as probabilistic information about players' chances for future success. On the side of the associations, the study results underline the necessity for a broad approach for talent development with multi-level selections and well-educated coaches with a good "subjective eye" for talent identification.

Furthermore, the motor diagnostics in the German TID are able to provide nationwide reference values regarding the talents' current state and development in prognostic relevant abilities and skills. Therefore, it is an advantage that nationwide standardised and reliable benchmarks are available to coaches. However, the coaches must be taught that benchmark profilings – collateral to the presented limited diagnostics' sensitivity – also present several pitfalls, as discussed by Carling and Collins (2014). For example, the reference values do not consider the players' maturity status, and there is often a bias in motor diagnostics within the age groups (Votteler & Höner, 2014). In addition, using standardized norm values bears the risk of producing player "stereotypes". This may be counterproductive (even if the profile is well constructed), as it is undesirable for football associations to develop players with the same profile. Furthermore, nationwide large assessments suffer constraints regarding test economy and therefore focus on performance factors that are easy assessable. More complex diagnostics that enable the assessment of a wider range of multidimensional and more representative characteristics are often not viable for nationwide assessments. Therefore, coaches must be informed that nationwide benchmark profilings are useful for their practical work only if they serve as an additional guiding regarding their talents' strengths and weaknesses and not as a standard to sort out different types of players.

Perspective

To reduce the uncertainty in the prediction of future success, additional characteristics with prognostic relevance should be assessed. Therefore, it will be necessary to extend the range of examined player characteristics to include other factors. For example, psychological characteristics (Feichtinger & Höner, 2014; Macnamara & Collins, 2013; Zuber & Conzelmann, 2014), more valid measures for analysing complex game performance (Unnithan et al., 2012) and dynamic aspects of predictors (Feichtinger & Höner, 2015; Roescher et al., 2010; Till, Cobley, O' Hara, Cooke, & Chapman, 2014) are important challenges for future talent research. Talent research in these directions may provide more reliable prognostic statements or diagnostics with higher sensitivities/specificities. This may support the decisions of talent coaches or sports associations, but it could never substitute for or determine decisions based on practical experience. This seems to be a quite trivial statement because of the natural uncertainty of prognosis in complex circumstances. However, this study did not aim to interpret this statement as a “stop signal” for future research on the prognostic power of diagnostics but as a great challenge for talent research to go beyond group-mean analysis and to quantify the uncertainty of the prognosis.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Anhang 2

Table 1.

Sample Size and Descriptive Statistics for the U12 Motor Diagnostics Separated by Players' Selection Level in Middle-to-Late Adolescence (U16-U19)

Performance variables	Achieved selection level (selection rate within examined sample): Youth national team (*N*=195; top 0.9%)	Regional association (*N*=731; top 1.0-4.1%)	Youth academy (*N*=1,025; top 4.2-8.5%)	Not selected (*N*=20,892; last 91.5%)	ANOVA	
	M ± *SD* (*N*)				F	η^2
Score (points)	43.70 ± 2.08 (178)	43.11 ± 2.03 (655)	42.91 ± 2.09 (916)	41.85 ± 2.04 (17,889)	196.04	.03**
Sprint (s)	3.58 ± 0.17 (190)	3.64 ± 0.17 (710)	3.63 ± 0.17 (996)	3.70 ± 0.18 (20,130)	97.50	.01**
Agility (s)	8.35 ± 0.43 (189)	8.45 ± 0.43 (706)	8.44 ± 0.43 (996)	8.56 ± 0.46 (20,002)	44.17	.01**
Dribbling (s)	11.18 ± 0.87 (190)	11.38 ± 0.88 (706)	11.38 ± 0.91 (995)	11.84 ± 1.03 (20,003)	129.92	.02**
Ball control (s)	10.84 ± 1.46 (186)	10.99 ± 1.49 (699)	11.33 ± 1.67 (971)	11.90 ± 1.79 (19,476)	107.36	.02**
Shooting (points)	16.71 ± 4.10 (188)	16.76 ± 3.80 (693)	17.11 ± 3.89 (978)	17.81 ± 3.67 (19,512)	33.22	.01**

Note. **p < .01. For different reasons (e.g., injury), a random group of players (8-14%) for each selection level did not complete the entire testing procedure. For the sprint, agility, dribbling, ball control and shooting tests, lower results indicate better performances.

Anhang 2

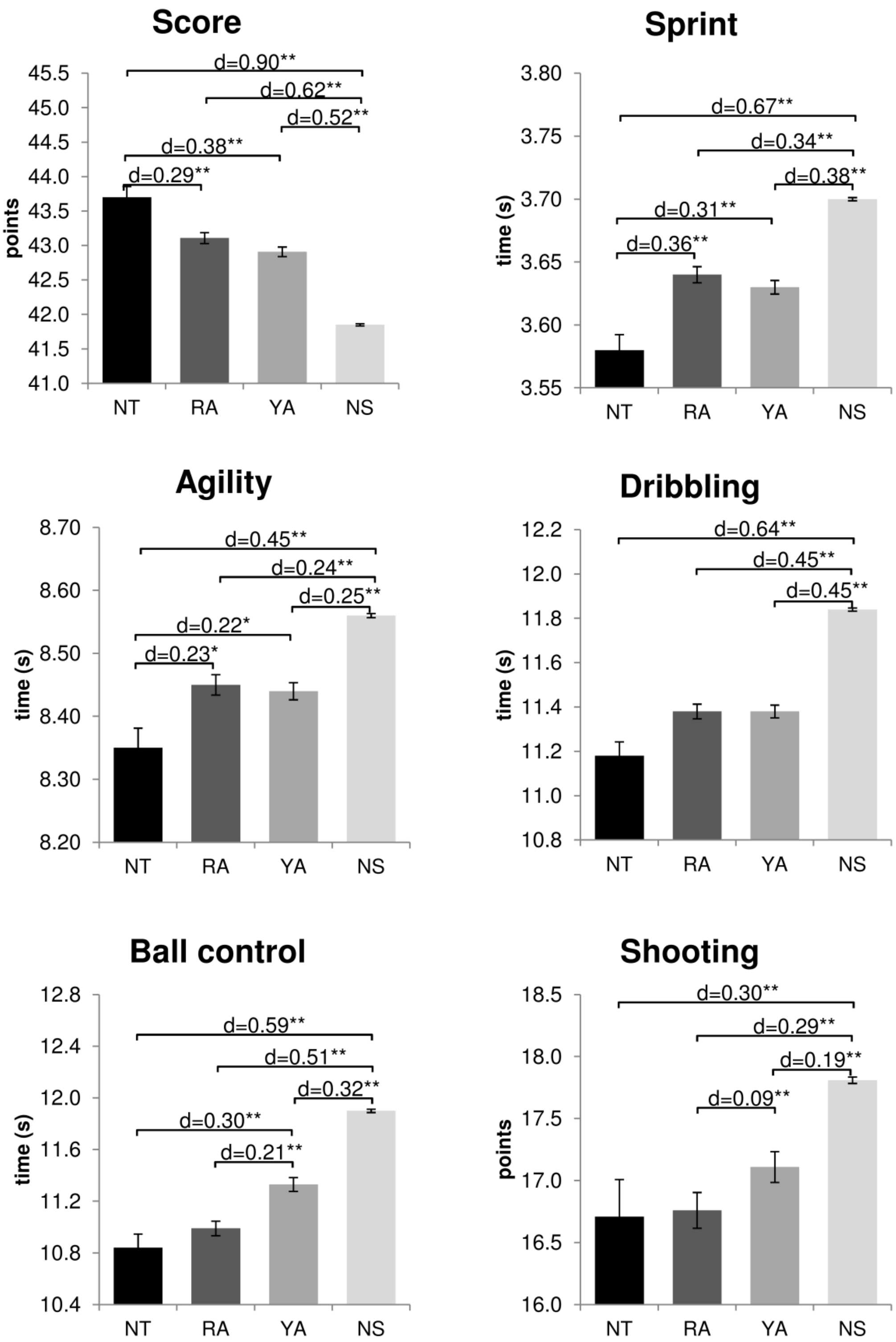
Table 2.

Logistic Regression Coefficients, Estimated Selection Probabilities and Odds Ratios (OR_{PR}) Based on the Dummy-Coded Prediction Variable Score Dichotomised at PR50 (=41.98 points), PR90 (=44.58 points), and PR99 (=46.73 points)

Selection level	Logistic regression coefficients			Estimated selection probabilities			ORs for being selected (group 1 vs. group 0)		
	constant	b	e^{β} [95%-CI]	P (PR50)	P (PR90)	P (PR99)	OR_{PR50}	OR_{PR90}	OR_{PR99}
Youth national team	-23.71	0.45	1.56 [1.45; 1.68]	0.01	0.02	0.06	5.35	4.53	12.19
Regional association	-16.29	0.31	1.36 [1.31; 1.41]	0.03	0.07	0.12	2.82	3.22	3.74
Youth academies	-13.84	0.26	1.29 [1.25; 1.34]	0.04	0.08	0.14	2.21	2.53	4.02

Figure 1.

*Results of Post-Hoc Tukey's Tests and Effect Sizes (Cohen's d) for Differences Between the Selection Levels Youth National Team (NT), Regional Association (RA), Youth Academy (YA) and Non-Selected (NS) (*p < .05, **p < .01). For the sprint, agility, dribbling, ball control and shooting tests, lower results indicate better performance.*



Anhang 2

Figure 2.

Selection Probabilities Obtained from Logistic Regression for Reaching Different Selection Levels in U16-U19 Depending on the U12 Score. The range of the x-values displays the minimum (percentile rank PR0) and maximum score results (PR100) in the sample. The thresholds for the predictor variable score were PR50=41.98 points, PR90=44.58 points and PR99=46.73 points.

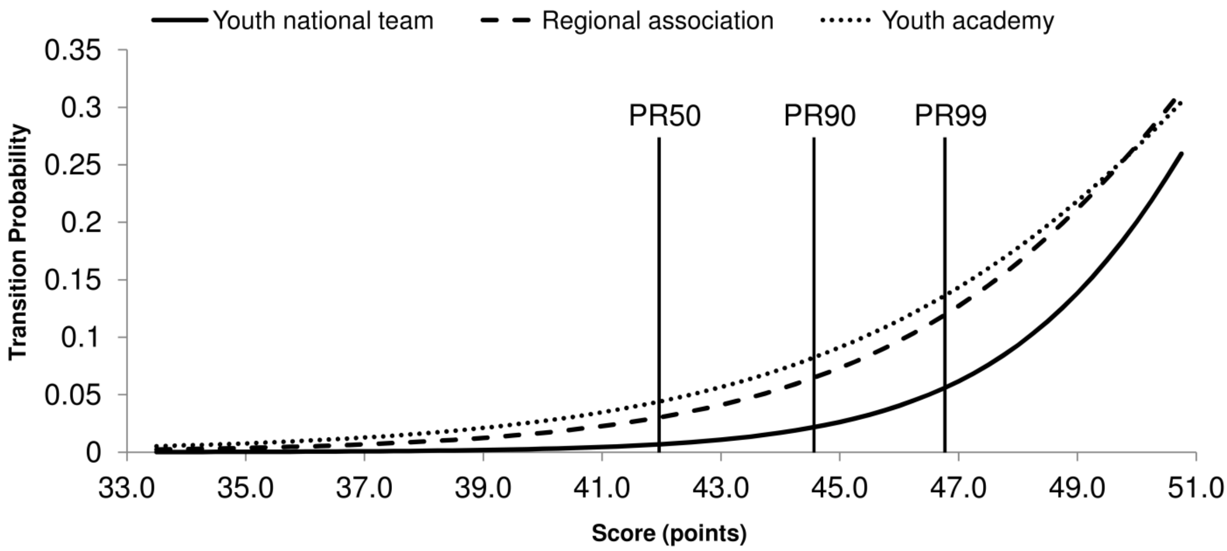


Figure 3.

Percentage of Correctly Identified Talents (Sensitivity) and Correctly Identified Non-Talents (Specificity) of the Diagnostics as a Talent Screening-Instrument. For the score's general specificity, the proportion of non-talented players (according to cut-off value score) was compared with the proportion of players on the selection level "not selected" for all higher selection levels. The specificity differences between the higher selection levels are marginal (<2%).