Prognoserelevanz personbezogener Talentprädiktoren im Fußball

Eine systematische Analyse zur empirischen Evidenz unter Berücksichtigung von Merkmalen des Studiendesigns

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Zusammenfassung

Für ambitionierte Fußballvereine und -verbände haben die Prozesse der Identifikation, Selektion und Entwicklung von Talenten im Rahmen einer effektiven Nachwuchsförderung in den letzten Jahren stark an Bedeutung gewonnen. Die Identifikation und Selektion von Spielern in Talentförderprogrammen erfolgt bisher überwiegend anhand subjektiver Bewertungen von Trainerexperten. Eine Aufgabe der Talentforschung ist es zu klären, inwiefern diese subjektiven Urteile über zukünftigen Erfolg von Spielern durch objektive Diagnostiken unterstützt werden können. In letzter Zeit wurden hierzu Studien mit heterogenen Befunden vorgelegt, jedoch existiert aktuell kein Gesamtüberblick über die prognostische Relevanz von Talentprädiktoren unter Verwendung objektiver Diagnostiken im Nachwuchsfußball.

In zwei systematischen Reviews verfolgte die vorliegende Dissertation das Ziel einer kritischen Auseinandersetzung mit dem aktuellen Forschungsstand zur prognostischen Relevanz von personbezogenen (d.h. physiologischen, anthropometrischen und psychologischen) Talentprädiktoren im Fußball. Dabei standen eine systematische Aufarbeitung existierender Studien zur Prognoserelevanz sowie zur empirischen Evidenz einzelner Prädiktoren aus dem Merkmalsspektrum personbezogener Talentprädiktoren im Mittelpunkt der Betrachtung. Aufgrund unterschiedlicher methodischer Herangehensweisen der analysierten Prognosestudien lag ein weiteres Augenmerk dieser Arbeit auf den verwendeten Merkmalen der Studiendesigns und deren potentiellen Einfluss als Variable. Die Ergebnisse aus den beiden Reviews zeigten hohe prognostische Validität für die Prädiktoren Ausdauer, Schnelligkeit sowie den technischen Fertigkeiten Dribbling oder Ballkontrolle. Dagegen konnten für die anthropometrischen Prädiktoren Körpergröße und Gewicht keine empirischen Evidenzen nachgewiesen werden. Für die prognostische Relevanz von psychologischen Persönlichkeitsdispositionen und kognitiven Prädiktoren sind die Befunde einzelner Studien bisher in-

konsistent bzw. aufgrund ihrer geringen Berücksichtigung in der Forschungslandschaft wenig aussagekräftig. Eine weitere zentrale Erkenntnis dieser Arbeit lag in den stark heterogenen Studiendesigns zur Überprüfung der Prognoserelevanz im Rahmen der analysierten Studien. Hinsichtlich der insgesamt geringen Anzahl der in den Reviews vorliegenden Studien (21) und der vielen unterschiedlichen Merkmale innerhalb der einzelnen Studiendesigns, fällt es zum jetzigen Zeitpunkt noch schwer, klare Aussagen darüber zu treffen, in welchem Maße einzelne Merkmale einen Einfluss auf die prognostische Relevanz von bestimmten Prädiktoren haben können. Es kann jedoch festgehalten werden, dass eine identifizierte prognostische Relevanz nicht zwingend auf jedes Leistungsniveau oder auf die verschiedenen Entwicklungsphasen der Spieler zu übertragen ist. Um zukünftig genauere Aussagen treffen zu können, in welchem Maße einzelne Merkmale die prognostische Relevanz beeinflussen können, sollten sich Studien bezüglich ihrer Studiendesigns nur in wenigen Merkmalen unterscheiden. Unabhängig davon sollte bei der Durchführung weiterer Studien zur Prognoserelevanz personbezogener Talentprädiktoren auf eine hohe methodologische Qualität geachtet werden. Vor diesem Hintergrund liefert die Dissertation einen Leitfadenentwurf zur Orientierung bei der Erstellung zukünftiger prospektiver Talentstudien im Fußball.

Auf Basis festgestellter Erkenntnisse aus den beiden Reviews, wurden in einem weiteren Schritt dieser Arbeit aktuelle Forschungsdefizite in zwei empirischen Studien bearbeitet. In diesem Zusammenhang wurde zum einen eine neu entwickelte, fußballspezifische Diagnostik basierend auf realitätsnahen Videoszenen zum Entscheidungshandeln evaluiert und hinsichtlich prognostischer Validität überprüft. Zum anderen wurde in einer prospektiven Studie im Rahmen des DFB-Talentförderprogramms die bisher nicht untersuchte prognostisches Relevanz technomotorischer Prädiktoren im Mädchenfußball analysiert.

Aufbauend auf einer theoretischen Gesamtbetrachtung der Prognoserelevanz personbezogener Talentprädiktoren und zwei daraus abgeleiteten empirischen Studien dient diese Dissertationsschrift dazu, sowohl die praktische als auch die wissenschaftliche Perspektive bezüglich der Prozesse Talentidentifikation, Talentselektion und Talententwicklung zu erweitern.

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1. Einleitung

In einer heutzutage sportbegeisterten Welt stoßen herausragende Leistungen von Spitzenathleten[1] stets auf große Bewunderung. Beispielsweise konnte im Januar 2018 der Gewinn des 20. Grand-Slam-Titels der inzwischen 36-jährigen Tennislegende Roger Federer bestaunt werden. Der von vielen Tennisexperten als bester Spieler in der Geschichte des Tennissports bezeichnete Schweizer führte in seiner einzigartigen Karriere die Weltrangliste bis dato über 300 Wochen lang an (Rehling, 2018). Die fußballbegeisterte Population fiebert hingegen dem jährlichen Kampf um den Titel des Weltfußballers zwischen den beiden bereits mehrfach ausgezeichneten Preisträgern Christiano Ronaldo und Lionel Messi nach. Mittlerweile vergeht kaum eine Fußballsaison, in der diese beiden Ausnahmeathleten ihre Mannschaften dank ihrer besonderen Fähigkeiten nicht zu Titeln führen. Während sich der gewöhnliche Fan über die aktuellen Leistungen solcher Fußballstars erfreut, bekunden Trainer, Vereine und Verbände ein großes Interesse daran, frühzeitig Kinder bzw. Jugendliche zu identifizieren, die zukünftig in die Fußstapfen dieser Topathleten treten können. Sowohl Federer als auch Ronaldo und Messi mussten sich im Kinder- und Jugendbereich gegen eine Großzahl anderer Konkurrenten durchsetzen, um den langen Weg bis in den Profisport zu meistern. In diesem Zusammenhang stellt sich die Frage, inwiefern Athleten, die das Potenzial besitzen, im Erwachsenenalter absolute Höchstleistungen zu erbringen, in jungen Jahren identifiziert und dementsprechend gefördert werden können (Elferink-Gemser, Jordet, Coelho-E-Silva & Visscher, 2011). Sowohl in Individualsportarten wie Tennis, als auch in Mannschaftssportarten wie Fußball, erfolgt eine Selektion der Spieler (z. B. in die nächsthöhere Altersklasse oder in eine Auswahlmannschaft) vorwiegend über subjektive Urteile von Trainerexperten, die aufgrund langjähriger Berufspraxis über

[1] Der Verzicht auf die geschlechtsspezifische Form im Rahmen der Nennung von Personen und Personengruppen geschieht in dieser Arbeit im Sinne einer besseren Lesbarkeit. Sofern keine Unterscheidung von femininen und maskulinen Grammatikformen explizit stattfindet, ist grundsätzlich von beiden Geschlechtern auszugehen.

bestimmte Erfahrungswerte verfügen, die ihnen eine Einschätzung darüber ermöglichen, welche Talente sich zukünftig zu Topspielern entwickeln sollten (Christensen, 2009; Meylan, Cronin, Oliver & Hughes, 2010).

1.1 Identifikation, Selektion und Entwicklung von Talenten im Fußball

Aus definitorischer Sicht beschreibt Talent die besonderen Fähigkeiten und Fertigkeiten eines jungen Menschen, der ein individuelles Leistungspotenzial für spätere Höchstleistungen in einem bestimmten Tätigkeitsfeld aufweist (Cobley, Schorer & Baker, 2012). Ferner weisen Hohmann und Carl (2002) auf den Unterschied zwischen einem engen und weiten Verständnis von Talent hin. Nach Güllich (2013) gelten im Sinne eines engen Talentbegriffs Spieler, die sich frühzeitig durch eine positive Auffälligkeit in sportmotorischen Leistungen kennzeichnen, als besonders talentiert. In Anbetracht eines engeren Verständnisses von Talent, verdeutlichen Cobley et al. (2012) das Problem, dass in der Praxis Verantwortliche den Talentbegriff mit der aktuellen Leistungsfähigkeit eines Spielers gleichsetzen. Unter der Kenntnisnahme, dass der Entwicklung von sportlichen Spitzenleistungen ein nicht linearer Prozessverlauf zugrunde liegt (Gulbin, Weissensteiner, Oldenziel & Gagné, 2013), ist der aktuell beste Spieler bei den Junioren nicht zwangsläufig auch der Topathlet im Erwachsenenalter. Dagegen bedingen im Sinne eines weiten Talentbegriffs multiple Faktoren wie Umweltprädiktoren (z. B. Trainingsumfeld, Unterstützung der Eltern) oder personbezogene Prädiktoren (z. B. technische Fertigkeiten, Persönlichkeitseigenschaften), ob ein Spieler das Talent besitzt, um später erfolgreich zu sein (Güllich, 2013; Williams & Reilly, 2000). In Bezug auf die verschiedenen Entwicklungsphasen, die ein Fußballer durchläuft, werden zudem bestimmten Prädiktoren unterschiedlich große Bedeutungen zugschrieben (Pearson, Naughton & Torode, 2006).

Für ambitionierte Fußballvereine und -verbände haben die Prozesse der Identifikation, Selektion und Entwicklung von Talenten im Rahmen einer effektiven Nachwuchsförderung in den letzten Jahren stark an Bedeutung gewonnen (Huijgen, Elferink-Gemser, Lemmink & Visscher,

2014; Vaeyens, Lenoir, Williams & Philippaerts, 2008). Das Bestreben von und die Herausforderung für solche Talentfördersysteme ist es, diejenigen Nachwuchsspieler zu fördern, denen das größte Potenzial zugeschrieben wird, später erfolgreich im Profifußball anzukommen (Talentidentifikation; Williams & Reilly, 2000). Darüber hinaus erfolgt ein immer wiederkehrender Prozess, meist im jährlichen Rhythmus, nach bestimmten Kriterien Talente für nächsthöhere Altersstufen oder für Auswahlkader (z. B. Landesauswahl, Juniorennationalmannschaft) zu selektieren (Talentselektion; Höner, Larkin, Leber & Feichtinger, 2018, in Druck). Nach erfolgreicher Identifikation und Selektion ist es zudem von großer Bedeutung, den Spielern optimale Entwicklungsbedingungen und das notwendige Umfeld bereitzustellen, um ihr Potenzial vollständig ausschöpfen zu können. Dazu gehören insbesondere gut ausgebildete Trainer, eine angemessene Infrastruktur sowie die Unterstützung in der Schule (Talententwicklung; Reilly, Bangsbo & Franks, 2000a; Vaeyens et al., 2008; vgl. Abb.1).

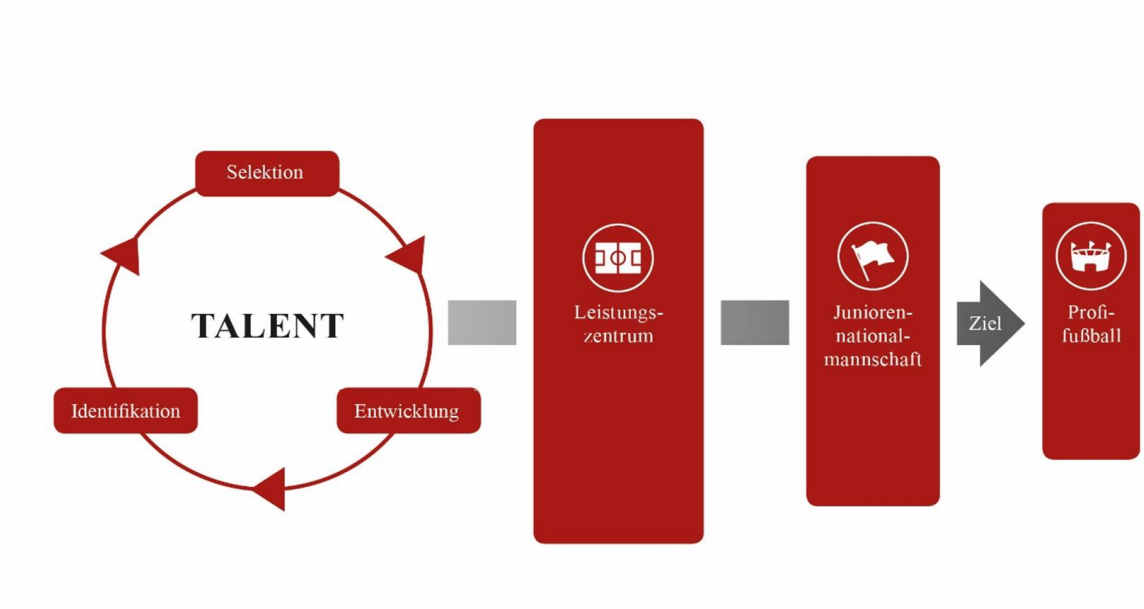

Abb. 1: Ständig wiederkehrender Prozess der Talentidentifikation, -selektion und -entwicklung mit dem Ziel, Nachwuchsspieler mit dem größtmöglichen Potenzial über verschiedene Talentförderstufen für den Profifußball zu fördern (modifiziert nach Williams & Reilly, 2000).

1.2 Sportwissenschaftliche Begleitung als Unterstützung in der Talentförderung

Um das richtige Talent unter Vielen zu finden, investieren mittlerweile sowohl die großen Fußballverbände wie beispielsweise der Deutscher Fußball-Bund (DFB), als auch zahlreiche Vereine aus den Profiligen der jeweiligen Länder große Summen in die Nachwuchsförderung (DFB, 2017a, S. 26). Nach Abbott, Button, Pepping und Collins (2005, S. 61) ist die Suche nach Talenten mittlerweile zum „big business“ geworden. In Deutschland zeigen sich diese Investitionsmaßnahmen vor allem in der Errichtung von modernen Nachwuchsleistungszentren, der stetigen Zunahme an hauptamtlich angestellten Mitarbeitern, sowie dem Ausbau von Abteilungen, die sich ausschließlich mit der Talentförderung beschäftigen (Franzke, 2017). In diesem Zusammenhang gehört inzwischen in vielen Vereinen der 1. und 2. Bundesliga sowie beim DFB die Integration einer sportwissenschaftlichen Begleitung, sowohl im Profi- als auch im Nachwuchsbereich, zum festen Bestandteil der Vereins- respektive Verbandsstruktur (DFB, 2009). Neben neuen Trainingsmethoden oder sportmedizinischen Erkenntnissen kann die Zusammenarbeit mit Experten aus der anwendungsorientierten Forschung die Entwicklung von Talenten bereichern. Beispielsweise können anhand einer standardisierten Leistungsdiagnostik zahlreiche Entwicklungsfortschritte transparent gemacht und geeignete Messinstrumente für eine optimale Trainingssteuerung eingesetzt werden (Drust, Atkinson & Reilly, 2007; Meyer, 2006).

Hinsichtlich der Talentidentifikation und -selektion bietet eine sportwissenschaftliche Unterstützung die Chance einer objektiven Erfassung potentieller Talentprädiktoren als optimale Ergänzung zum subjektiven Urteil eines Trainers oder Scouts (Christensen, 2009; Vaeyens, Coelho e Silva, Visscher, Philippaerts & Williams, 2013). Eine elementare Voraussetzung, dass eine objektive Diagnostik zur Unterstützung in der Talentselektion eingesetzt werden kann, ist die Gewährleistung einer sorgfältigen Reliabilitäts- und Validitätsprüfung der Messinstrumente. Ebenso sollten Kosten, Zeitaufwand und Praktikabilität in einem angemessenen Verhältnis stehen (Ali, 2011). Entspricht eine Diagnostik den testtheoretischen Gütekriterien, kann

von der Annahme ausgegangen werden, dass die gemessenen Ergebnisse zum Zeitpunkt der Erhebung im Rahmen wissenschaftlicher Standards interpretiert werden dürfen. Eines standardisierten Testverfahrens vorausgesetzt, erfolgt die Verwendung objektiver Messinstrumente in der Talentforschung meist in querschnittlichen Studien. Dabei werden Prädiktoren zwischen Spielern unterschiedlicher Leistungsniveaus (z. B. Spieler aus der Juniorenbundesliga im Vergleich zu gleichaltrigen Spielern aus der Kreisstaffel) bestimmt und basierend auf Gruppenmittelwertsvergleichen auf ihre Trennkraft geprüft (Mann, Dehghansai & Baker, 2017). Resultate, die über derartige Vergleiche auf Ebene des Leistungsniveaus gewonnen werden, haben hinsichtlich einer einmaligen Merkmalserhebung im Juniorenalter nur eine eingeschränkte Bedeutung für zukünftige Leistungen im Erwachsenenalter. Die Nichtberücksichtigung hoher interindividueller Unterschiede und eine schwache Merkmalsstabilität (z.B. für den Prädiktor Körpergröße) sind Ursachen, die bei einmaligen Erhebungen des Prädiktors die Prognose über zukünftige Erfolge erschweren (Buchheit & Mendez-Villanueva, 2013). Des Weiteren steht der Einsatz von Testverfahren zur Erhebung isolierter Prädiktoren in Zusammenhang mit Talentidentifikation und -selektion kritisch zur Debatte (Carling & Collins, 2014). Sportwissenschaftler beziehen sich dabei auf die multidimensionalen und daraus resultierenden komplexen Leistungsanforderungen im Fußball, die bei der Erfassung eines einzelnen Prädiktors nicht abgedeckt werden können (Lidor, Côté & Hackfort, 2009; Till et al., 2016)

Eine häufig eingesetzte Methode, um erfolgreiche Entwicklungsverläufe späterer Spitzenathleten zu identifizieren, ist eine retrospektive Herangehensweise. Im Mittelpunkt stehen dabei strukturierte Interviews oder Fragebögen, die rückblickend frühere Aktivitäten (Trainingsumfang, Spezialisierung auf die ausgeübte Sportart) und Fähigkeiten (in welchem Bereich war der Athlet im Juniorenalter schon herausragend?) aktuell erfolgreicher (Experten) und weniger erfolgreicher (Novizen) Athleten bestimmen (Elferink-Gemser et al., 2011). Am retrospektiven Ansatz kritisch anzumerken ist, dass es für die Athleten aufgrund der größtenteils lang zurück-

liegenden Zeitspanne problematisch sein kann, die gewünschten Informationen exakt wiederzugeben. Darüber hinaus besteht bei der subjektiven Selbsteinschätzung der Spieler die Gefahr einer verzerrten Wahrnehmung (Coutinho, Mesquita & Fonseca, 2016). Infolgedessen ist ein weiterer Ansatz der Talentforschung, die Karrierewege von talentierten Nachwuchsspielern aus einer prospektiven Sichtweise zu betrachten (Hohmann, 2004). Ziel dieser Vorgehensweise, unter Anwendung objektiver Testverfahren bzw. subjektiver Trainereinschätzungen, ist der Vergleich zwischen zukünftig erfolgreichen und weniger erfolgreichen Spielern, auf Basis ihrer im Kinder- bzw. Juniorenalter untersuchten oder bewerteten Leistungen (Höner & Votteler, 2016).

1.3 Konkrete Problemstellung und Aufbau der Dissertation

Viele Talentförderprogramme unterliegen der Hoffnung, frühzeitig die "richtigen" Talente auszuwählen, um zukünftig die besten Spieler für sich zu beanspruchen. Aus Sicht der Talentforschung ist der "Wunschgedanke" einer zuverlässigen Prognose eine sehr problematische Thematik. Ausgehend von einer inkonsistenten Befundlage prospektiver Studien liegt das Hauptaugenmerk dieser Dissertationsarbeit darin, den aktuellen Forschungsstand zur Prognoserelevanz personbezogener (physiologischer, anthropometrischer, psychologischer) Talentprädiktoren im Fußball systematisch zu analysieren. In einem einleitenden Überblick wird in Kapitel 1 über den Talentidentifikations, -selektions und -entwicklungsprozess sowie über die sportwissenschaftliche Unterstützung in der Talentförderung berichtet.

Darauf aufbauend wird in Kapitel 2 der theoretische Hintergrund, unter Veranschaulichung etablierter Rahmenmodelle potentieller Talentprädiktoren, beleuchtet. Dazu wird die Studienlage bezüglich vorhandener Prädiktoren vorgestellt, die sich in Bezug auf den Leistungsvergleich zwischen Spielern unterschiedlicher Ligen als relevant im Juniorenalter erwiesen haben. Abgerundet wird das Kapitel 2 mit einem kurzen Anriss des empirischen Forschungsstands zur

prognostischen Relevanz dieser Prädiktoren sowie der Darstellung eines möglichen Einflusses von Merkmale der Studiendesigns auf die Prognoserelevanz.

Das Fundament der vorliegenden Dissertation, die drei in internationalen Zeitschriften eingereichten bzw. bereits publizierten Manuskripte sowie das zur Einreichung aufbereitete Manuskript, wird in Kapitel 3 vorgestellt. Mit zwei Übersichtsarbeiten beginnend, wird an dieser Stelle der aktuelle Forschungsstand zur Prognoserelevanz physiologischer und anthropometrischer (Review 1) sowie psychologischer (Review 2) Talentprädiktoren systematisch (und im Vergleich zu Kapitel 2 deutlich ausführlicher) aufgearbeitet und auf empirische Evidenz geprüft. Aufgrund unterschiedlicher Herangehensweisen bei den Untersuchungen dieses Gegenstandes seitens der Sportwissenschaft, soll ein weiterer Aspekt dieser Reviews sein, Merkmale des Studiendesigns zu berücksichtigen, die einen potentiellen Einfluss auf die Prognosekraft haben können. Dies sind beispielsweise die Auswahl der Versuchspersonen (z. B. Altersklasse, Leistungsniveau zu dem Zeitpunkt der Erhebung), Untersuchungspläne und -durchführungen (z. B. Prognosezeitraum, implementiertes Diagnostikinstrument), sowie angewandte statistische Verfahren (z. B. univariat, multivariat) zur Ergebnisauswertung:

(1) Murr, D., Raabe, J., & Höner, O. (2018). The prognostic value of physiological and physical characteristics in youth soccer: A systematic review. *European Journal of Sport Science, 18*(1), 62-74. doi:10.1080/17461391.2017.1386719.

(2) Murr, D., Feichtinger, P., Larkin, P., O' Connor, D. & Höner, O. (2018). Psychological Talent Predictors in Youth Soccer: A Systematic Review of the Prognostic Relevance of Psychomotor, Perceptual-cognitive and Personality-related Factors. *PLoS One,* 13(10). doi:10.1371/journal.pone.0205337.

In Kapitel 3 fortführend, ist ein weiteres Bestreben dieser Arbeit die Durchführung empirischer Studien, die aufbauend auf den Erkenntnissen der systematischen Übersichtsarbeiten abgeleitete Forschungsdefizite analysieren. Aufgrund einer sehr geringen Studienlage hinsichtlich der

kognitiven Prädiktoren wird eine neuentwickelte fußballspezifische Entscheidungsdiagnostik evaluiert und auf Reliabilität sowie diagnostische und prognostische Validität überprüft:

(3) Murr, D., Larkin., P., & Höner, O. (2018, in Aufbereitung). Elite youth soccer players' decision-making skills: Validating a perception-action coupling video diagnostic based on age, playing status and playing position.

In einem weiteren Manuskript wird die bisher nicht behandelte Untersuchung zur Prognoserelevanz von Talentprädiktoren im Mädchenfußball beleuchtet. Dabei steht die Analyse schnelligkeits- und technikbezogener Prädiktoren im Verhältnis zukünftiger Erfolge der Mädchen im Vordergrund:

(4) Höner, O., Raabe, J., Murr, D. & Leyhr, D. (2018, in Revision). Prognostic relevance of motor talent predictors in elite girls' soccer: A prospective cohort study within the German talent development program. *Science and Medicine in Soccer.*

Im abschließenden Kapitel 4 werden die zentralen Erkenntnisse der in dieser Dissertation eingeschlossenen Manuskripte übersichtlich zusammengetragen und in einem Ausblick hinsichtlich ihrer praktischen und wissenschaftlichen Perspektiven bewertet.

2. Theoretischer Hintergrund und empirischer Forschungsstand

2.1 Rahmenmodelle potentieller Talentprädiktoren im Fußball

Gute Leistungen im Spitzenfußball zu erbringen, erfordert das Beherrschen einer Reihe von unterschiedlichsten Fähigkeiten und Fertigkeiten, die ständig in sich verändernder Umgebung abgerufen werden müssen (Unnithan, White, Georgiou, Iga & Drust, 2012). Das komplexe Anforderungsprofil eines Fußballspielers ist demnach, wie in vielen Mannschaftssportarten, multidimensionaler Natur und beinhaltet Leistungsfaktoren aus den Bereichen Physiologie, Anthropometrie, Technik, Taktik und Psychologie (Buekers, Borry & Rowe, 2015; Burgess & Naughton, 2010).

Viele dieser Leistungsfaktoren, die im Erwachsenenalter von hoher Bedeutung sind, spielen jedoch im Kindes- und Jugendalter zwangsläufig nicht immer die gleiche wichtige Rolle (Baker, Schorer & Wattie, 2018). Demnach ist die Talentforschung bestrebt, eine Auswahl potentieller Talentprädiktoren zu bestimmen, die in der Praxis für die Identifikation und Selektion von Nachwuchsspielern förderlich ist. Wie auch in anderen Spielsportarten beschränken sich diese Talentprädiktoren (ebenso wie die relevanten Leistungsfaktoren im Erwachsenenbereich) im Fußball nicht auf einzelne dominante Faktoren, sondern stammen aus multidimensionalen Merkmalsbereichen (Vaeyens et al., 2013). Rahmenmodelle helfen dabei, diese Vielfalt an potentiellen Talentprädiktoren systematisch zu kategorisieren. Die Sportwissenschaft beruft sich dabei auf leistungsorientierte Begabungsmodelle aus der Bildungsforschung. Beispielsweise zeigt Güllich (2013) eine modifizierte Version des Münchner Hochbegabungsmodells (Munich Model of Giftedness, MMG) nach Heller, Perleth und Lim (2005) in einem sportspezifischen Kontext. Ebenso findet das differenzierte Begabungs- und Talentmodell (Differentiated Model of Giftedness and Talent, DMGT) von Gagné (2010) bezüglich der Frage nach dem Talent im Sport großen Anklang (Vaeyens et al., 2008). In beiden Modellen wird die Entwicklung einer

vorhandenen und zum Teil angeborenen Begabung, hin zum Talent für spätere Spitzenleistungen vorausgesetzt. Die Entfaltung des Potenzials, d. h. die Umwandlung von Begabung in Talent, geschieht durch die Interaktion von umweltbezogenen und intrapersonalen Einflussfaktoren (Höner et al., 2018, in Druck). Die in diesem Zusammenhang häufig verwendete Einteilung potentieller Talentprädiktoren im Fußball findet sich im heuristischen Talentmodell von Williams und Reilly (2000) wieder. Ähnlich wie im MMG und DMGT wird in diesem Rahmenmodell auf oberster Ebene zwischen umweltbezogenen und personbezogenen Talentprädiktoren unterschieden. Umweltbezogene Prädiktoren können vom Talent selbst nur bedingt beeinflusst werden. Hierzu zählen Williams und Reilly (2000) soziologische Prädiktoren wie die familiäre und finanzielle Unterstützung, die Rolle des Trainers, Trainingsbedingungen, die Schule oder auch auftretende Verletzungen. Auf der in dieser Arbeit im Fokus stehenden personbezogenen Ebene differenzieren Williams und Reilly physiologische, anthropometrische und psychologische Prädiktoren (vgl. Abb. 2).

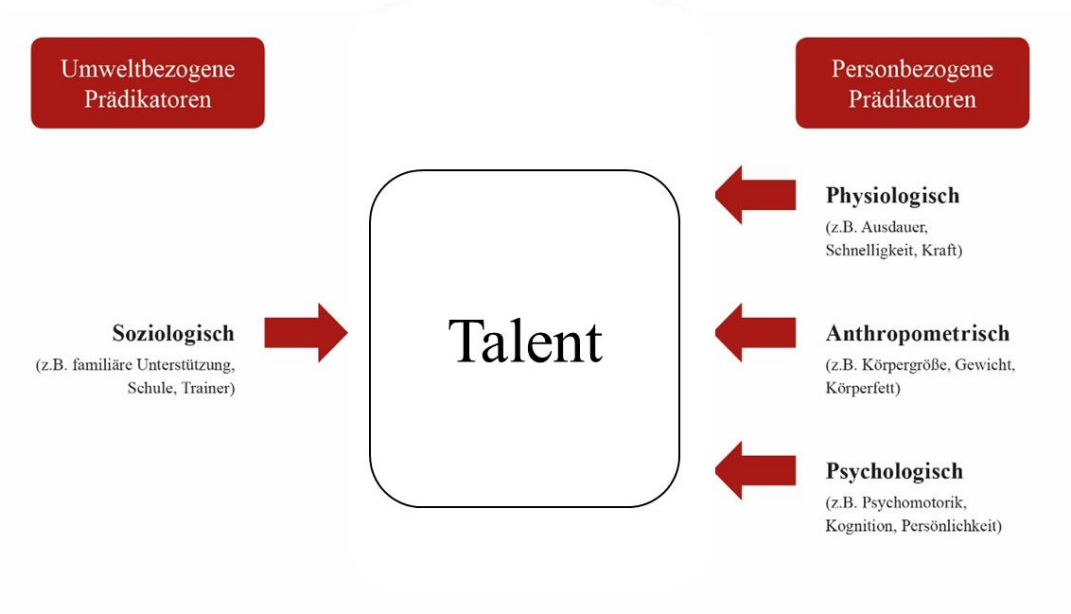

Abb. 2: Potentielle Prädiktoren eines Talents im Fußball (modifiziert nach Williams & Reilly, 2000).

Innerhalb der physiologischen, anthropometrischen und psychologischen Talentprädiktoren nach Williams und Reilly (2000) sind es wiederum eine Vielzahl einzelner Prädiktoren, die für zukünftige Leistungen im Fußball in unterschiedlichem Maße Relevanz vorweisen. So ist es

auch nicht ungewöhnlich, dass Fußballverbände viel Zeit und Geld in die Entwicklung evidenzbasierter Methoden investieren, um bei der Identifikation von Talenten die Nase vorne zu haben (Johnston, Wattie, Schorer & Baker, 2018). Zahlreiche Talentforscher suchen, überwiegend in einem querschnittlichen Design, innerhalb des breiten Merkmalspektrums auf personbezogener Ebene nach einzelnen Prädiktoren, die erfolgreiche von weniger erfolgreichen Juniorenspielern trennen (Coutinho et al., 2016).

In Bezug auf physiologische Talentprädiktoren wie aerobe Ausdauer, Linearsprint, Gewandtheit oder Kraft zeigen sich in verschiedenen Studien bessere Leistungen für Nachwuchsfußballer auf höherem Leistungsniveau im Vergleich zu gleichaltrigen Spielern in unteren Spielklassen (Coelho e Silva et al., 2010; Gissis et al., 2006; Malina, Ribeiro, Aroso & Cumming, 2007; Reilly, Williams, Nevill & Franks, 2000b; Vaeyens et al., 2006). Demnach spielen diese physiologischen Komponenten schon in jungen Jahren eine wichtige Rolle für erfolgreiche Leistungen (Stolen, Chamari, Castagna & Wisloff, 2005). In Betrachtung der anthropometrischen Prädiktoren sind auf bestimmten Spielpositionen Differenzen in Körpergröße und Gewicht zwischen Spielern unterschiedlicher Leistungslevels zu erkennen. Nach Rebelo et al. (2013) sind es vor allem die Positionen der Torhüter und der Innenverteidiger, auf denen Spieler aus der Nachwuchsabteilung von Proficlubs im Vergleich zu Spielern in unteren Spielklassen größer und schwerer sind. Darüber hinaus sind auch innerhalb des facettenreichen psychologischen Merkmalsspektrums Leistungsunterschiede hinsichtlich diagnostischer Validität wissenschaftlich belegt. Angelehnt an Williams und Reillys Modell (2000) fassen Höner et al. (2018, in Druck) psychomotorische Faktoren (z. B. technische Fertigkeiten) im weiteren Sinne als psychologische Talentprädiktoren auf. Für Wilson et al. (2017) beeinflussen technische Fertigkeiten die Spielleistung sogar weitaus mehr als physiologische oder anthropometrische Eigenschaften. In diesem Kontext gelten im Wettkampf häufig auftretende Aktionen wie Dribbling und Ballkontrolle (Passspiel oder Ballan- und -mitnahme) bei Spielern auf höherem Leistungs-

niveau als besser ausgeprägt (Vaeyens et al., 2006; Waldron & Worsfold, 2010). Zu den psychologischen Prädiktoren im engeren Sinn zählen nach Höner et al. (2018, in Druck) persönlichkeitsbezogene (z. B. Motivation, Volition oder Emotionen) sowie kognitive Faktoren (z. B. Exekutive Funktionen, Antizipation, Entscheidungskompetenz). Untersuchungen lassen darauf schließen, dass sowohl spezifische psychologische Persönlichkeitsdispositionen (Toering, Elferink-Gemser, Jordet & Visscher, 2009) aber auch mentale Fertigkeiten (Reilly et al., 2000b) in Zusammenhang mit aktueller Leistungsfähigkeit im Juniorenalter stehen. In Bezug auf kognitive Leistungsfaktoren überprüfen Huijgen et al. (2015) in sportunspezifischen Tests (z. B. Trail-making-test, Stop-signal-test, Design-fluency-test) niedrige Wahrnehmungsaufgaben und höhere kognitive Leistungsfaktoren (exekutive Funktionen) zwischen verschiedenen Leistungslevel bei niederländischen Nachwuchsfußballern. Entsprechend den Ergebnissen von Verburgh, Scherder, van Lange und Oosterlaan (2014), zeigen höherklassige Spieler vor allem in den exekutiven Funktionen (wie beispielsweise Inhibitionskontrolle) signifikant bessere Leistungen. Leistungsstarke Spieler zeichnen sich zudem in ihrer Kompetenz aus, bestimmte taktische Handlungen in unterschiedlichen Spielsituationen auf Basis perzeptuell-kognitiver Faktoren, wie der Wahrnehmung oder Antizipation (Lex, Essig, Knoblauch & Schack, 2015; Ward & Williams, 2003), optimal zu lösen. Des Weiteren unterstreicht Höner (2005) in einem querschnittlichen Vergleich Leistungsvorteile in der Entscheidungskompetenz bei Juniorennationalspielern gegenüber gleichaltrigen, niederklassigen Spielern..

Auf Basis zahlreicher querschnittlicher Studien zeigt sich, dass Nachwuchsspieler, die an einem Talentförderprogramm teilnehmen oder in Juniorenteams von Profivereinen spielen, hinsichtlich ihrer aktuellen Leistungsfähigkeit eine höhere Kompetenz in personbezogenen Talentprädiktoren gegenüber gleichaltrigen Spielern niedrigerer Leistungslevels aufweisen können. Zwar belegen querschnittliche Forschungsansätze im Rahmen eines solchen Leistungsniveauvergleichs eine Relevanz diverser Talentprädiktoren, jedoch ist eine zuverlässige Prognose hin-

sichtlich zukünftiger Erfolge von Spielern in späteren Jahren damit noch nicht gegeben. Konkret stellt sich dabei die Frage, ob die Spieler, welche zum Zeitpunkt einer durchgeführten Diagnostik zur Überprüfung der aktuellen Leistungsfähigkeit die besten Ergebnisse lieferten, auch noch in fünf Jahren zu den stärksten Spielern zählen (Abbott & Collins, 2002; Saward, Morris, Nevill, Nevill & Sunderland, 2015).

2.2 Das Leistungs-Potenzial-Dilemma

Das Risiko, im Talentidentifikations- und Selektionsprozess die "falschen Talente" auszuwählen, verdeutlichen Baker et al. (2018) in einer Leistungs-Potenzial-Matrix (Abb. 4). Als problematisch gilt die Trennung zwischen den Begriffen Potenzial und Leistung. Trainer selektieren Spieler demzufolge oft nach ihrer aktuellen Leistungsfähigkeit, jedoch nicht bezüglich des möglichen Potenzials, dass der Spieler zukünftig entfalten kann (Vaeyens et al., 2008). Elferink-Gemser et al. (2011; S. 683) sprechen in diesem Kontext von „the best youth performers are the ones who are invited to join talent development programmes or selection teams". In der Matrix von Baker und Kollegen stellen drei Typen von Spielern (vgl. dunkelgraue Boxen in Abb. 4) das größte Risiko für eine suboptimale Talentselektion dar. Auf der einen Seite nehmen Spieler, die aufgrund eines körperlichen Entwicklungsvorsprungs gegenwärtig bessere Leistungen erbringen, jedoch nicht zu den potenziell Besten gehören (Box 3), talentierteren Spielern Plätze in der nächsten Altersstufe oder in Auswahlkadern weg. Auf der anderen Seite können Spielertypen verloren gehen, die zwar ein sehr hohes Potenzial besitzen, jedoch aktuell körperlich noch nicht leistungsstark genug sind, um sich von anderen Spielern abzuheben (Box 7 und 8).

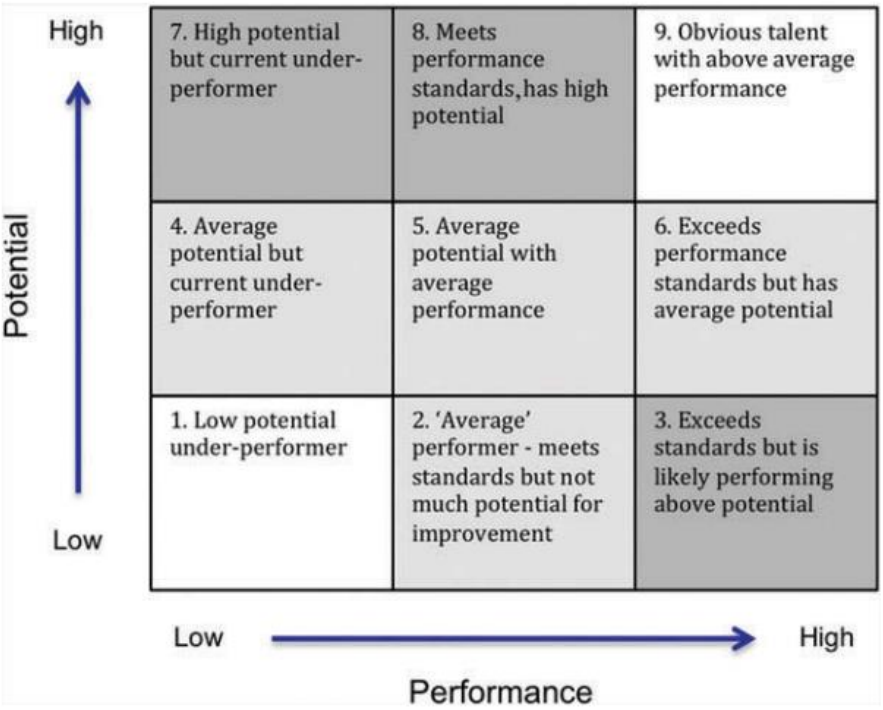

Abb. 3: Leistungs-Potenzial Matrix (Baker et al., 2018, S. 52)

Die Problematik einer starken Fixierung auf die aktuelle Leistungsfähigkeit eines Spielers spiegelt sich nicht nur in der Talentidentifikation und -selektion wider, sondern auch wenn es darum geht, welche Spieler in den Meisterschaftsspielen auf dem Platz stehen (Goto, Morris & Nevill, 2018).

> „Manchmal habe ich das Gefühl, dass das Wichtigste für die meisten Jugendtrainer das Gewinnen von Spielen ist. Sie interessieren sich hauptsächlich für den eigenen Erfolg und die eigene Reputation. Mein Interesse galt stets dem Verein. Wenn ein talentierter Spieler nicht verteidigen konnte, dann habe ich ihn in die Abwehr gesteckt, damit er es lernt, was uns einiges an Punkten gekostet hat. Aber ich habe mich nicht um Punkte gesorgt, denn ich war damit beschäftigt, den Spieler weiterzuentwickeln.“ Zitat Johann Cruyff (1947-2016)

Diese Worte der mittlerweile verstorbenen niederländischen Fußballlegende Johann Cruyff decken sich sehr gut mit der Situation in den Leistungszentren der Profivereine. Zum einen möchten die Vereine die besten Spieler ausbilden, um im optimalen Fall viele davon zukünftig in der

eigenen Profimannschaft spielen zu sehen (Ryan, Lewin, Forsythe & McCall, 2018), um jedoch Erfolge zu erzielen, handeln anderseits viele Trainer der einzelnen Mannschaften nach eigenem Interesse und setzen lieber auf die aktuell besten Spieler anstatt auf die Talentiertesten. Dies ist zum Teil dem bereits in den jüngsten Altersklassen herrschenden Erfolgsdruck für Trainer seitens der Vereine geschuldet. Folglich bleibt den Trainern oftmals keine andere Möglichkeit, als sich dem Erfolgsdruck zu beugen. Resultierend daraus handeln die Trainer in einer nicht zukunftsorientierten Denkweise, worin nämlich grundlegend nur die Spieler mit dem größten Potenzial ausgebildet werden würden, anstatt sich auf den kurzfristigen Erfolg zu fokussieren. Verfolgt der Verein jedoch das Ziel, die zukünftig besten Spieler möglichst lange zu fördern, müssen Strategien erarbeitet werden, um dadurch auch Spätentwickler zu berücksichtigen.
Um ein besseres Verständnis zu erlangen welche Talentprädiktoren mit höherer Wahrscheinlichkeit mit zukünftigen Erfolgen eines Spielers zusammenhängen, spielen prospektive Forschungsansätze für die Betrachtung der Spielerentwicklung eine große Rolle.

2.3 Zusammenhang von personbezogenen Talentprädiktoren und zukünftigem Erfolg im Fußball

Im Sinne einer prospektiven Talentforschung werden potentielle Talentprädiktoren nicht nur im Rahmen eines Vergleichs der aktuellen Leistungsfähigkeit (z. B. Leistungszentrumsspieler vs. Kreisstaffelspieler) bestimmt, dementsprechend wird auf Grundlage juveniler Talentprädiktoren angestrebt, die finale Leistungsfähigkeit eines Spielers in späteren Talentstufen bzw. im Erwachsenenfußball zu prognostizieren (Stadtmann, 2012, S.184). Höner et al. (2018, in Druck) sprechen von der Untersuchung der „prognostischen Relevanz einzelner oder mehrerer Prädiktoren …, d.h. der statistische Zusammenhang der Ausprägung eines Merkmals (Prädiktor) im Nachwuchsalter mit dem zukünftigen Leistungsniveau (Kriterium, z. B. Nationalkader) des Athleten“.

In Anbetracht des daraus resultierenden Interesses an der Prognoserelevanz personbezogener Talentprädiktoren besteht eine Notwendigkeit an prospektiven Studiendesigns im Fußball (Mann et al., 2017). Die Talentforschung kann dabei zwar auf bestehende Forschungsliteratur zurückgreifen, in der empirische Studien zur prognostische Relevanz einzelner Prädiktoren vorliegen, jedoch liefern die Ergebnisse bis dato heterogene Befunde. Beispielsweise erweist sich der physiologische Prädiktor Ausdauer in einer Studie von Figueiredo, Gonçalves, Coelho E Silva und Malina (2009) mit portugiesischen U12-U15 Juniorenfußballspielern auf mittlerem Leistungsniveau in hohem Maße als prognostisch valide hinsichtlich einer Selektion in die nächste Altersstufe. Dagegen belegen Le Gall, Carling, Williams und Reilly (2010) bei französischen Leistungszentrumsspielern in teilweise analogen Altersgruppen (U14-U16) keine signifikanten Unterschiede zwischen zukünftigen Profi- und Amateurspielern. In Bezug auf kognitive Leistungsfaktoren erzielen Forsman, Blomqvist, Davids, Liukkonen und Konttinen (2016) und Kannekens, Elferink-Gemser und Visscher (2011) unter der Verwendung eines vergleichbaren Studiendesigns (Erhebung des Prädiktors bei U16-U19 Leistungszentrumsspieler mit dem festgelegten Selektionskriterium zukünftiger Profispielerstatus) gegensätzliche Ergebnismuster bezüglich der Prognosekraft von perzeptuell-kognitiven Faktoren sowie der Entscheidungskompetenzen.

Aufgrund einer bisher sehr undurchsichtigen Studienlage bezüglich der Prognoserelevanz personbezogener Talentprädiktoren fällt es schwer, allgemeingültige Aussagen über einzelne Prädiktoren und deren Zusammenhang mit zukünftigen Leistungen von Spielern zu treffen. Demnach ist es erstrebenswert, bestehende Studien zur Prognoserelevanz personbezogener Talentprädiktoren systematisch aufzuarbeiten und darauf aufbauend eine sorgfältige Analyse zur empirischen Evidenz bestimmter Prädiktoren durchzuführen.

2.4 Heterogenität an Merkmalen des Studiendesigns

Um eventuell gefundene Tendenzen besser in den wissenschaftlichen Kontext einordnen zu können, sollte bei den bisher durchgeführten Studien auch die methodische Herangehensweise in den Fokus gerückt werden. Die teilweise sehr heterogenen Studiendesigns erschweren zum einen die Vergleichbarkeit der Resultate, zum anderen können Merkmale des Studiendesigns im Sinne von Moderatoren Auswirkungen auf gefundene oder nicht gefundene Effekte haben (Biddle, Markland, Gilbourne, Chatzisarantis & Sparkes, 2001; Johnston et al., 2018). Beispielsweise kann bei der eben beschriebenen inkonsistenten Ergebnislage zur Prognoserelevanz des Prädiktors Ausdauer, die deutlich längere Zeitspanne bei Le Gall et al. (2010) vom Zeitpunkt der Erhebung bis zur Bestimmung des Kriteriums (Prognosezeitraum von U14 bis zum Erwachsenenfußball entspricht sieben Jahren) im Vergleich zu Figuieredo et al. 2009 (Prognosezeitraum zwei Jahre) als Ursache in Betracht gezogen werden. Die widersprüchlichen Resultate bei Forsman et al., (2016) und Kannekens et al., (2011) könnten einerseits auf ein möglicherweise bestehendes, unterschiedliches Leistungsniveau der Spieler in finnischen und niederländischen Nachwuchsakademien zurückgeführt werden, anderseits wird der Einsatz des Selbsteinschätzungsfragebogen TACTSIS zur Ermittlung kognitiver Leistungsfaktoren generell kritisch bezüglich validen Ergebnissen betrachtet (Nortje, Dicks, Coopoo & Savelsbergh, 2014). Tab. 1 veranschaulicht eine Übersicht gängiger Studiendesignmerkmale und deren Bedeutung, sowie ebenfalls konkrete Beispiele wie sie in prospektiven Studien im Fußball verwendet werden.

Tab. 1: Merkmale des Studiendesigns

	Merkmal	Bedeutung	Beispiele
Personenstichprobe	Geschlecht	Geschlecht der Studienteilnehmer	Mädchen, Jungen
	Entwicklungsphase	Einteilung der Studienteilnehmer nach Entwicklungsstufen in Abhängigkeit des chronologischen Alters	< U12, U12-U15, U16-U19
	Leistungsniveau	Leistungsniveau der Studienteilnehmer zum Zeitpunkt der Merkmalserhebung	Nachwuchsleistungszentrum, Regionalauswahl, Juniorennationalteam
	Land	Land, in dem die Untersuchung durchgeführt wird	Deutschland, England, Niederlande
Untersuchungsdesign	Prognosezeitraum	Zeitpunkt zwischen der ersten Datenerhebung und der Selektion	kurz (< 1 Jahr), mittel (1-3 Jahre), lang (< 3 Jahre)
	Merkmalsdimension	Auswahl aus dem physiologischen, anthropometrischen und psychologischen Merkmalsspektrum	unidimensional, multidimensional
	Selektionskriterium	Ausgewähltes Leistungskriterium der Studienteilnehmer am Ende des Prognoszeitraums	Nächsthöhere Altersstufe, Berufung in Auswahlkader, Profistatus im Erwachsenenbereich
	Stichprobengröße	Anzahl der untersuchten Spieler	klein (N < 100), groß (N > 200)
Diagnostik	Erhebungsinstrument	Charakteristik des Erhebungsinstruments bei der Merkmalserhebung	Fragebogen, videobasierte Diagnostik
Statistik	Auswertungsverfahren	Statistische Auswertung der erhobenen Daten	univariat, mulitvariat, personorientiert

3. Manuskripte

3.1 Systematische Reviews

3.1.1 The Prognostic Value of Physiological and Physical Characteristics in Youth Soccer: A Systematic Review

(1) Murr, D., Raabe, J., & Höner, O. (2018). The prognostic value of physiological and physical characteristics in youth soccer: A systematic review. *European Journal of Sport Science, 18*(1), 62-74. doi:10.1080/17461391.2017.1386719.

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Abstract

Talent identification and selection in soccer is typically based on subjective evaluations of experienced coaches. Recently, there has been a trend to complement these subjective assessments with objective tests. However, there is currently no comprehensive overview of the prognostic relevance of objective measurements in youth soccer. Therefore, the primary purpose of the current study was to systematically review published empirical studies related to the prognostic relevance of physiological (e.g., endurance, speed) and physical characteristics (i.e., height and weight). Of 6,876 initially identified studies, nine articles were included. In those studies, endurance (nine studies), change of direction (7), height (7), and weight (7) received the most meaningful consideration within the literature. In regard to physiological predictors, between 16 and 29 effect sizes were tested for endurance, sprint, and change of direction, and about half of them were found to be significant with small to moderate effects ($0.37 \leq Mdn(d) \leq 0.57$). In addition, while only investigated in two studies all tested effect sizes for repeated sprint ability were found to be significant. Despite their frequent consideration in the literature, low numbers of significant effect sizes ($\leq 26\%$) and magnitude ($0.23 \leq Mdn(d) \leq 0.29$) were found for the physical predictors height and weight. Overall, results appear to be dependent on the respective study design and, in particular, moderator variables (i.e., soccer development stage, performance level T1/T2, prognostic period, sample size). Consequently, additional research seems warranted to more comprehensively investigate the predictive relevance of the individual characteristics using more homogeneous study designs.

***Keywords*:** Talent identification, talent development, football, physiology, physique

Introduction

In popular sports like soccer, the path from being a talented youth player to having a successful career in adulthood presents a significant challenge (Huijgen, Elferink-Gemser, Ali & Visscher, 2013). Accordingly, in order to promote the players with the highest potential for success as soon as possible, the process of talent identification (i.e., finding players with the potential for future success) and development (i.e., providing players with the necessary conditions that help them reach their potential) has become increasingly important in recent years (Vaeyens et al., 2008). However, the requirements for and antecedents of high level performance in soccer are extremely complex (Unnithan et al., 2012). Players' potential is typically evaluated by experienced coaches (Christensen, 2009) based on subjective criteria that are influenced primarily by their personal taste and knowledge (Meylan et al., 2010). For example, coaches decide who will be selected for a club, advanced to a higher age group, or drafted for a national team. Recently, there has been a trend to complement these subjective assesments with objective tests in order to provide a more comprehensive perspective in the talent identification and development process (Reilly et al., 2000b). Researchers have suggested that this approach can help to reduce the loss of potentially talented youth players who may go unnoticed by coaches for various reasons (e.g., playing philosophy at the club; Unnithan et al., 2012). In addition, an objective evaluation for players can provide reference points to monitor individuals' performance development (Prieto-Ayuso, Pastor-Vicedo & Contreras-Jordán, 2017) and to analyze the effects of training (Svensson & Drust, 2005).

In order to optimize the identification of talented players, it is necessary to identify important indicators for young players' potential future success in adulthood (Huijgen et al., 2013). Due to the intricacy of these predictors, a multidimensional spectrum of potentially relevant prognostic factors must be considered (Vaeyens et al., 2006; Williams & Reilly, 2000). Arguably the most prominent heuristic model for the categorization of talent predictors in soccer has been

provided by Williams and Reilly (2000), who organize these factors within physical, psychological, physiological, and environmental dimensions. As Wilson et al. (2016) recently acknowledged, most quantitative approaches for detecting talented players build on the "generic athletic attributes of team sports such as speed, strength, agility and endurance" (p. 1). In addition, coaches frequently "select young players based on their anthropometry characteristics rather than their technical and tactical performances" (Wong, Chamari, Dellal & Wisloff, 2009, S. 1208). Thus, it appears reasonable to suggest that physiological and physical factors have arguably received the most meaningful consideration by previous researchers and practitioners alike.

Physiological predictors such as endurance, speed, strength, and flexibility have been found to be influential factors for successful performance in soccer (Faude, Schlumberger, Fritsche, Treff & Meyer, 2010). A high aerobic and anaerobic endurance capacity as well as diverse speed abilities (e.g., acceleration, maximum speed) are regarded as essential characteristics for professional soccer players (Little & Williams, 2005). Furthermore, at an elite level soccer players are required to run at a high intensity approximately every 70 seconds (Impellizzeri, 2013). Accordingly, repeated sprint ability (RSA) represents another important physiological performance factor (Dellal & Wong, 2013). In addition, Benvenuti, Minganti, Condello, Capranica und Tessitore (2010) suggested that succesful soccer players do not only have to be fast but need to also possess good agility or, more specifically, change of direction (COD) speed. Such explosive movements are dependent individuals' power, which is a product of speed and strength (Stolen et al., 2005). Strength in itself (i.e., maximum strength) simultaneously helps to stabilize joints and posture and, therefore, prevents injuries (Sander et al., 2012). Lastly, according to Gustedt (2013), strong core muscles and overall flexibility can further decrease the risk of injury and have a positive impact on performance (e.g., good hamstring flexibility enhanced individuals' sprint and vertical jump performance; Bidaurrazaga-Letona, Lekue, Amado, Santos-Concejero & Gil, 2015).

Physical characteristics can be attributed another important role in the performance of soccer players (Bidaurrazaga-Letona et al., 2015). That is, at an elite level, certain playing positions (e.g., central defender, goalkeeper) are frequently occupied by taller players (Rebelo et al., 2013; Reilly et al., 2000a). In turn, the characteristics height and weight can be meaningfully influenced by individuals' maturity as young players who are physically shorter and lighter than their peers are typically at a disadvantage in their physiological performance. For example, Wong et al. (2009) found that heavier U14 players demonstrated greater ball shooting speed and lower sprint times. In addition, taller individuals performed better in the vertical jump, sprint, and maximum oxygen uptake (VO_{2max}) tests.

The present study

While there seems to be an emphasis on physiological and physical characteristics in research and practice (Wilson et al., 2016; Wong et al., 2009), there is also an ongoing debate about the usefulness of physiological and physical tests for talent identification (e.g., Carling & Collins, 2014). Researchers have questioned the applicability of such objective assessments due to the unstable performance development of youth athletes (especially in early developmental phases; Lidor et al., 2009). Scholars have argued that such measurements often consist of test batteries that assess performance independent of athletes' maturity (Vandendriessche et al., 2012), which results in the frequently discussed relative age effect (e.g., Cobley et al., 2012; Votteler & Höner, 2014).

Therefore, the *primary purpose* of the current study was to systematically review and describe published research exploring the prognostic relevance of physiological and physical characteristics in youth soccer. More specifically, this review included studies that examined the influence of youth soccer players' performance in physiological and physical tests on future performance outcomes (Hohmann, 2004). In this process, the empirical evidence for the individual predictors found in the reviewed studies was analyzed. This can help to provide a more in-depth understanding of the factors that play a meaningful role in youth soccer players' development.

Former reviews of physiological and physical characteristics in soccer provide important knowledge by highlighting different profiles of players in various age groups and nations (Stolen et al., 2005; Strauss, Jacobs & Van den Berg, 2012), analyzing the impact of physical maturity (Meylan et al., 2010), or evaluating test procedures (Ali, 2011). However, researchers have yet to systematically review the literature with regard to the prognostic relevance of physiological and physical characteristics making it difficult to draw adequate conclusions regarding their influence on youth players' future performance.

It appears reasonable to suggest that the inconsistent findings in the literature regarding the prognostic relevance of physiological and physical characteristics can – at least partially – be attributed to heterogeneous study designs. Therefore, when reviewing existing research, it is essential to account for features in the methodological design that may influence the predictive value of the individual characteristics (i.e., moderator variables). Possible moderator variables include players' soccer development stage (e.g., age classification), performance level (i.e., on which the predictor was surveyed [time point 1; T1] or on which the subsequent selec-tion took place [time point 2; T2]), and the duration of the prognostic period between T1 and T2; Abbott et al., 2005; Güllich, 2014). Furthermore, sample size could have an impact on the prognostic relevance, because tests of significance depend on the number of investigated subjects (Ackerman, 2014; Höner, Votteler, Schmid, Schultz & Roth, 2015). Accordingly, the *secondary purpose* of the current endeavor was to operationalize and examine relevant characteristics of the reviewed studies' research designs. This was done to descriptively analyze the literature and to investigate to what extent methodical aspects of the study design have an impact on the prognostic relevance of certain talent predictors.

Methods

Procedures

The current study was embedded in a larger project in which peer-reviewed articles published between 2000-2015 regarding the prognostic relevance of multidimensional personal factors

from Williams and Reilly's model (2000) were systematically reviewed. In this overarching project, appropriate databases (i.e., Academic Search Premier, Medline, PsycArticles, Psycinfo, PsycTESTS, PSYINDEX, PubMed, SPORTDiscus, Web of Science Core Collection) were reviewed and potentially relevant articles were identified using the following combination of search terms (both in English and German):

> *[Soccer OR football] AND [Youth OR elite OR talent OR junior* OR adolescent*] AND [Diagnos* OR test* OR predict* OR prognos* OR identif* OR select* OR develop*]*

The initial search revealed 11,822 potentially relevant articles across all databases. After removing duplicates 6,876 articles remained. Subsequently, specific research characteristics were defined as inclusion criteria (see Tab. 2) by means of which all studies were investigated with respect to their relevance for the current review. It should be noted that only articles published in English and German (the authors' native language) were retained.

Tab. 2: Inclusion criteria for the current systematic review of literature[#]

Characteristic	Inclusion criteria
Participants	Youth soccer player (≤U19)
Study design	Predicting future success based on physiologcial, physical, and/or psychological diagnostics
Predictor	Included an assessment of physiological, physical, and/or psychological characteristics
Future performance level	Included information about participants' future performance
Results	Statistical indices for prognostic relevance are given
Publication status	Peer-reviewed articles published between 2000 and 2015

The review process was conducted in four phases (see Fig. 4). *First*, two reviewers (i.e., the first author and a research assistant) independently examined whether the titles of the 6,876 identified articles met the inclusion criteria. In this initial screening, both reviewers agreed in their decision to include or exclude a study for 95.04% of the articles. An article was retained if at least one of the reviewers argued for inclusion. Following this title screening 584 articles were included for subsequent procedures. *Second*, both reviewers examined whether the abstracts of the remaining articles met the inclusion criteria and they reached consensus for 89.38% of the abstracts. Again, articles were retained if at least one of the reviewers argued for

inclusion. The abstract screening helped to identify 95 potentially relevant articles. *Third*, the first author reviewed the full texts of the remaining 95 articles and investigated whether they met the inclusion criteria. For ambiguous cases, the first author consulted with the research assistant and both discussed the respective full text until consensus was reached. At this stage 16 studies were deemed relevant and included in the overall project. *Fourth*, six out of the 16 identified studies in the overarching project were excluded for the present review because they did not investigate physiological or physical predictors. Instead, those endeavors explored psychological predictors such as personality, technique, or cognition. In addition, Carling, Le Gall and Malina, (2012) and Le Gall et al. (2010) used the same sample for their studies. Hence, a decision was made to only retain Le Gall et al. (2010) due to its emphasis on prognostics. In sum, nine studies were included for further analysis as part of this systematic review.

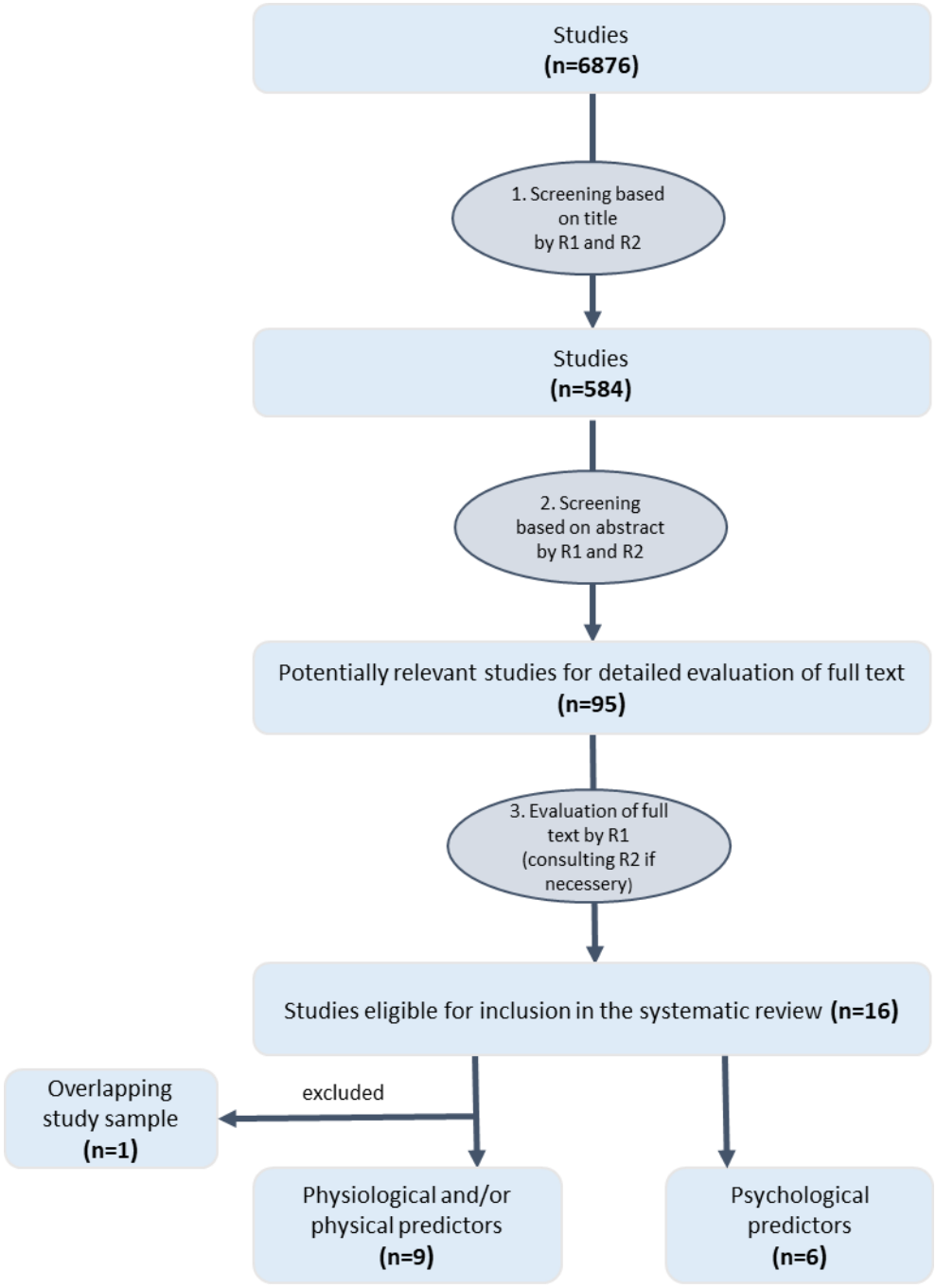

Fig. 4: Flow diagram of systematic process[#]

Data extraction and statistical analysis

Williams and Reilly's (2000) heuristic model highlights the importance of physiological and physical predictors of talent in soccer. In addition, these two factors have also received meaningful consideration in research and practice (Wilson et al., 2016; Wong et al., 2009). Therefore, the existing literature was reviewed for studies that investigated variables from these two cate-

gories of talent characteristics (see procedures). Subsequently, data for physiological characteristics was extracted through an inductive approach in which all factors that were examined in the reviewed studies were included for further analysis. These included endurance[2] (e.g., aerobic or anaerobic capacity), speed abilities (i.e., ≤ 20 m, > 20 m, COD, and RSA), power[3], maximum strength), and flexibility. For physical characteristics, a more deductive approach was employed as only data for the anthropometric factors height (i.e., stature) and weight (i.e., mass) was extracted for further review. Maturity was not considered for further analyses as it can be characterized as a confounding variable in childhood and adolescence instead of a predictor for individuals' success in adulthood. That is, maturity can influence players' physical and physiological characteristics at a young age, but this effect does not influence players' talent and dissolves once individuals reach adulthood.

Most of the reviewed studies in the present research investigated two-group comparisons. Two exceptions were the endeavors of Figueiredo et al. (2009) and Le Gall et al. (2010) in which the researchers included three groups. Three-group comparisons complicate the intended analyses within this systematic review because there are likely meaningful differences between the competitive levels across the reviewed studies (Höner & Votteler, 2016); particularly since the two studies were conducted in different countries (i.e., Portugal and France). Therefore, all analyses of the findings from Figueiredo et al. (2009) and Le Gall et al. (2010) were restricted to a comparison of participants from the highest and lowest competitive level (i.e., "best" vs. "worst"

[2] Endurance comprises various facets, including aerobic and anaerobic capacity. However, within the reviewed studies the factor endurance was explored through multiple different tests which focus on varying aspects of endurance (see online supplement tab. 2). Due to this heterogeneity and the fact that several authors do not specify the precise endurance component they are investigating, this characteristic was extracted as a composite factor.

[3] The terms power and explosive strength – while distinct concepts – are strongly correlated. In the reviewed studies, authors did not distinguish or acknowledge which of the specific concepts they were assessing. Instead, both terms were generally used synonymously for the examination of explosive movements and measured via vertical jump tests. Hence, power and explosive strength were extracted as a composite factor and labeled power.

players), which likely offers the most valid assessment. Furthermore, several researchers investigated participants from multiple age groups. Findings from those studies were explored separately for each individual age group to highlight potential age-specific effects.

To compare the respective study results, we computed the well-established Cohen's d for every tested effect, based on descriptive statistics provided in the original articles and using the following equation (with the pooled standard deviation; Cohen, 1988):

$$d = \frac{M_1 - M_2}{\sqrt{\frac{(n_1 - 1) * SD_1^2 + (n_2 - 1) * SD_2^2}{n_1 + n_2 - 2}}}$$

The effect sizes were characterized as small ($0.2 \leq d \leq 0.5$), moderate ($0.5 < d \leq 0.8$), and large ($d > 0.8$) based on the recommendations of Cohen (1988). To provide an overview of their respective prognostic relevance, the range and median (Mdn) for the individual talent predictors' effect sizes as well as the percentages of significant effects (relative frequency of significant effects) were calculated. To give additional information about the effect sizes, confidence intervals were computed and provided as an online supplement (supplemental tab. 1). For a critical discussion and alternative interpretations of effect sizes please refer to Batterham and Hopkins (2006).

In order to address the secondary purpose of the current research the following five *moderator variables* were operationalized:

- Soccer development stage: Foundation stage (< U12), talent stage (U12-U15), and elite stage (U16-U19) based on the classifications of the German Soccer Association's talent identification and selection program (DFB, 2009).
- Performance level T1: Players' level of competition at the initial time of data collection can influence the prognostic relevance of individual predictors (Höner & Feichtinger, 2016). Thus, performance level T1 was operationalized as regional/elite club or talent development program.

- Performance level T2: Participants' performance at the time of subsequent measurement (i.e., following T1). This moderator was operationalized by assessing whether individuals turned professional (PRO), were selected for a youth national team (NT), became a first-team regular player (FTP), or simply reached the next age class at the same competitive playing level (NEXT).
- Prognostic period: The time between T1 and T2. Vaeyens et al. (2008) suggested that the length of the prognostic period influences the effects associated with individual factors' predictive relevance. Prognostic period was operationalized as short-term (less than one year), middle-term (between one and three years), and long-term (more than three years).
- Sample size: Statistical power to find significance of the relationship between two groups is linked to the sample size (Ackerman, 2014). Accordingly, the statistical software G*Power (Version 3.1.9.2) was used to calculate the necessary sample sizes for medium (d = 0.5) and strong (d = 0.8) effects. Based on the results (alpha error = 0.05) the following categories were chosen: Small ($N < 100$), medium ($100 \leq N \leq 200$), or large ($N > 200$).

Results

Descriptive overview of existing research

All nine studies (see Tab. 3) that were included in this systematic review were conducted in Europe (i.e., Austria, Belgium, France, Netherlands, Portugal, and Spain) and published in English. None of them comprised female youth soccer players. Seven of nine studies examined both physiological and physical talent predictors. Investigations of physiological characteristics included endurance (nine studies), speed abilities (8), strength (7), and flexibility (1). More specifically, the majority of researchers examined the influence of sprint (seven studies using distances > 20m and five studies using distances ≤ 20m), COD (7), and power (7). RSA (2) and

maximum strength (3) received less consideration. While some of the authors investigated several talent predictors (e.g., Gil et al., 2014) others delimited their research to only one particular factor and distinguished between different age groups (e.g., Roescher, Elferink-Gemser, Huijgen & Visscher, 2010). In sum, a total of 3811 data points (i.e., individual measurements for physiological and physical predictors across all participants) were analyzed. The largest study was conducted by Gonaus and Müller (2012) who examined 1642 data points.

Empirical evidence of the prognostic relevance of physiological and physical predictors

The effect sizes of the physiological and physical characteristics that were investigated in the reviewed studies are presented in Tab. 3.

Physiological predictors. In all nine studies, reseachers examined the prognostic relevance of the predictor *endurance*, which included 29 individual effect sizes. In nearly half of the tests (14 out of 29 ≙ 48%) the prognostic relevance was significant. The effect sizes had a median of d = 0.41 and a range of -0.29 ≤ d ≤ 1.56. In regard to *speed abilites*, investigations of longer sprint distances (> 20m) revealed a higher percentage of signficant effects (53%) compared to those for shorter distances (≤ 20m; 44%). When examining the median effect sizes for the different sprint distances, short distances (≤ 20m) had a small to moderate effect (Mdn(d) = 0.37; 0.0 ≤ d ≤ 1.00) and long distances (> 20m) had a moderate effect (Mdn(d) = 0.57; 0.06 ≤ d ≤ 1.39). An even higher rate of significant effect sizes was found in the seven studies that explored *COD* (i.e., 13 of 21 ≙ 62%) with a moderate effect (Mdn(d) = 0.42; -0.14 ≤ d ≤ 1.71). While only two studies explored *RSA*, both demonstrated signficant effect sizes (Mdn(d) = 1.21; 0.47 ≤ d ≤ 1.23). In contrast, meaningfully less significant effect sizes were found for *power* (five out of 23; 26%) with small to moderate effects (Mdn(d) = 0.31; -0.51 ≤ d ≤ 1.09). None of the three studies that investigated *maximum strength* found any significant effect sizes (0%). Finally, only Gonaus und Müller (2012) examined the prognostic relevance of the predictor flexibility and showed no significant effect sizes across all tested age groups.

Tab. 3: Overview of the tested effect sizes for the individual predictors[#]

			Dimensions of predictor			Physiology								Physique	
						Endurance	Speed				Strength		Flexibility	Anthropometry	
			Predictor			Endurance	Sprint (≤20 m)	Sprint (>20 m)	COD	RSA	Power	Maximum	Full body	Height	Weight
		Number of studies				9	4	6	7	2	7	3	1	7	7
		Number of tested effect sizes				29	16	19	21	3	23	5	4	20	20
		Percentage of sig. effect sizes				48	44	53	62	100	26	0	0	25	15
		Median (*d*)				0.41	0.37	0.57	0.42	1.21	0.31	0.14	0.18	0.29	0.23
Study	Sample	PL T1	PL T2	PP	Age group	ES (*d*)	ES (*d*)	ES (*d*)	ES (*d*)	ES (*d*)	ES (*d*)	ES (*d*)	ES (*d*)	ES (*d*)	ES (*d*)
Deprez et al. (2015)	147	Elite	NEXT	2 years	U10	0.47	0.43*	0.59*	0.15		0.24			0.04	–0.36*
	132	Belgian		2 years	U11	0.64	0.44*	0.32	0.81*		0.32			0.13	–0.14
	112			2 years	U12	0.66*	0.17	0.62*	0.50		0.47			0.11	–0.06
	102			2 years	U13	0.48*	0.35	0.56*	–0.14		0.53			–0.08	0.14
	108			2 years	U14	0.81*	0.64*	1.04*	0.25		0.98*			0.31	0.51*
	97			2 years	U15	0.82*	1.00*	1.07*	0.40		1.09*			0.50*	0.59*
	87			2 years	U16	0.36	0.15	0.58*	0.17		0.18			0.33	0.24
	79			2 years	U17	0.85*	0.15	0.48	0.71*		0.00			0.36	0.26
Figueiredo et al. (2009)	33	Regional	NEXT	2 years	U12/U13	1.56*		1.05*	1.02*	1.23*	0.70			1.03*	0.41
	36	Portugal		2 years	U14/U15	0.72*		1.04*	1.71*	1.21*	1.07*			1.72*	1.23*
Gil et al. (2007)	48	Regional	NEXT	<1 year	U15	0.68*		0.88*	0.42*		0.13			0.81*	0.43
	53	Spain		<1 year	U16	0.08		0.06	0.55*		–0.51			–0.22	0.31
	41			<1 year	U17	–0.24		0.10	0.87*		0.38			0.28	0.22
	52			<1 year	U18	0.41		0.08	0.13		–0.13			0.11	0.02
Gil et al. (2014)	85	Elite Spain	NEXT	1 year	U10/U11	0.67*	0.49	0.48	0.67*		0.06	0.58		–0.18	0.13
Gonaus & Müller (2012)	410	Elite	NT	3 years	U15	0.28*	0.28*		0.49*		0.31*		0.21		
	504	Austria		2 years	U16	0.27*	0.15		0.39*		0.42*		0.20		
	456			1 year	U17	0.28*	0.46*		0.32*		0.28*		0.15		
	272			1 year	U18	0.09	0.50*		0.36*		0.21		0.02		
Gravina et al. (2008)	66	Elite Spain	FTP	<1 year	U11–U14	–0.11		1.39*	0.78*		0.00	0.14		0.27	0.29
Huijgen et al. (2014)	113	Elite Netherlands	NEXT	1 year	U16–U19	0.07			0.41	0.47*				–0.14	0.07
Le Gall et al. (2010)	105	Elite	PRO	6 years	U14	0.49	0.00	0.11			0.18	–0.05		0.34	0.18
	92	France		5 years	U15	0.38	0.28	0.64			0.51	0.25		0.29	0.05
	86			4 years	U16	0.20	0.39	0.59			0.54	–0.45		0.87*	0.71
Roescher et al. (2010)	26	Elite	PRO	5 years	U15	–0.29									
	59	Netherlands		4 years	U16	–0.10									
	55			3 years	U17	0.24									
	55			2 years	U18	0.55*									
	53			1 year	U19	0.78*									

Notes: PL T1: performance level T1; PL T2: performance level T2; NEXT: next age class at the competitive playing level; NT: joined a youth national team; PRO: turned professional; FTP: became a first-team regular player; PP: prognostic period, ES: effect size (Cohen's *d*); *$p < .05$.

*Physical predictors***.** Four different studies included investigations of the factor *height.* Only five out of the 20 (25%) tested effect sizes were significant and found to be small to moderate (Mdn(d) = 0.29; -0.22 ≤ d ≤ 1.72). The prognostic validity of the predictor *weight* was established in only three out of 20 (15%) tested effect sizes while the median effect size had a small to moderate effect (Mdn(d) = 0.23; -0.36 ≤ d ≤ 1.23).

Impact of moderator variables

The distribution of the tested effect sizes with respect to the individual categories of moderator variables is presented in Tab. 4. It is important to note that the predictors RSA, maximum strength, and flexibilty were not included in the table or the following results. Only a limited number of studies investigated these three predictors and no discrepancies in effect sizes were indicated, which made it impossible to explore variations due to moderator variables.

Most researchers evaluated predictors at T1 by collecting data from participants who were in the talent (12 tested effect sizes) or elite *soccer development stages* (14 tested effect sizes). In only four studies reseachers tested prognostic validity with players who had been assessed at T1 in the foundation stage. It should be noted that Gravina et al. (2008) investigated overlapping age groups (U11-U14), which resulted in a large number of tested effect sizes for the moderator soccer development stage. Overall, the majority of significant effect sizes were found when T1 was tested in the talent stage, especially for the physiological predictors endurance and sprint (> 20m; 66% and 80%, respectively). In fact, only for the factors COD (75%) and sprint (≤ 20m; 67%) researchers indicated higher percentages of prognostic relevance in a different soccer development stage (i.e., foundation stage). In the elite stage, researchers primarily found non-significant effect sizes across all predictors.

Two studies explored predictors by assessing the *performance level T1* at regional clubs. With the exception of COD (83%), prognostic relevance was found to be less than 50% for all of characteristics. A total of seven studies explored predictors by measuring T1 at the elite club level. In those studies, 23 effect sizes were investigated for endurance, sprint (both ≤ 20m and

> 20m), and COD, with an almost even split between those found to be significant and non-significant.

With respect to the *performance level T2*, the most tested effect sizes (16) were based on whether players reached the next age group at the same competitive level. However, only for the predictor sprint (> 20m), more than half of the tested effect sizes were found to be significant (67%). The achievement of professional status (eight effect sizes), the selection for a youth national team (four effect sizes), and the comparison between first-team regular and reserve players (one effect size) were used less frequently as a criterion variable at T2. Among these investigations, a particularly high prognostic relevance was found when predictors were assessed using youth national team (e.g., endurance; 75%) or first-team regular status (e.g., COD; 100%). However, it is important to note that these findings are based on a limited number of studies.

The *prognostic period* that was utilized most frequently was the middle-term (19 tested effect sizes) with high percentages of significant effect sizes for the predictors endurance (68%) and sprint (> 20 m; 67%). In contrast, only five tested effect sizes existed for both short- and long-term prognostic periods, respectively. The majority of those studies found poor prognostic relevance across all predictors. More explicitly, with the exception of the predictor height (33%) no significant effect sizes were found when researchers utilized long-term prognostic periods. Similarly, in investigations with short-term periods the percentage of significant effect sizes ranged between 0% and 40%.

When exploring the *sample size* used in the reviewed studies, the most tested effect sizes were found for small samples (18) with varying percentages of significance across the different predictors. Similarly, the seven effect sizes that were tested using medium samples also revealed varying percentages of significance across the different predictors. Lastly, only Gonaus and Müller (2012) utilized a large sample size and the largest percentage of significant effect sizes across all predictors was found in this endeavor.

Tab. 4: Impact of moderate variables on the empirical evidence of the prognostic relevance[#]

Moderator variable	Category	Number of tested effect sizes (general)	Physiology					Physique	
			Endurance	Sprint (≤20 m)	Sprint (>20 m)	COD	Power	Height	Weight
Soccer development stage	Foundation stage (<U12)	4	25% (3)	67% (2)	50% (3)	75% (3)	0% (3)	25% (3)	0% (3)
	Talent stage (U12–U15)	12	66% (7)	43% (3)	80% (5)	56% (5)	40% (6)	40% (5)	30% (5)
	Elite stage (U16–U19)	14	38% (6)	29% (3)	17% (3)	44% (4)	22% (4)	14% (4)	0% (4)
Performance level T1 (Predictor)	Elite	23	48% (7)	44% (4)	54% (4)	53% (5)	29% (5)	14% (5)	14% (5)
	Regional	6	50% (2)	–	50% (2)	83% (2)	17% (2)	50% (2)	17% (2)
Performance level T2 (Selection criteria)	Professional	8	25% (2)	0% (1)	0% (1)	–	0% (1)	50% (1)	0% (1)
	Youth national team	4	75% (1)	75% (1)	–	100% (1)	75% (1)	–	–
	Continue playing level	16	50% (5)	44% (2)	67% (4)	38%	20% (4)	31% (5)	19% (5)
	First-team regular player	1	0% (1)	–	100% (1)	100% (1)	0% (1)	0% (1)	0% (1)
Prognostic period	Short term (<1 year)	5	20% (2)	–	40% (2)	80% (2)	0% (2)	20% (2)	0% (2)
	Middle term (1–3 years)	19	68% (5)	54% (3)	67% (3)	56% (5)	40% (4)	25% (4)	25% (4)
	Long term (>3 years)	5	0% (2)	0% (1)	0% (1)	–	0% (1)	33% (1)	0% (1)
Sample size	Small *(N < 100)*	18	40% (7)	25% (3)	55% (6)	55% (5)	18% (6)	36% (6)	15% (6)
	Medium *(100 ≤ N ≤ 200)*	7	60% (3)	38% (2)	50% (2)	17% (1)	13% (2)	11% (4)	38% (4)
	Large *(N > 200)*	4	75% (1)	75% (1)	–	100% (1)	75% (1)	–	–

Note: Because of the low number of studies that investigated RSA, maximum strength and flexibility, those variables were omitted.

Discussion

The purpose of the present research was to systematically review the existing literature regarding the prognostic relevance of physiological and physical talent predictors in soccer. Both the empirical evidence of individual predictors and the possible impact of moderator variables was investigated.

Empirical evidence of the prognostic relevance of physiological predictors

The physiological predictors endurance, sprint (both $\leq$ 20 m and $>$ 20 m), COD, and power are frequently mentioned in previous literature as important performance indicators in soccer (Boone, Vaeyens, Steyaert, Vanden Bossche & Bourgois, 2012). The present review showed that these factors also received a meaningful consideration in the literature regarding their prognostic relevance for young soccer players' future success in adulthood. For the factor *power*, which is often considered an important performance indicator (Ruiz-Ariza, Garcia-Pinillos, Molina-Molina & Latorre-Roman, 2015), only small prognostic relevance was found (26%,

Mdn(d) = 0.31). Nevertheless, power can be considered an essential component of other relevant predictors like sprint (Wisloff, Castagna, Helgerud, Jones & Hoff, 2004) and should, accordingly, not be entirely neglected.

In contrast, researchers found more evidence for the prognostic relevance of *endurance*, *sprint*, and *COD*. More specifically, about half of the tested effect sizes were revealed to be significant with small to medium effects ($0.37 \leq Mdn(d) \leq 0.57$). It appears noteworthy that a higher prognostic relevance was found for sprint when researchers measured longer distances (i.e., > 20 m), when short sprints are generally more common in soccer matches (Di Salvo et al., 2010). This may indicate that fast players are fast regardless of the distance, but that their advantage over slower players manifests more significantly in longer distances. Nevertheless, due to the importance of short sprints in competition those should not be neglected when testing players and more research appears warranted to validate the current results. The factor COD was found to be particularly relevant with 62% of all effect sizes reaching significance. This finding is likely due to the demands soccer places on players to constantly and instantly change directions (Benvenuti et al., 2010). Articles in the current review often measured COD using the term agility. It is important to consider that there are inconsistent definitions of agility (Sheppard, Dawes, Jeffreys, Spiteri & Nimphius, 2014), as it can be considered either a speed-related motor ability that does not include cognitive aspects such as reactive decision-making (e.g., Deprez, Fransen, Lenoir, Philippaerts & Vaeyens, 2015; Gonaus & Müller, 2012) or as an entirely distinct construct from COD speed (Young, Dawson & Henry, 2015). Thus, future researchers should explore potential differences in findings based on how agility – and COD – is being operationalized and, consequently, measured.

The predictors *RSA*, *maximum strength*, and *flexibility* received limited consideration in the current research. This gap in the literature appears particularly surprising for RSA as all tested effect sizes were found to be significant. This finding is likely due to the high-intensity (i.e., number of sprints) required for soccer players to perform effectively during a match (Barbero-

Álvarez, Pedro & Nakamura, 2013). However, it is important to note that this trend should be considered cautiously since only two studies investigated the predictive value of RSA (i.e., Figueiredo et al., 2009; Huijgen et al., 2014). This gap in the literature could be due to the factor receiving no explicit consideration in many heuristic models of talent predictors (e.g., Williams & Reilly, 2000) and because satisfactory RSA tests had not been developed until recently (Dawson, 2012). In addition, Schimpchen, Skorski, Nopp and Meyer (2016) questioned the construct validity of "classical tests of RSA" in soccer because they do not adequately reflect game demands. Therefore, further research appears warranted to investigate the prognostic relevance of RSA.

Empirical evidence of the prognostic relevance of physical predictors

Despite their frequent consideration in the literature, low numbers of significant effect sizes ($\leq$ 26%) and magnitude ($0.23 \leq \text{Mdn(d)} \leq 0.29$) were found for the physical predictors *height* and *weight*. Thus, it appears that they likely cannot adequately predict young soccer players' future success in adulthood. This finding supports the conclusions of (Mendez-Villanueva & Buchheit, 2013), who highlighted a low long-term stability in physical factors for young athletes (i.e., large inter-individual differences in the development of height). Vandendriessche et al. (2012) further support this trend by indicating that physical characteristics are confounding factors because of the varying biological maturity of youth players in different development stages. For example, Ostojic et al. (2014) found that late-maturing players were more likely to be successful in adulthood than their early-maturing counterparts. This finding again highlights that talented players might be overlooked due to their disadvantages in physique or relative age when talent selection is solely based on subjective decisions by coaches; backing the call of Höner and Votteler (2016) to protect players against the relative age bias. Furthermore, it should at least cautiously be questioned whether predicting young players' future success based on a single measurement and at a single point in time is the best possible approach. Overall, while

the current research did not include any data related to maturity the authors advocate for more research with respect to the prognostic relevance of this confounding variable.

Impact of moderator variables

Despite these current trends in the literature, it should be noted that the heterogeneous study designs and resulting findings limit the ability to report accurate conclusions regarding the prognostic relevance of certain predictors. Accordingly, the present study's secondary purpose was to investigate to what extent methodological aspects of the study design have a possible impact on the prognostic relevance of individual talent predictors. An exploration of moderator variables revealed that when players were tested in the foundation and talent stage a higher percentage of significant effect sizes were found for all predictors than when individuals were tested in the elite stage. This highlights the importance of conducting objective measurements in early *soccer development stages*, as the prognostic relevance of such tests appears to decrease as players reach the elite stage.

An investigation of the moderator *selection criteria* showed that particularly strong prognostic relevance was found when the draft for a youth national team was utilized as the measure at performance level T2. In contrast, low prognostic relevance was found when using professional status as the selection criteria. Thus, while only based on the results of one study, it appears that selection at a high competitive level at a young age distinguishes more sharply between successful and non-successful players. In addition, researchers found the most prognostic relevance when assessing selection criteria one to three years following the initial assessment, indicating a potential lack of validity for short- and long-term prognostics. However, it is particularly long-term measurements that hold the most practical merit for promoting players with the highest potential for success at the youngest possible age.

Potential issues with standardized tests

It is likely that the use of different instruments for the elicitation of the predictors can also have an influence on their prognostic relevance. A large number of different instruments were used in the reviewed literature (please refer to online supplemental tab. 2 for a list of all tests), which impedes the ability to compare study findings. For example, even when using a standardized diagnostic to assess linear sprint, there are typically variations in starting position or measuring instruments (Altmann et al., 2015; Haugen & Buchheit, 2016). A more in-depth investigation of the prognostic relavance of the predictor endurance helps to explain why this lack of consistency appears problematic. That is, when only considering studies that implemented a Yo-Yo intermittent test (Krustrup et al., 2003) for measuring endurance (Deprez et al., 2015; Figueiredo et al., 2009; Gil et al., 2014), the percentage of significant effect sizes increases from 48% to 82%. Therefore, a more consistent use of measurements appears desirable in order to adequately compare study results and make meaningful conclusions about the prognostic relevance of certain predictors (Höner et al., 2015).

Conclusion

In sum, the current review provides insight into the prognostic relevance of physiological and physical talent predictors for young soccer players' future success in adulthood. Only nine studies were included in the current review, which highlights a gap in the current literature regarding the process of talent identification and development. Due to the limited number of studies, the trends presented in this study likely have limited generalizability. Thus, additional research is needed to more comprehensively investigate individual talent predictors and explore their validity when measured at different age groups. Such efforts can provide clubs and coaches valuable information to support the promotion of talented players within their organizations.

3.1.2 Psychological Talent Predictors in Youth Soccer: A Systematic Review of the Prognostic Relevance of Psychomotor, Perceptual-cognitive and Personality-related Factors

(2) Murr, D., Feichtinger, P., Larkin, P., O' Connor, D. & Höner, O. (2018, akzeptiert). Psychological Talent Predictors in Youth Soccer: A Systematic Review of the Prognostic Relevance of Psychomotor, Perceptual-cognitive and Personality-related Factors. *PLoS One,* 13(10). doi:10.1371/journal.pone.0205337 [This is an accepted manuscript of an article published online by Public Library of Science in Plos One on 15th October 2018 available at 10.1371/journal.pone.0205337].

Abstract

Within the multidimensional nature of soccer talent, recently there has been an increasing interest in psychological characteristics. The aim of this present research was to systematically review the predictive value of psychological talent predictors and provide better comprehension of the researchers' methodological approaches and the empirical evidence for individual factors (i.e., psychomotor, perceptual-cognitive and personality-related). Results highlighted heterogeneous study designs (e.g., participants, measurement methods, statistical analyses) which may limit the comparability of studies' findings. Analyzing the number of included studies, psychomotor (n = 10) and personality-related factors (n = 8) received more consideration within the literature than perceptual-cognitive factors (n = 4). In regard to empirical evidence, dribbling ($0.47 \leq d \leq 1.24$), ball control ($0.57 \leq d \leq 1.28$) and decision-making ($d = 0.81$) demonstrated good predictive values as well as the achievement motives hope for success ($0.27 \leq d \leq 0.74$) and fear of failure ($0.21 \leq d \leq 0.30$). In conclusion, there is growing acceptance of the need for more complex statistical analyses to predict future superior performance based on measures of current talent. New research addresses the necessity for large-scale studies that employ multidisciplinary test batteries to assess youth athletes at different age groups prospectively.

Keywords: Talent identification, talent-development, football, technical skills, perceptual-cognition, personality-related dispositions

Introduction

Talent identification, selection and development of youth soccer players is an important issue for clubs and soccer federations, as they are challenged to find talented youth players who may have successful professional careers in adulthood (Huijgen et al., 2013). Thus, talent development programs aim to detect players' potential for future success at a young age. However, with the multifaceted characteristics of sport performance and the high inter-individual differences during athlete development (Lidor et al., 2009), this endeavor remains highly challenging (Mann et al., 2017). Due to the complex nature of the developmental process from youth player to elite status, which depends on various interacting personal and external factors, a multivariate and dynamic approach to research is required (Haugaasen & Jordet, 2012; Vaeyens et al., 2006).

In order to understand the intricacy of these predictors, a multidimensional spectrum of potentially prognostic relevant factors has to be considered (Vaeyens et al., 2006). This is acknowledged by Williams and Reilly (2000), who developed a heuristic model for the categorization of talent predictors, which identifies potential predictors in four sport science dimensions, including, physical, physiological, psychological and sociological characteristics. Within this multidimensional spectrum, both in research and practice, there has been increasing interest in the psychological dimension (Mann et al., 2017). More specifically, the psychological area comprises psychomotor, perceptual-cognitive and personality-related factors (Höner et al., 2018, in Druck).

Usually, players are evaluated by experienced coaches or scouts who make subjective judgements on their potential based on current levels of performance (Christensen, 2009). In order to provide a more comprehensive understanding of the identification and selection process, there has been growing support for more scientific evidence assessing relevant talent predictors with objective diagnostics that may indicate future sporting success (Larkin & O'Connor, 2017).

Wilson et al. (2016) demanded a stronger consideration of psychomotor factors for talent research and acknowledged that players with good *psychomotor factors (e.g., technical skills)* are highly coveted players. This is supported by current findings which highlighted techniques such as dribbling and ball control are the most frequently performed skills during a soccer match (Williams & Reilly, 2000). Several authors (e.g., Vaeyens et al., 2006; Waldron & Worsfold, 2010)) reported evidence to support the notion of testing technical skills as a discriminating factor between playing levels in youth soccer. For example, dribbling performance was acknowledged as an important indicator when comparing the performance of elite and sub-elite youth players (Vaeyens et al., 2006). Höner, Leyhr, and Kelava (2017) reported higher predictive power for the latent factor variable "technical skill" (consisting of dribbling, ball control and shooting) compared to "speed abilities". In a professional team context, Rampinini, Impellizzeri, Castagna, Coutts and Wisløff (2009) established that during matches successful teams (ranked in the first five positions of the Italian Serie A league) completed a higher passing rate as well as more dribbling actions and shots on target compared to less successful teams (ranked in the last five positions).

Perceptual-cognitive performance factors such as anticipation and decision-making have been found to be crucial for soccer players (Roca, Williams & Ford, 2012). More specifically, the ability to anticipate what is likely to happen in the next situation is as important for soccer performance as the ability to decide and execute suitable actions in certain situations under time constraints. Several studies proved the importance of these factors with regard to discriminating players in performance level, age group or playing position (Causer & Ford, 2014; Höner, 2005; Lex et al., 2015; Ward & Williams, 2003; Williams & Drust, 2012). For example, Kannekens et al. (2011) recently highlighted that besides technical factors, tactical facets (e.g., decision-making) are critical when identifying talented youth soccer players.

Regarding *personality-related factors*, talent models (e.g., Hohmann, 2004; Vaeyens et al., 2008; Williams & Reilly, 2000) consider psychological dispositions (i.e., the tendency to…) and mental skills (i.e., the ability to…), predominantly within the areas of motivation, volition, self-referential cognition, and emotion. The research on motivational characteristics and their relationships with performance in soccer (e.g., Coelho e Silva et al., 2010; Feichtinger & Höner, 2014; Kavussanu, White, Jowett & England, 2011) has predominantly focused on achievement motives (i.e., dispositions that provide information about how individuals perceive and evaluate achievement situations; Atkinson, 1957) and motivational orientations of athletes (i.e., dispositions that provide information about the criteria that individuals use to define success and judge their level of ability (i.e., dispositions that provide information about the criteria that individuals use to define success and judge their level of ability; Nicholls, 1984). Further research has addressed how volitional competencies are associated with performance in soccer and has focused principally on aspects of self-regulation such as reflection and effort (Toering, Elferink-Gemser, Jordet, Pepping & Visscher, 2012). Regarding self-referential cognition, physical self-concept (i.e., the aspects of general self-concept that comprise any self-referential information about a person's own body (Shavelson, Hubner & Stanton, 1976) and self-efficacy (i.e., a person's belief in his or her own capabilities to succeed in specific situations (Bandura, 1997) can be regarded as particularly relevant. Previous studies in soccer have also considered self-confidence to be relevant for performance (e.g., Reilly et al., 2000b). With respect to emotional characteristics, research has focused on competition anxiety as an important factor that can influence soccer performance (Reilly et al., 2000b; Spamer & Coetzee, 2002).

Regarding the current state of research, several studies have revealed the importance of psychological factors in soccer (e.g., Mann, Williams, Ward & Janelle, 2007). While the majority of these studies are cross-sectional in nature (i.e., comparing performance between known age groups or performance levels (Coelho e Silva et al., 2010; Rebelo et al., 2013; Toering et al., 2009), more recently, researchers have attempted to use more longitudinal study designs to

assess the stability and/or predictive value of psychological factors for future success (Johnston et al., 2018). At this stage, however, there exists no systematic overview of such studies. Previous reviews provide important knowledge by analyzing the impact of personality traits on perceptual-cognitive skills (Meylan et al., 2010) or reviewing the relevance of psychosocial factors associated with talent development (Gledhill, Harwood & Forsdyke, 2017). While Johnston et al. (2018) systematically reviewed the efficacy of talent identification programs in predicting levels of achievement in sports generally, researchers have yet to systematically review existing empirical studies with regard to the prognostic relevance of psychological talent predictors in soccer. To analyze the value of the prognostic relevance it is important to consider the mostly inhomogeneous study designs of the individual studies. It is therefore central to take into account design features (e.g., participants, measurement methods, design and statistical analysis) that may influence the predictive value.

In 2000, Williams and Reilly provided a narrative review of prognostic studies in soccer and suggested a heuristic model in which personal talent factors were propagated as physical, physiological and psychological predictors. With respect to physical and physiological talent predictors in soccer, Murr, Raabe and Höner (2018b) highlighted in their systematic review the prognostic value of these "non-psychological" predictors. The present systematic review extends this knowledge leading to a comprehensive overview about prognostic relevance of personal talent predictors. Therefore, this systematic review focusses on psychological talent predictors and aims to improve the understanding of the current research via two objectives. *First,* existing research exploring the prognostic value of psychological factors for youth soccer players was systematically reviewed. Furthermore, relevant design features (i.e., methodological issues) of the included studies were examined in order to provide an overview of the researchers' methodological approaches (objective 1). *Second,* the empirical evidence for the individual predictors found in the reviewed studies was described precisely (objective 2).

Method

The systematic review was conducted in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman & The, 2009). Given these guidelines were originally developed for clinical studies, some items of the PRISMA checklist (S1 Appendix) could not be reported as they are not relevant for the current systematic review.

Procedures

This current study on psychological predictors complements the systematic review of the prognostic relevance of physiological and physical characteristics in soccer by Murr et al. (2018b), having the same initial procedures in common: Studies were included on the basis of the following criteria (i) study sample consisted of youth soccer players (≤ U19); (ii) studies predicted future success based on fitness, anthropometric, and/or psychological diagnostics; (iii) studies included an assessment of physiological, physical, and/or psychological characteristics; (v) information about participants' future performance was provided; (vi) statistical indices for prognostic relevance are given; and (vii) articles were peer-reviewed published in English or German (the authors native language) between 2000-2016. Afterwards, studies in the overarching project were excluded if they did not investigate psychological predictors.

Search strategies

To identify potentially relevant articles from applicable databases (i.e., Academic Search Premier, Medline, PsycArticles, Psycinfo, PsycTESTS, PSYINDEX, PubMed, SPORTDiscus, Web of Science Core Collection) the following combination of search terms (in both English and German) was used:

[Soccer OR football] AND [Youth OR elite OR talent OR junior OR adolescent*] AND [Diagnos* OR test* OR predict* OR prognos* OR identif* OR select* OR develop*]*.

A final electronic search for each database (time span for searches: 1 January 2000 to 31 December 2016) were performed on January 5th, 2017. The initial search identified 13,320 relevant articles across all databases. After removing duplicates – both manually and automatically (using Endnote X7) – 7,800 articles remained.

Article screening

Two reviewers (i.e., the first author and a research assistant) screened the articles independently to find relevant studies that met the defined inclusion criteria. The selection process consisted of four stages (see Fig. 5). In the *first* stage, both reviewers screened article titles against the inclusion criteria. In total, 698 articles were retained for review, with a 93.86% agreement between the reviewers (articles were retained, if at least one of the reviewers argued for inclusion, otherwise, they were excluded). *Second*, the remaining 698 abstracts were evaluated against the inclusion criteria by both reviewers with 110 articles retained (90.11% agreement between the reviewers). In the *third* stage, the first author reviewed the full texts against the inclusion criteria. Any uncertainty about the appropriateness of an article was resolved through a discussion and consensus approach by the first author and a research assistant. *Finally*, 16 studies were deemed to have satisfied all inclusion criteria relating to psychological predictors.

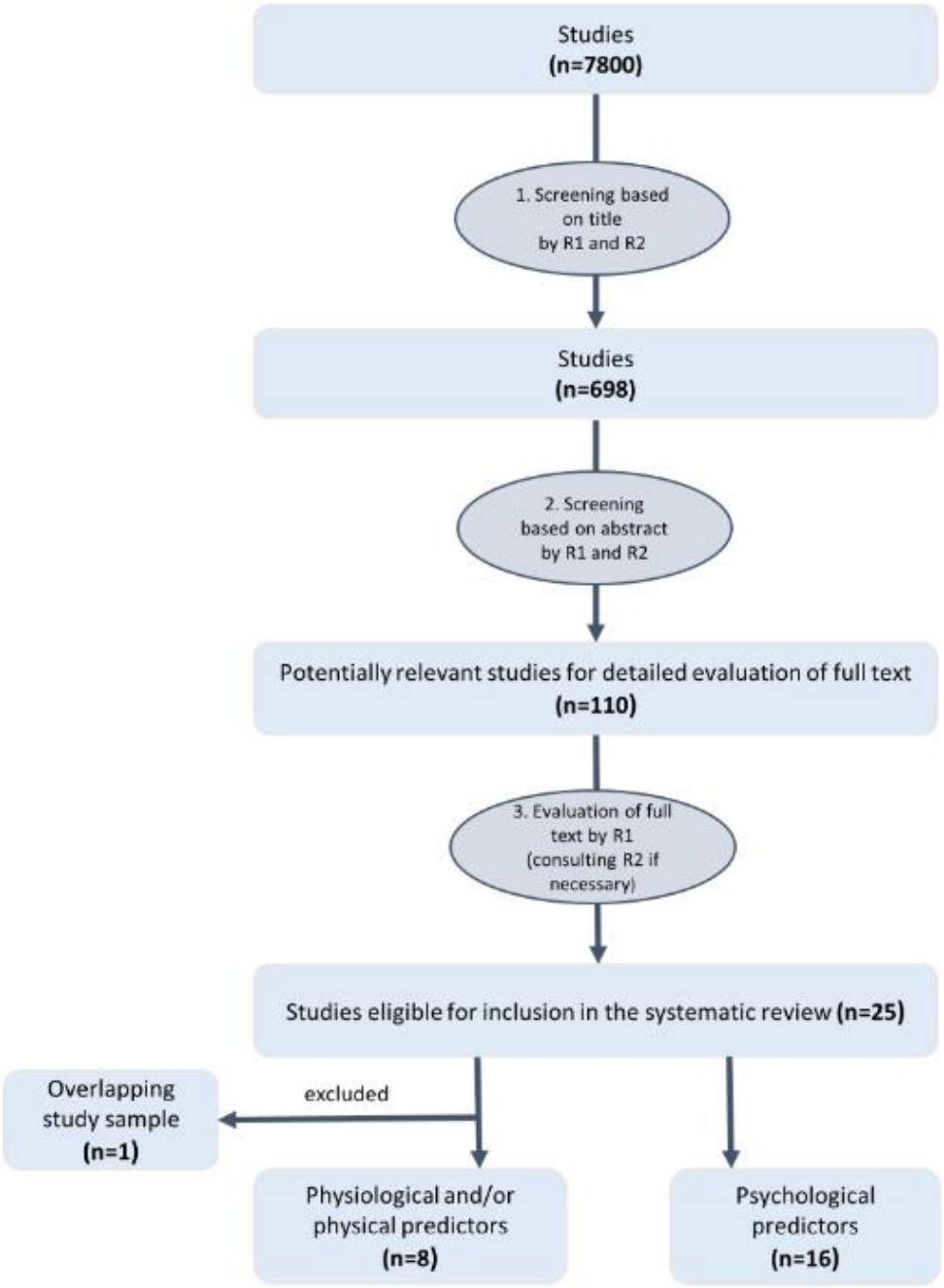

Fig. 5: Flow diagram of the selection procedure[#]

Data extraction and statistical analysis

To address the first objective, a descriptive overview of existing research was prepared for three different psychological factors (i.e., psychomotor, perceptual-cognitive, personality-related). In this context, the following central features of the study were operationalized (see Tab. 5) and analyzed in their appearance. The *participants* were differentiated by *sex* (i.e., female or male)

and *country* of origin where investigations took place. *Soccer development stages* were categorized based on established classifications of talent development programs (e.g., German Football Association's talent identification and selection program; DFB, 2009). The participants' *performance level* at the time of the initial survey (measurement T1), was separated pragmatically based on its appearance in the included studies. In relation to studies' *measurement methods diagnostics* were described listing the type of instrument administered to elicit predictors (e.g., self-report questionnaires, video-based tests). The operationalization of the *criterion variable* (participants' performance at the time of subsequent measurement T2) followed (as best possible) the terminology utilized by the authors of the included studies. With respect to study *design and statistical analysis,* the number of players who participated in the studies was considered as statistical power to find the significance of the relationship between two groups linked to *sample size* (Ackerman, 2014). Furthermore, the time interval between initial data collection (T1) and determination date of future success (T2) can have an impact on an individual factors' predictive relevance. Therefore, it is important to consider different length *prognostic periods.* To address the complex characteristics of performance, the *dimension of domains* (i.e., number of psychological predictors' domains that were investigated) were examined. In this context, it is worthwhile to compare procedures based on the distinction between different *statistical approaches* (e.g. ANOVA, MANOVA, LICUR). It should be noted that several authors investigated overlapping development stages or conducted studies with different prognostic periods. This led to several studies being reported in numerous catergories and consequently the results could indicate more than the 16 included studies.

To determine the *methodological quality* of the studies, an adapted version of the Critical Review Form for Quantitative Studies by Law (1987) was implemented. This modified assessment tool has been used in a systematic review of talent identification and development in soccer by Sarmento, Anguera, Pereira and Araújo (2018). To assess the methodological quality of the studies in the present review, only criteria from Sarmento et al., (2018, p. 990) that are related

to studies' methodological design features were applied: "appropriateness of the study design (item 3), sample included (items 4 and 5), informed consent procedure (item 6), outcome measures (item 7), validity of measures (item 8), method description (item 9), significance of results (item 10), analysis (item 11); see supplemental tab 3). The ratings per quality criteria were 1 (meets the criteria), 0 (does not meet the criteria fully or is not described).

Tab. 5: Overview of relevant design features of existing research on the prognostic value of psychological factors[#]

Participants		**Measurement Methods**		**Design and Statistical Analysis**	
Gender	female	*Diagnostic*	type of instrument	*Sample size*	N < 100
	male	*Criterion variable* (Selection level T2)*	PRO		100 ≤ N ≤ 200
Continent	Europe		NT or YA		N > 200
	Australia		SCHO	*Prognostic period*	< 1 year
Development stage	<U12		CR		1-3 years
	U12-U15		NEXT		> 3 years
	U16-U19			*Dimension of domains*	unidimensional
Performance level T1	youth academy				multidimensional
	talent development program			*Procedures*	univariate
	regional clubs				multivariate
					person-oriented

Note: Criterion variable at the time of subsequent measurement, assessing whether individuals turned professional (PRO), joined a youth national team or a youth academy (NT or YA), received a scholarship for an elite program (SCHO), performance was rated by their coaches (CR) or simply reached next age class at the competitive playing level (NEXT).

Next, the number of studies that investigated each psychological dimension and the frequencies of individual measured predictors (e.g., dribbling, decision-making, achievement motive) were reported. Furthermore, effect sizes and significant results were highlighted in order to analyze the empirical evidence for these individual predictors (objective 2). Cohen's d were obtained from two-group comparisons reported in the individual studies with regard to the different development stages (<U12, U12-U15, U16-U19). In case Cohen's d was not indicated in the original articles or only was investigated for individual age groups, reconstructed effect sizes for the development stages based on descriptive statistics were attained using the equation of Cohen's d with the pooled standard deviation (Cohen, 1988). The effect sizes were characterized as small ($0.2 \leq d < 0.5$), moderate ($0.5 \leq d < 0.8$), and large ($d \geq 0.8$) based on the recommendations of Cohen. To determine significant group differences ($p < 0.05$) independent t-sample test were conducted. In accordance with Murr et al. (2018b), when descriptive results were not presented or a holistic approach (e.g., person-oriented approach where clusters are formed) was used ($n = 5$), the authors of these studies were contacted by the researchers and were asked to provide their descriptive statistics for effect size computation. Furthermore, a reconstructed Cohen's d was also used when researchers compared three or more groups. Therefore, all analyses were restricted to a comparison of participants from the highest and the remaining competitive levels (i.e., "best" vs. "middle" and "weaker" players). In one study in which coaches rated the performance of their players, a product-moment correlation between coaches' rating and individual predictors was computed by employing the Fisher Z-transformation.

Results

Objective 1: Analysis of relevant design features of existing research on the prognostic value of psychological factors

Participants

In general, all 16 reviewed studies investigated male youth soccer players, with no study examining the performance or characteristics of female youth soccer players. In terms of location, 15 of these studies were conducted in Europe (i.e., Austria, Belgium, Finland, Germany, Netherlands, Portugal, Spain and Switzerland) and one in Australia. With regard to developmental stage, the talent stage (U12-U15, n = 12) was the most frequently investigated, with the elite stage (U16-U19) examined in seven of the articles and the foundation stage (< U12) accounting for two of the studies. Relating to the participants' performance level, a total of eight studies (50%) explored predictors of players attending a national youth development program, seven studies investigated prognostic validity with players from a youth academy, and one study examined predictors with regional club players (Figueiredo et al., 2009).

Measurement methods

Concerning diagnostics, specific types of instruments were applied in the studies to investigate variables in the three domains of predictors. To assess technical skills, the majority of authors (n = 9) used soccer-specific motor tests, with six implementing tests developed by several soccer federations (i.e., Football Association of Finland, German Football Association, Portuguese Football Federation). Only Gravina et al. (2008) and Huijgen et al. (2014) implemented non-soccer specific assessments. Of the four studies that measured perceptual-cognitive factors, three utilized the Tactical Skill Inventory for Sports (TACSIS; Elferink-Gemser, Visscher, Richart & Lemmink, 2004), and one study used a video-based diagnostic. In the area of personality-related factors, all of the eight studies used self-report questionnaires. Each psycho-

logical disposition or skill was assessed by one particular measurement instrument, for example, the 'Achievement Motive Scale' (AMS) was always used to measure achievement motive. However, motivational orientations were addressed using two different questionnaires, either 'Task and Ego Orientation in Sport Questionnaire' (TEOSQ) or 'Sport Orientation Questionnaire' (SOQ).

The operationalization used by the researchers to describe the selection level at the time of subsequent measurements (T2) varied greatly. Four studies examined whether players reached the next age group at the same competitive level or achieved a professional status. Other authors used the selection for a youth national team (n = 5) or youth academy (n = 2), a coaches rating of player performance (n = 2), or obtainment of a scholarship for an elite program as criterion variable at T2 (n = 1).

Design and statistical analysis

The majority of the 16 studies consisted of sample sizes between 100 and 200 (n = 9). The remaining authors conducted their investigations with less than 100 (n = 3) or more than 200 (n = 4) participants, with the investigation by Höner and Votteler (2016) consisting of a sample of 22,843 players. The prognostic period varied from less than one year (n = 5) to 15 years (i.e., Van Yperen, 2009). The majority of the studies utilized middle term prognostic periods (1-3 years, n = 7). Investigations with prognostic periods longer than three years were performed in six studies. With regard to dimension, two studies (Forsman et al., 2016; Huijgen et al., 2014) examined talent predictors in all three psychological domains. Three authors conducted investigations of only two psychological factors. The majority of the studies were unidimensional divided between technical skills (n = 6), perceptual-cognitive factors (n = 2) and personality-related dispositions or mental skills (n = 3).

With respect to statistical analysis 62, 5% (n = 10) of the studies conducted univariate analysis (e.g., ANOVA, two-sample t-tests, logistic regression), and the remaining six applied a multivariate method (e.g., MANOVA, structural equal modelling) linked with follow up analyses. Finally, in the research project of the Swiss talent promotion program (Zuber, Zibung & Conzelmann, 2016) a holistic concept was applied using a person-oriented approach (based on LICUR method).

Methodological quality of the studies

For all eligible studies, the applied methodological quality criteria were almost fulfilled exclusively (see supplemental tab. 3). Ten of the 16 studies (62.5%) met all nine criteria (i.e., Deprez et al., 2015; Höner & Feichtinger, 2016; Höner & Votteler, 2016; Huijgen et al., 2013; Huijgen et al., 2014; Huijgen, Elferink-Gemser, Post & Visscher, 2009; Kannekens et al., 2011; O' Connor, Larkin & Williams, 2016; Zibung, Zuber & Conzelmann, 2016; Zuber, Zibung & Conzelmann, 2015), while five studies (31.3%) fulfilled eight of the criteria (i.e., Figueiredo et al., 2009; Forsman et al., 2016; Van Yperen, 2009; Zuber & Conzelmann, 2014; Zuber et al., 2016) and one study (i.e., Gravina et al., 2008) only met six of the nine criteria. With respect to the methodological quality, in three cases both the informed consent was not obtained (i.e., criteria 4; Van Yperen, 2009; Zuber & Conzelmann, 2014; Zuber et al., 2015) and the validity of the outcome measures (i.e., criteria 6; Figueiredo et al., 2009; Forsman et al., 2016; Gravina et al., 2008) were failed. With only a few exceptions (i.e., criteria 2: detailed description of the sample, and criteria 5: reliable measurement of the outcome both in Gravina et al. (2008), all the other criteria were fulfilled in the 16 studies.

Objective 2: Empirical evidence of prognostic relevance of psychological predictors in soccer

The psycholgocial factor which had the greatest representation was *technical skill* with ten studies, while four studies explored the prognostice relevance of *perceptual-cognitive factors.* Eight studies examined *personality-related dispositions and/or mental skills.*

Psychomotor factors

Tab. 6 provides an overview of the ten studies that examined the prognostic relevance of technical skills. The predictor dribbling (n = 9) was the most investigated skill, with seven out of nine studies finding at least one significantly positive relationship with future performance level, indicating its prognostic relevance. The reported or reconstructed effect ranged from 0.47 $\leq d \leq$ 1.24. The largest effect sizes were reported by Figueiredo et al. (2009) who compared elite players vs. club or drop out players at the talent stage U12-U15 (d = 1.24). On the other hand, Deprez et al. (2015), who investigated different development stages, found the smallest yet still moderate effect size (d = 0.47) between club and drop-out players. The results of Gravina et al. (2008) did not reveal significant differences in dribbling skill when comparing adolescent first team regular players and reserve players based on coaches' ratings, and this result was also supported by Zibung et al. (2016) when considering the predictor dribbling individually. For ball control (n = 6), in five out of six studies, players who performed significantly better, went on to have future soccer success. The reported effect sizes were moderate to large (0.57 $\leq d \leq$ 1.28). Shooting (n = 2) and juggling (n = 2) received less consideration. Only Höner and Votteler (2016) found a small to moderate significant effect (d = 0.28), with youth national players outperforming non-selected players in a shooting test. Finally, Zuber et al. (2016) chose a holistic concept for investigations about talent research based on a person-oriented approach. This study with youth soccer players who were members of regional teams of the Swiss Football Association revealed that highly-skilled players with above average performances in a technical score consisting of dribbling, ball control and juggling skills, might be assumed to receive a higher-than-random number of future youth national players (d = 1.04).

Tab. 6:Overview about studies investigated psychomotor factors and their empirical evidence[#]

Objective 1										Objective 2	
Participants				Measurement Methods			Design and Statistical Analysis			Empirical Evidence	
Study	*Size (N)*	*Development stage*	*Performance level T1*	*Investigated predictor variable*	*Diagnostic*	*Criterion variable (Selection level T2)*	*Prognostic period*	*Dimension of domains*	*Procedures*	*Significant predictor variable*	*Significant effect sizes between groups (reconstructed if not given)*
Deprez et al. (2015)	388	<U12, U12-U15, U16-U19	youth academies Belgium	dribbling skill	UGent dribbling test	continue playing level (club vs. drop-out)	2 years	unidimensional	MANOVA, t-test	dribbling skill	d=0.47* (< U12)
Figueiredo et al. (2009)	159	U12-U15	regional clubs Portugal	dribbling skill, ball control, shooting accuracy, passing skill	test battery of the Portuguese Football Association	continue playing level (elite vs. club and drop-out)	2 years	multidimensional	MANOVA, ANOVA, pairwise comparison	dribbling skill	d=1.24*
Forsman et al. (2016)	114	U16-U19	youth academies Finland	dribbling skill, ball control	dribbling and passing test, passing and centering test	professional (elite vs. sub-elite)	4 years	multidimensional	logistic regression, t-test	dribbling skill, ball control	d= 0.61*, d= 0.84*
Gravina et al. (2008)	66	<U12, U12-U15	talent development program Spain	dribbling skill	slalom dribble test	coaches rated the performance of their players (FTP vs. R)	< 1 year	unidimensional	ANOVA; t-test	none	n.s.
Höner & Votteler (2016)	22843	U12-U15	talent development program Germany	dribbling skill, ball control, shooting	motor test battery of the German Football Association	drafted for youth national teams (NT vs. RA and YA and NS)	4-7 years	unidimensional	ANOVA, Tukey's test	dribbling skill, ball control, shooting	d=0.61*, d=0.57*, d=0.28*

Huijgen et al. (2014)	113	U16-U19	youth academy Netherlands	dribbling skill	SlalomSDT, ShuttleSDT	continue playing level (selected vs. deselected)	< 1 year	multidimensional	MANCOVA, post-hoc Bonferonni-corrected pairwise comparisons, discriminant analysis	dribbling skill (only ShuttleSDT)	d=0.60*
Huijgen et al. (2013)	270	U12-U15, U16-U19	youth academy Netherlands	ball control	Loughborough soccer passing test	continue playing level (selected vs. deselected)	< 1 year	unidimensional	multilevel modelling, t-test	ball control	d=0.69* (U16-U19)
Huijgen et al. (2009)	131	U12-U15, U16-U19	youth academy Netherlands	dribbling skill	shuttle dribble test	professional (professional vs. amateur)	2-6 years	unidimensional	Multilevel modelling	dribbling skill	d=0.67* (U12-U15), d=0.77* (U16-U19)
Zibung et al. (2016)	104	U12-U15	talent development program Swiss	dribbling skill, ball control, juggling	motor test battery of the German Football Association	drafted for youth national team or regional clubs (NT vs. RC and NS)	1 year	unidimensional	LICUR method	ball control	d=1.28*
Zuber et al. (2016)	119	U12-U15	talent development program Swiss	dribbling skill, ball control, juggling	motor test battery of the German Football Association	drafted for youth national team or regional clubs (NT vs. RC and NS)	1 year	multidimensional	LICUR method	dribbling skill, ball control, juggling	d=1.04* (technical skill score)

Note: Criterion variable: First team player (FTP); Reserve Player (R); Youth national team (NT); Regional association (RA); Regional club (RC); Youth academy (YA); Non-selected (NS)
*$p < 0.05$.

Perceptual-cognitive factors

Four studies explored the prognostic relevance of perceptual-cognitive factors (see Tab. 7). In three of these studies, a self-reported tactical skill test (i.e., TACSIS) was utilized that comprises four subscales (i.e., 'Knowing about ball actions', 'Knowing about others', 'Positioning and deciding' and 'Acting in changing situations'). All three studies highlighted a significant effect size on one of the four subscales. Forsman et al. (2016) identified a signifcantly better result for elite players (d = 0.50) for the subscale 'Acting in changing situations', both Huijgen et al. (2014) and Kannekens et al. (2011) reported that lower performing players showed descriptevly higher values in this subscale. However, Huijgen et al. (2014) and Kannekens et al. (2011) found significantly better results for future successful players in 'Positioning and Deciding' ($0.43 \leq d \leq 0.63$). In regard to the video-based assessment procedure used by O' Connor et al. (2016) that included four different tasks (i.e., decision-making, anticipation, pattern recognition and situational probaility), only the decision-making activity significantly discriminated between selected and non-selected players, with a large effect size (d = 0.81). When considering descriptive statistics, superior results for selected players were found in anticipation and situational probability but not for pattern recognition.

Tab. 7: Overview about studies investigated perceptual-cognitive factors and their empirical evidence[#]

Objective 1										**Objective 2**	
Participants				**Measurement Methods**			**Design and Statistical Analysis**			**Empirical Evidence**	
Study	*Size (N)*	*Development stage*	*Performance level T1*	*Investigated predictor variable*	*Diagnostic*	*Criterion variable (Selection level T2)*	*Prognostic period*	*Dimension of domains*	*Procedures*	*Significant predictor variable*	*Significant effect sizes between groups (reconstructed if not given)*
Forsman et al. (2016)	114	U16-U19	youth academies Finland	positioning and deciding, knowing about ball actions, knowing about others, acting in changing situations	TACSIS	professional (elite vs. sub-elite)	4 years	multidimensional	logistic regression, t-test	acting in changing situations	d= 0.50*
Huijgen et al. (2014)	113	U16-U19	youth academy Netherlands	positioning and deciding, knowing about ball actions, knowing about others, acting in changing situations	TACSIS	continue playing level (selected vs. deselected)	< 1 year	multidimensional	MANCOVA, post-hoc Bonferonni-corrected pairwise comparisons, discriminant analysis	positioning and deciding	d= 0.63*
Kannekens et al. (2011)	105	U16-U19	youth academy Netherlands	positioning and deciding, knowing about ball actions, knowing about others, acting in changing situations	TACSIS	professional (professional vs. amateur)	3-5 years	unidimensional	Logistic regression	positioning and deciding	d= 0.43*
O'Connor et al. (2016)	127	U12-U15	talent development programme Australia	decision-making, anticipation, situational probability, pattern recognition	video-based assessment	scholarship for an elite player residential programme (selected vs. deselected)	< 1 year	unidimensional	ANOVA Chi-Square analysis Stepwise discriminant analysis	decision-making	d= 0.81*

Note: *p < 0.05.

Personality-releated factors.

Regarding *personality-related factors and/or mental skills* (see Tab. 8), seven studies addressed personality-related dispositions. In this context, four studies analyzed the prognostic relevance of achievement motive for future success. Whereas in most of these studies (n = 3) the achivement component hope for success was (significantly) positively associated with future performance (d = 0.27; d = 0.74; r = .27), two of the four studies demonstrated a (significantly) negative association between fear of failure and future soccer success (d = 0.21*;* d = 0.30). This relationship was not found by Zuber and Conzelmann (2014; correlation between coaches judgement and fear of failure r = -.01). Zuber et al. (2016) revealed a negative relationship in net hope (d = -0.42), which is determined by the difference between hope for success and fear of failure. Furthermore, four studies examined motivational orientations (i.e., performance orientations, assessed by TEOSQ: ego or SOQ: competition, win; and mastery orientations, assessed by TEOSQ: task or SOQ: goal). With regard to performance orientations, three of these studies addressed ego orientation, and none of them found significant relationships between this disposition and future success. Two studies analyzed win orientation and its relationship to future success in soccer. Zuber et al. (2015) revealed that talented soccer players with a higher win orientation (d = 0.28) were more likely to obtain a higher performance level compared to players with low win orientation. However, Höner and Feichtinger (2016) did not find any significant relationship between win orientation and future soccer success. Additionally, the authors considered competition orientation and found a significantly positive relationship between this type of performance orientation and youth players' future performance level (d = 0.26). Regarding mastery orientations, three studies examined task orientation. The study by Höner and Feichtinger (2016) revealed a significantly positive relationship between this variable and future success in soccer (d = 0.20), whereas the two other studies did not find any significant associations. Both studies that examined goal orientation (Höner & Feichtinger, 2016; Zuber et al., 2015) found (significantly) positive relationships

between this type of mastery orientation and future soccer success (d = 0.20*;* d = 0.33). Two studies examined further dispositions within the area of achievement motivation. Van Yperen (2009) demonstrated the prognostic value of goal commitment for future success in soccer and found significantly higher values in a group of professionals compared to less successful players (d = 0.86). Zuber et al. (2015) indicated that talented soccer players with superior self-determination were more likely (d = 0.81) to get selected to a higher performance level compared to players with lower self-determination. In addition to motivational characteristics, Höner and Feichtinger (2016) examined personality-related dispositions and their relationships with youth soccer players' future performance level. The volitional competency self-optimization (d = 0.23), the self-referential cognitions self-efficacy (d = 0.19*)*, specific (d = 0.30) and general physical self-concept *(*d = 0.22), and the competition anxiety component worry (d = 0.20) were significantly related to future success. In contrast, neither the three volitional deficits (self-impediment, lack of initiation, loss of focus), nor the anxiety components (i.e., concentration disruption, somatic anxiety) were found to be prognostically significant.

To address mental skills, two studies used the Psychological Skills Inventory for Sports (PSIS). Forsman et al. (2016) found a significantly positive relationship between motivational skills and the future performance level of youth soccer players (d = 0.79). In comparison, Huijgen et al. (2014) did not find motivational skills to be significant predictors, and these skills were negatively associated with future success. Furthermore, Van Yperen (2009) demonstrated that subsequently successful players showed significant higher values in seeking social support (d = 0.60).

Tab. 8: Overview about studies investigated personality-related factors and their empirical evidence[#]

Objective I										**Objective 2**	
Subjects				**Measurement Methods**			**Design and Statistical Analysis**			**Empirical Evidence**	
Study	*Size (N)*	*Development stage*	*Performance level T1*	*Investigated predictor variable*	*Diagnostic*	*Criterion variable (Selection level T2)*	*Prognostic period*	*Dimension of domains*	*Procedures*	*Significant predictor variable*	*Significant effect sizes (reconstructed if not given) between groups*
Figueiredo et al. (2009)	159	U12-U15	regional clubs Portugal	Goal Orientation	TEOSQ	continue playing level (elite vs. club and drop-out)	2 years	multidimensional	MANOVA, ANOVA, post-hoc	none	n.s.
Forsman et al. (2016)	114	U16-U19	youth academies Finland	Mental Skills	PSIS	professional (elite vs. sub-elite)	4 years	multidimensional	t-tests; Logistic regression analysis	Motivational skills	d= 0.79*
Höner & Feichtinger (2016)	1701 / 1804	U12-U15	talent development program Germany	Achievement Motive, Sport Orientation, Task and Ego Orientation, Volitional Components, Physical Self-Concept, Self-Efficacy, Competition Anxiety	AMS; TEOSQ; SOQ; VCS; PSC; SES; CAI-T	drafted for youth academies (YA vs. NS)	4 years	unidimensional	Logistic regression analysis, ANOVA, Tukey test	Hope for success, fear of failure, completion orientation, goal orientation, task orientation, self-estimation, general self-concept, specific self-concept, self-efficacy, worry	d= 0.27*, d= 0.21*, d= 0.26*, d= 0.20*, d= 0.20*, d= 0.23*, d= 0.22*, d= 0.30, d= 0.19*, d= 0.20*
Huijgen et al. (2014)	113	U16-U19	youth academy Netherlands	Goal Orientation, Mental Skills	TEOSQ, PSIS	continue playing level (selected vs. deselected)	< 1 year	multidimensional	MANCOVA + Post-hoc; Discriminant analysis	none	n.s
Van Yperen (2009)	65	U16-U19†	youth academy Netherlands	Goal Commitment, Coping, Seeking Social Support	Van Yperen Scale	professional (successful vs. unsuccessful)	15 years	unidimensional	ANCOVAs; Discriminant analysis	Goal Commitment, Coping, Seeking Social Support	d= 0.86*, d= 0.6*

Zuber et al. (2016)	119	U12-U15	talent development program Swiss	Achievement Motive	AMS	drafted for youth national team or regional clubs (NT vs. RC and NS)	1 year	multidimensional	LICUR analysis	none	n.s.
Zuber et al. (2015)	92	U12-U15	talent development program Swiss	Achievement Motive, Orientation, Self-Determination	AMS, SOQ	drafted for youth national teams (NT vs. NS)	1 year	unidimensional	LICUR analysis	Hope for success, self-determination	d= 0.74*, d= 0.81*
Zuber & Conzelmann (2014)	140	U12-U15	talent development program Swiss	Achievement Motive	AMS	coaches rated the performance of their players (fictions NT vs. NS)	< 1 year	unidimensional	Structural equation models	Hope for success	r = 0.27*

Note: Criterion variable: Youth national team (NT); Regional club (RC); Youth academy (YA); Non-selected (NS), *p < 0.05, †There are a few players who are under the age of 16

Discussion

The aim of this systematic review was to analyze the existing literature regarding the prognostic relevance of psychological talent predictors in soccer. Based on systematic reviews in other talent identification domains (e.g., Gledhill et al., 2017; Johnston et al., 2018; Meylan et al., 2010; Murr et al., 2018b), the number of studies to examine the prognostic relevance of psychological predictors (n = 16) seems suitable. However, the large number of different domains of psychological predictors and variable findings across individual factors limits the conclusions that can be drawn. Nevertheless, the findings demonstrated the importance of investigating empirical evidence and considering relevant study design features. In addition to current research, this systematic review provides a detailed analysis of the predictive value of psychomotor, perceptual-cognitive and personality-related factors on soccer performance. Therefore, this article illustrates the key findings of the extant research in relation to psychological characteristics associated with talent development in soccer.

Relevant design features of existing research on the prognostic value of psychological factors

In order to discuss current trends in the literature, it should be noted that heterogeneous study designs have an impact on the findings and limit the scope of accurate conclusions. Therefore, one aim of the present study was to provide an overview of the methodological approaches of the researchers. With respect to *participants* country of origin**,** it is noteworthy that psychological predictors are largely ignored in nations such as the United States or the United Kingdom, where comprehensive talent research is predominant (Johnston et al., 2018). While in the United States other team sports (e.g., American Football or basketball) are more popular (Peterman & Suntornpithug, 2013), explaining the focus of research on those activities, it is surprising that for soccer in the United Kingdom, which is known as the

homeland of the game, there are no recent studies investigating the predictive value of psychological predictors. Moreover, there is a dearth of studies investigating prognostic relevance for youth female athletes. These results are in line with other studies that highlighted a lack of research in talent development and identification in female soccer, even as participation and professionalization has recently increased (Gledhill & Harwood, 2014; Murr et al., 2018b).

Referring to developmental stages, there are very few investigations (n = 2) with players under 12 years of age. This could be attributable to several factors. For instance, federations often do not start a systematic talent identification and promotion program before the age of 12 (e.g., Huijgen et al., 2014). Another reason may be the complex and dynamic nature of the development process of youth players and the question about efficacy of early identification in general (Fransen et al., 2017). Some researchers have questioned the applicability of objective assessments due to the unstable performance development of youth athletes (especially in early developmental phases; Lidor et al., 2009). In addition, scholars have argued such diagnostics often consist of test batteries that assess performance independent of athletes' maturity (Vandendriessche et al., 2012), which results in the frequently discussed relative age effect that can lead to maturation-related biases in diagnostics (Cobley et al., 2012; Votteler & Höner, 2014). While fluctuations in physical and physiological characteristics throughout (adolescent) development is well-established (Pearson et al., 2006), information about the stability of psychological factors and how they adjust during early years of an athlete's career are limited (Feichtinger & Höner, 2015; Johnston et al., 2018). Consequently, for a comprehensive understanding of talent identification and development, it would be worthwhile for researchers to investigate the prognostic relevance of individual talent predictors in all developmental stages (Vaeyens et al., 2006), which would

provide greater insight into the importance of possible structural adjustments for a given factor in a particular stage of factors.

To compare study results from different research groups it is necessary to correctly classify the investigated participation performance level at T1. In one study Forsman et al. (2016) noted the different findings of comparing the performance level of a youth academy player in Finland with such players in the Netherlands or Germany. Except for Figueiredo et al. (2009), all studies included in this review explored predictors for players attending a youth development program or who were members of youth academies, thus representing a high performance level group. This result aligns with Toering et al. (2009) who corroborate more comparisons within elite groups. When reporting participant levels, only a few studies provide readers with an exact description of the performance level of players. For instance, Huijgen et al. (2013) reported that the investigated players belong to the best 0.5% of the total number of Dutch soccer palyers in their age group. For future research it would be helpful to present more detailed information for instance, a percentage value for the performance level of the meausered players (e.g., best 1% players at the age group U15).

Similar discrepancies are present in the *measurement methods* relating to the terminology used by researchers to express the selection level at the subsequent measurements T2. The substantial variation in largely self-determined definitions by the authors (e.g., selected for next age group, achieving a professional contract, drafted for youth national team) impede comparability between the studies. This observation is in line with previous research by Swann, Moran and Pigott (2015) and Johnston et al. (2018), who highlighted an inconsistency in the terminology of skill levels. Frequently, the comparison of perfomance levels between different professional leagues is a challenge, as is the way authors define future success for players. Vaeyens et al. (2008) stressed that the main aim of talent development programs is to identify young athletes with the potential for elite success in

adulthood. Nevertheless, only four of the included studies in this review chose this selection criteria. In the future, researchers can maintain current approaches, and, where possible, also follow the players into adulthood. Furthermore, it appears desirable to use more consistent measurements to adequately compare study results and make meaningful conclusions about the prognostic relevance of certain predictors. Understandably, the large domain of psychological predictors requires the implementation of specific types of diagnostics. In this context, psychometric properties of measurement instruments are crucial for investigating talent predictors and increase the comparability of results (Höner et al., 2015). Another option to compliment classical testing that would provide relevant insights into performance would be to use an inventory of instruments in which players self-report their performance in combination with an external judgement by experts. For example, Musculus and Lobinger (2018) provided recommendations on how to ensure scientifically sound coaches' assessment of psychological characteristics.

With regard to *design and statistical analyses*, large sample sizes such as Höner and Votteler (2016) constituted an exception. This finding emphasizes the appeal by Mann et al. (2017) for more large-scale longitudinal studies. Vaeyens et al. (2008) also suggested that the length of the prognostic period influences the effects associated with the individual factors' predictive relevance. The majority of the studies in this review investigated prognostic relevance over a short or middle term period (three years or less). On the one hand, consideration of shorter periods can help to understand important transitions in adolescence, but can also be more susceptible to confounding factors such as instability. For instance, very short prognostic periods in adolescence could be detrimental to late matured players because of physical handicaps (e.g., height and weight). However, the more relevant question for talent development programs should be which factor indicate that an athlete has the potential to develop positively and become a successful player in adulthood (Vaeyens et al., 2008). Even

better would be studies that combine investigations of developmental processes and the predictive value in different age groups (Leyhr, Kelava, Raabe & Höner, 2018). Therefore, long-term prognostic periods are of interest and have the most practical merit. Due to the complex spectrum of talent predictors Till and colleagues (2016) preferred to adapt a multidimensional approach as was conducted by Forsman et al. (2016) or Huijgen et al. (2014). In contrast to Tills' et al. (2016) perspective, the majority of authors investigated unidimensional approaches which has been criticized in previous research (Carling & Collins, 2014; Vaeyens et al., 2008). In a statistical context, a multidimensional approach provides the possibility of using both univariate and multivariate analysis. Therefore, on the one hand a crucial point is an individual consideration of the factors (e.g., prognostic relevance of individual factors), and on the other hand multidimensional diagnostics or procedures are important as part of complex theory models. For instance, some of the studies used a multidimensional design and applied multivariate statistics. Whenever this was conducted, no significant effects of personality-related characteristics were revealed. This may be explained by the fact that psychological dispositions and skills – compared to, for example, technical skills – only explain a small portion of future performance, and therefore their influence gets lost in multidimensional, multivariate designs. An exception to this observation is the study by Forsman et al. (2016) which revealed a significant effect of motivational skills. However, this study showed contradictory results in comparison with other research (Huijgen et al., 2014). For a deeper discussion of different analytical procedures see Höner et al. (2017).

To sum up, central features of study design may influence the prognostic relevance of individual talent predictors. Based on the heterogeneous methodological approaches, the ability to report accurate conclusions regarding prognostic relevance is limited. For instance, independent of the developmental stage, significant effects were found for various predictors.

From a practitioners' perspective it would be more valuable to specify important factors for different stages.

In previous systematic reviews, the *methodological quality of eligible studies* has been evaluated using well-established assessment tools (e.g. PEDROscale, Mixed-model appraisal tool, MINORS (Maher, Sherrington, Herbert, Moseley & Elkins, 2003; Pluye & Hong, 2014; Slim et al., 2003)). However, most of these evaluation scales were designed for intervention studies and not applicable to the papers within the current review. Using an adapted version of the Critical Review Form for quantitative studies to compare the methodological quality of the empirical literature on male soccer talent identification and development (Sarmento et al., 2018), the studies included in this current review nearly fulfilled all chosen quality criteria, while only a few studies did not meet the quality assessment (e.g., criteria 4; informed consent was not obtained). This is in line with Sarmentos' review in which the average fulfillment of criteria for 63 selected quantitative studies is very high, too.

Overall, there seems to be minimal benefit in applying existing quality assessment tools, which are generally used for intervention studies, to the talent identification and development research. Therefore, future efforts should be directed at defining methodological quality assessment criteria which are 1) described in detail, and 2) relevant to the talent identification and development literature. Based on the analysis of the respective study design features (objective 1) this review provides an opportunity for identifying appropriate assessment criteria. For instance, with respect to participants, it is not sufficient to state general descriptors (e.g., number of participants, age, country etc.), but rather, more detailed information should be provided, such as levels of performance (e.g., detail categorization within the investigated country; elite, sub-elite, novice). Further, more comprehensive assessment of the statistical analyses undertaken would improve the interpretation of results (e.g., in

addition to descriptive statistic, both uni- and multivariate examination in investigating multidimensional predictors). With respect to measurement methods, more specific criteria concerning the psychometric properties of diagnostics (e.g., determination of instrumental reliability and criterion-related validity) would support the methodological quality of studies. Therefore, future studies in the talent identification and development area, should consider the development of a methodological quality assessment measure which considers some of these potential criteria. In doing so, this would more appropriately assess the strength and quality of the talent identification and development studies, compared to more well-established tools (e.g. PEDROscale, Mixed-model appraisal tool, MINOR).

Empirical evidence of prognostic relevance of psychological predictors in soccer

Analyzing the number of studies dealing with psychological predictors revealed an imbalance between more frequently regarded technical skills and personality-related factors on the one side and relatively underrepresented perceptual-cognitive factors on the other side.

The fact that most studies investigate the prognostic relevance of dribbling and ball control could be based on previous literature in which studies demonstrated the importance of these key factors (e.g., Keller, Raynor, Bruce & Iredale, 2016). The results of this review support previous findings that emphasize the importance of both technical skills independent of the investigated development stage. In almost all reviewed studies, the prognostic relevance of dribbling and ball control (e.g., passing or trap the ball) was significant with moderate to large effect sizes ($0.47 \leq d \leq 1.28$). By contrast, only two authors investigated the prognostic relevance of the factor shooting, despite its central role in scoring goals in games. At this juncture, it appears surprising that a factor as essential as shooting only revealed a low predictive value. The gap in the literature with regard to shooting could be a result of the complexity of this characteristic and the difficulty of developing reliable measurements (Ali, 2011; Russell, Benton & Kingsley, 2010). One possible approach to receive more attention

for shooting is the development of standardized shooting tests (at least for certain playing positions (e.g., forwards)), in combination with subjective judgements from expert coaches. In the current research, the factor juggling also received limited consideration. This finding is likely due to juggling being an activity, conducted in training or leisure time, not a key component of in-game performance.

A possible reason for the lack of studies about the predictive value of perceptual-cognitive factors might be the difficulty in capturing such latent variables. Appropriate diagnostic instruments are often very time-consuming and complex, especially in a sport-specific context. In this review, three studies examined the predictive value of perceptual-cognitive factors using TACSIS and highlighting contradictory significant effect sizes between higher and lower performing players. However, the use of self-reported tactical skills to examine perceptual-cognitive skills should be considered critically. In this context, Nortje, Dicks, Coopoo and Savelsbergh, (2014, p. 330) argued that there is a difference between self-reported questionnaires and real game situations where players are "competing against opposing players and cooperating with their teammates". With regard to the prognostic relevance of decision-making, O' Connor et al. (2016) demonstrated a large significant effect size (d = 0.81) utilizing a soccer-specific video-based assessment. Overall, the results indicated a lack of studies examining perceptual-cognitive skills with a perceptual-action coupling which would be closer to real game situations.

With respect to personality-related factors, most of the research examined the prognostic relevance of psychological dispositions, and only a few studies considered mental skills. In the context of talent research, this may make sense, because dispositions are regarded to be more stable over time and across situations than state-based skills, which can change from situation to situation or from day to day (Morris, 2000). A number of studies demonstrated that psychological dispositions and skills discriminate between youth players of different

performance levels (e.g., Höner & Feichtinger, 2016; Van Yperen, 2009; Zuber et al., 2015). However, other research has found no significant differences between high- and low-performing youth players with regard to such characteristics (e.g., Figueiredo et al., 2009; Huijgen et al., 2014). Furthermore, some of these studies have reported contradictory results (e.g., Forsman et al., 2016; Huijgen et al., 2014). Within the motivational characteristics, both components of the achievement motive (i.e., hope for success and fear of failure) assessed by the AMS-S seem to be associated with future success in soccer. In the majority of studies, hope for success was positively associated with future performance and fear of failure was negatively related to success. These findings support previous research (for an overview, see Achtziger & Gollwitzer, 1988) that revealed athletes with high dispositions toward hope for success demonstrated more functional behaviors (e.g., more endurance and effort, and self-serving attributions) compared with the individuals with high fear of failure values. Regarding the prognostic relevance of motivational orientations, sport psychology talent research provides findings that are more heterogeneous. Out of three studies addressing the prognostic relevance of goal orientations (i.e., ego and task orientation assessed by the TEOSQ), only Höner and Feichtinger (2016) found a significant relationship between task orientation and future success. In comparison to the TEOSQ, the SOQ seems to be a more reliable assessment of motivational orientations in the context of sport talent research. Although Höner and Feichtinger (2016) did not find win orientation to be a significant predictor of future success, their results revealed relevant associations between the SOQ subscales competition, goal and win orientation and players' future performance. As a consequence, further studies examining motivational orientations in sport talent research might prefer the SOQ over the TEOSQ because both questionnaires have the same theoretical foundation (Skordilis et al., 2001). A small number of studies examined further motivational

dispositions (e.g., goal commitment, self-determination) or characteristics from other personality domains such as volition, (self-referential) cognition, and emotion. This limited research can only provide an initial understanding of the prognostic relevance of personality-related dispositions such as volitional competencies, self-concept, self-efficacy, and competition anxiety. The same applies for mental skills. Nevertheless, mental skills play an important role in athletic performance (Abbott & Collins, 2004), and more prognostic studies are needed to be able to make reliable statements about their relevance for future success. In the area of personality-related dispositions, the focus so far has been on motivational characteristics (i.e., achievement motive, motivational orientations). For other personality areas, there are only limited prognostic studies (e.g., Höner & Feichtinger, 2016), which only provide an initial exploration of the relevance of volitional, (self-referential) cognitive, and emotional dispositions. Given the inconsistent state of empirical research (e.g., with regard to motivational orientations or mental skills), the relationship between personality-related characteristics and future performance level in soccer requires further examination. It should be mentioned (again) that different design features of the studies may have influenced the inconsistencies of all considered factors in this review.

Conclusion

The current study provided insights into the prognostic relevance of psychological talent predictors for young soccer players and complemented the review of the predictive value of physical and physiological characteristics by Murr et al. (2018b). Evidence was found for individual factors (e.g., dribbling, decision-making, achievement motive), however, additional research is warranted for investigating individual talent predictors more comprehensively. Large-scale studies that employ multidisciplinary test batteries to assess youth athletes at different age groups are required to improve the specificity of predictions (Mann et al., 2017). Such approaches can provide clubs and coaches with valuable information to

support the promotion of talented players within their organizations. Moreover, the prognostic relevance of personal talent predictors relating to different playing positions might be of future interest. Besides person-oriented factors, environmental factors (e.g., training or game play activities that may influence the level of ability a player can attain) should be considered as well (Li, Wang & Pyun, 2014).

3.2 Empirische Studien

3.2.1 Elite Youth Soccer Players' Decision-making Skills: Validating a Perception-action Coupling Video Diagnostic based on Age, Playing status and Playing Position

(2) Murr, D., Larkin., P., & Höner, O. (2018, in Vorbereitung). Elite youth soccer players' decision-making skills: Validating a perception-action coupling video diagnostic based on age, playing status and playing position. [Die vorliegende Version des Manuskripts dient als Vorlage für eine zeitnahe Einreichung]

Abstract

Introduction:

Cognitive skills, in particular players' ability to make the right decision in different game situations under time constraints, are an important performance indicator for soccer. However, there is a lack of diagnostics that accurately measure decision-making performance using soccer specific stimuli in combination with a sport-specific motor response. This study aimed to develop a reliable and valid video-based test battery that assesses decision-making at one German Bundesliga club youth academy.

Methods:

86 German youth academy players (16,7±0,9 yrs) interacted with a game situation projected on a large video screen by dribbling and passing to one of three targets. The test included 48 clips separated into two categories: Build-up (BU) and offensive decisions (OFF). Criterion-related validity was tested based on age (i.e., U16, U17, and U19) and playing status (i.e., first-team regular player (FTRP) vs. reserve player (RP)). Prognostic validity was examined relating to future youth national team status (i.e., drafted or non-drafted). Finally it was investigated if decision-making competence was influenced by playing position (i.e. defender vs. midfielder vs. forward).

Results:

Instrumental reliability demonstrated satisfactory values for SCbu (r=.72), and slightly lower for SCoff (r=.56). Results showed the diagnostic is suitable for discriminating age (SCoff: $p<.01$, $\omega=1.78$) and playing status (SCbu: $\Phi=.22$; SCoff: $\Phi=.14$). The predictive value of the test indicates a trend for future youth national team players to be better decision-makers (SCbu: $p<.05$, $\Phi=.20$), whereas playing position did not influence decision-making competence.

Conclusion:

Results indicate the video-based decision-making diagnostic can discriminate decision-making competence within a high performing youth group. Trends associated with national youth team participation demonstrate the predictive value of the diagnostic. This study provides initial evidence to suggest a new perception-action coupling video-based diagnostic can be used within talent identification process to assist with the assessment of decision-making performance

Keywords: football, talent identification, adolescence, perceptual-cognitive

Introduction

In team sports like soccer, a multidimensional spectrum of performance factors is required to perform at the elite level. This has been acknowledged by Williams and Reilly (2000) who developed a heuristic model for the categorization of soccer talent predictors. The model identifies potential talent predictors across four core areas of sport science, including physical, physiological, psychological and sociological characteristics. While there seems to be an emphasis on physiological and physical characteristics in research and practice (Johnston et al., 2018; Wilson et al., 2016), recently, there has been increased interest into psychological attributes, such as perceptual-cognitive factors (Mann et al., 2017). Researchers have highlighted the importance of perceptual-cognitive factors for skilled performance, with findings showing highly skilled players possess superior decision-making, anticipation and situational probability skills compared to their less skilled counterparts (e.g., Lex et al., 2015; Ward, Ericsson & Williams, 2013). In relation to this study, decision-making is the cognitive performance factor in particular focus, as the ability to make the correct decisions across a wide range of complex game situations under high game pressures and time constraints is a key component of in-game performance (Höner et al., 2018, in Druck).

Causer and Ford (2014) define decision-making as a cognitive process in which one uses their knowledge about a (current) situation to select an appropriate decision based on their perceived ability to execute a certain motor skill. From a sporting perspective, decision-making has been shown to be an important skill, with several cross-sectional studies assessing decision-making performance and demonstrating the ability to discriminate between skilled and less skilled players in team sports (e.g., Diaz del Campo, Gonzalez, Garcia & Mitchell, 2011; Lorains, Ball & MacMahon, 2013; Woods, Raynor, Bruce & McDonald, 2016). With respect to soccer, Ruiz Pérez et al. (2014) demonstrated better decision-making performance of Spanish club players with international experience in comparison to local

level players. Further, Höner (2005) found youth national players had superior decision-making skills compared to local youth players and additionally the results revealed older players (i.e., U17 age group) had a significant decision-making performance advantage over younger players (i.e., U15 age group). While the majority of studies have used an expertise approach and highlighted superior performances of expert/skilled players over novice/less skilled players (e.g., Ruiz Pérez et al., 2014), research is scarce within high performance homogeneous groups, such as talent promotion programmes (e.g., regional association or youth national teams) or youth academies.

In addition to the lack of assessment of high performance homogenous groups, a further limitation of the current decision-making literature is the limited understanding of the potential performance differences between playing positions. From a physical perspective, researchers have found physiological and anthropometric differ across playing positions. For example, Rago, Pizzuto and Raiola (2017) revealed more high-intensity running in midfielders and defenders than in forwards, and Boone et al. (2012) found central defenders are taller and heavier than midfielders and wing defenders. Therefore, it is plausible that playing position may also influence decision-making ability. Initial investigations by Höner (2005) and Kannekens et al. (2011) have attempted to address this issue and demonstrated that midfielders make better decisions compared to defenders and forwards. However, the results of Höner (2005) could be attributed to the situations used in the video scenes which presented more offensive decisions specific in midfield performance. Further, Kannekens et al. (2011) assessed tactical understanding of players from different positions on a self-reported tactical skill inventory (TACSIS; Elferink-Gemser et al., 2004). Despite the positive results found in each study, the methodological limitations of both may not provide a true reflection of decision-making performance of players from different positions. Therefore, this study will attempt to address this limitation by attempting to measure decision-making performance in

different game contexts, such as build up (i.e., wing and central defense situations) and offensive (i.e., forward and midfield situations) game-based decisions.

While many researchers have used cross-sectional approaches to discriminate between skills and less skilled decision-makers, a recent systematic review by Murr, Feichtinger, Larkin, O' Connor and Höner (2018, accepted) highlighted a significant gap in the present literature concerning empirical evidence related to the predictive value of decision-making assessments. Accordingly, three studies (Forsman et al., 2016; Huijgen et al., 2014; Kannekens et al., 2011) revealed contradictory significant effect sizes between higher and lower performing players using a self-reported tactical skill inventory. It should be noted however, the validity and reliability of this measure has been questioned in the literature, as players' competence is based on self-reported measures, rather than executing performance (Nortje et al., 2014). Another customary approach to investigating decision-making competence are video-based tests which prompt a verbal, written or button response from participants following the video presentation of an in-game decision situation (e.g., Larkin, O'Connor & Williams, 2016). While the majority of studies use footage from a broadcast perspective (i.e., Television broadcast), they still have demonstrated the ability to discriminate skilled and less skilled players (e.g., Roca et al., 2012). To date, only one investigation has used a soccer-specific video-based assessment to examine the predictive ability of decision-making skills. O' Connor et al. (2016) demonstrated a large significant effect in discriminating between selected and non-selected players within an Australian talent development programme. However, it should be noted the prognostic period for this study was very short (i.e., selection at the conclusion of the data collection), with further research investigating longer prognostic periods required. Despite this understanding, in general, more research is needed to develop valid and reliable measures that have a strong predictive value to assist with the identification of talent within high performing groups.

While traditional diagnostic instruments used to examine decision-making, such as video-based tests, provide advantages in test execution and methodological control, it remains unclear if their non-sport-specific responses (i.e., written, verbal or button responses) correspond to real game situations and performance (van Maarseveen, Oudejans, Mann & Savelsbergh, 2016). Furthermore, there could be a benefit of presenting the video stimulus from a first-person perspective which represents a more realistic environment compared to broadcast footage. Overall, the extant research lacks studies examining decision-making competence on measures which incorporate perceptual-action coupling to ensure the instrument closer reflects real in-game situations (Hagemann, Lotz & Cañal-Bruland, 2008). To address this limitation, Hagemann et al. (2008) utilized a video-based decision-making training tool with a soccer-specific motor response. Using a similar visual-motor response (i.e., in front of shown video scenes players had to pass the ball against different targets), Frýbort, Kokštejn, Musálek and Süss (2016) investigated the influence of varying exercise intensity on decision-making time and accuracy. While these investigations provide the foundation for incorporating sport-specific responses in context with decision-making, it should be noted that diagnostic studies assessing decision-making skills with a perceptual-action coupling response are not existent within the soccer talent identification literature. Travassos et al. (2013) reaffirmed this issue in their meta-analysis and emphasized that an expertise effect is more consistent if participants have to execute sport-specific actions in experimental studies. Therefore, Travassos et al. (2013) highlighted the need for further research to develop and examine the impact of decision-making instruments which require responses that consider the perceptual and technical constraints of the performance environment.

The present study

While there are studies which have provided a descriptive understanding of soccer decision-making performance (e.g., Diaz del Campo et al., 2011; Roca et al., 2012), there is still limited understanding of how this attribute maybe used to assess potential talent. This study aims to develop and evaluate a reliable and valid first-person perspective video-based diagnostic which incorporates a soccer-specific skill response to the decision process. *First*, the evaluation is focusing on the reliability of the diagnostic (Objective I). In the *second step*, diverse aspects of the validity were proved to examine whether a video-based diagnostic tool is sensitive enough to discriminate between groups of highly skilled players. More specifically, the criterion-related validity was tested using different approaches (diagnostic validity IIa + IIb; prognostic validity IIc):

IIa) Within middle-to-late adolescence older soccer players show better decision-making skills than younger players; and

IIb) The diagnostic's results discriminate significantly players with respect to minutes played in official matches in current season (i.e., first team players; reserve); and

IIc) Future youth national team players show better decision-making skills than non-drafted players.

Furthermore, based on a lack of empirical studies, in a subsequent (*third) step* the study explored if decision-making competence was influenced by playing position:

III) Do players in certain playing positions perform better on a decision-making diagnostic?

Method

Sample and design

The study sample consisted of 86 youth academy players resulted in 140 data points (Tab. 9), born between 1996 and 2001, from a professional German soccer club. The players were 15-19 years of age (M_{age} = 16.7 years, SD_{age} = 0.96) at their first measurement point and competed in the highest German youth league thus belonging to the top 1% of German players for their age groups (i.e., U16, U17 and U19). Players were tested yearly over a three year period (i.e., near the end of seasons 2014/15 to 2016/17), resulting in three measurement points between T2015 = T1, T2016 = T2 and T2017 = T3.

The ethics department of the Faculty of Economics and Social Sciences at the University of Tübingen and the youth academy of the professional soccer club approved the implementation of this study. All players and legal guardians (i.e., parents) provided informed consent prior to participation in the study.

Tab. 9: The data points collected with respect to age group and measurement time point[#]

	Measurement point			
Age group	T1	T2	T3	Total
U16	13	12	16	41
U17	21	17	17	55
U19	15	14	15	44
Total	49	43	48	140

Stimulus materials

Decision-making competence was assessed using a newly developed soccer-specific video-based diagnostic, which presented real game situations recorded from the first-person perspective of the ball carrier at different positions on the pitch (i.e., forward, midfield, wing defense, central defense; see Fig. 6). More than 300 real game on-ball decision-making situations, which contained a dynamic soccer sequence were designed and filmed as part of a

pilot study (Dieze, 2015). The video footage of each situation moved like a player in ball possession and were reviewed by a panel of expert coaches (i.e., one UEFA pro-level, one UEFA A-level and two UEFA B-level). During the review process, a round table forum was held, whereby the panel discussed the outcome of every clip, until 100% agreement was reached for the best (i.e., correct) decision of each video scene. Following this detailed evaluation by the expert panel, 30 video scenes were selected as the most realistic game situations and were thus used for the study.

To ensure a more comprehensive diagnostic, these 30 video scenes were mirrored (i.e., the same scene presented from the opposite direction). Thus, the final video-based diagnostic consisted of 60 game situations, which were then classified as either offensive decisions (i.e., forward and midfield) or decisions that occur in the build-up of a game (i.e., wing and central defense). For testing, the video scenes were presented in four video blocks (i.e., category forward, midfield, wing defense, central defense).

Fig. 6: Example of a midfield scene used within the first-person perspective video-based decision-making diagnostic[#]

Procedures

All assessments were conducted in the same indoor room at the youth academy, with all participants individually tested over a six week period at each respective measurement point. With regards to the test procedures, participants were required to interact with the video scene (i.e., a game situation) projected on a 2.76 m wide x 1.50 m high video screen by dribbling the ball and then passing to one of three possible targets (i.e., supporting teammates in the video), before overstepping a limiting line or the video scene ended (see Fig. 7). At the commencement of each test, each participant was provided with a standardized instruction (e.g., "In each scene you start to dribble from one out of five positions."; "A short freeze will help you to orientate in the current game situation."; "During the dribbling your decision is based on passing the ball to one of three targets that represent the position of your teammate."). Prior to each testing block, three familiarization video scenes were presented for participants to become accustomed to the testing procedures and the situation of the respective category. After the familiarization video scenes, participants were able to ask any questions they had in relation to video or response procedures. Following these familiarization videos, 12 testing videos were presented. For each trial (i.e., 3 familiarization videos plus 12 testing video scenes for forward, midfield, wing defense and central defense category), the first author recorded the target (i.e., decision) the participants passed the ball to, while a research assistant placed a ball on the next starting position. For participants' orientation, in each clip the first frame of each video scene was frozen for 1.5-seconds. Each video trail was 5-6 seconds in duration and had three possible passing options (with respect to the forward category players had the choice between two pass and one shoot option). Between the trials, a black screen remained for six seconds.

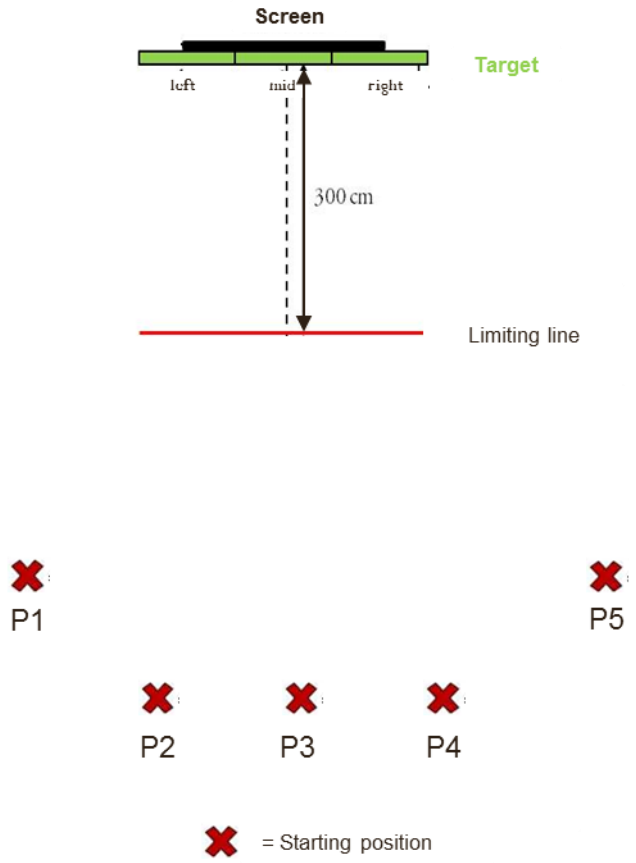

Fig. 7: The structure of the first-person perspective video-based decision-making diagnostic experimental set up[#]

Measures

For the analysis of the criterion-related validity of the diagnostics, the independent variable age group identified potential differences between age groups U16 (N = 41), U17 (N = 55) and U19 (N = 44) (Objective IIa). Further analysis of the criterion-related validity of the diagnostics, was based on the independent soccer performance-related variables playing status and future youth national team status. Playing status (IIb) was determined based on minutes played in official matches (i.e., U19/U17 German Youth Bundesliga and U16 Oberliga). Median split procedure was utilized to separate players into two categories; first team regular (i.e., FTRP who play more minutes than median) and reserve players (i.e., RP who play less minutes than median). With regard to playing status, 70 FTRP and 68 RP participated in the study. Further, to examine the predictive value of the decision-making instru-

ment relative to future youth national team status (IIc), data of the respective first measurement point of all 86 players were captured. Participants who were selected to participate in at least one German youth national team training course in subsequent seasons (i.e., 2015/2016; 2016/2017; 2017/2018) were identified as drafted (N = 16), and players who were not selected were identified as non-drafted (N = 70).

The decision-making accuracy for each video situation was assessed using a coding criteria of one for a correct decision (i.e., passed to the best option identified by the expert panel) and zero for an incorrect decision (i.e., passing to an option not rated the best). Any trial where the participant missed any target or did not decide before the scene ended was also coded as a zero. Subsequently, participants' decisions from 48 testing video situations were used for calculating offensive (SC_{off}; i.e., mean value of 24 corresponding scenes) and build-up (SC_{bu}; i.e., mean value of 24 corresponding scenes) decision accuracy scores. Both scores (i.e., SC_{off} and SC_{bu}) were converted to a percentage of correct decisions.

Statistical analyses

Inferential statistics were analyzed using SPSS version 24. Diagnostics' instrumental reliability was examined using a split-half procedure (odd-even-method corrected by Spearman-Brown formula; Lienert & Raatz, 1998) for players' first assessments' test results.

An examination of distributional properties revealed the decision-making accuracy scores SC_{off} and SC_{bu} were not normally distributed. Therefore, to investigate mean differences between age groups and playing positions, non-parametric Kruskal-Wallis-tests were conducted with post-hoc pairwise comparisons. Differences in regards to playing status and future youth national team status were analyzed with Mann-Whitney U-tests (one-tailed hypothesis) for both individual scores. Effect sizes ω and Φ for non-parametric tests were calculated and classified in accordance to Cohen (1992).

As objectives IIa) and IIc) investigated a group prediction, additional stepwise logistic regressions were conducted. The overall model fit was examined with the likelihood ratio chi-squared test. The SC_{bu} and SC_{off} regression coefficients as well as the odds ratios (ORs) e^{β} and their 95% confidence intervals were calculated with reference to the respective selection criteria (i.e., "reserve player" for IIa; "non-drafted" for IIc). Finally, individual selection probabilities were determined for playing status (i.e., first team regular player and drafted for youth national team) on the basis of a player's SC_{bu} and SC_{off}.

Results

Analyses of instrumental reliability demonstrated satisfactory values for SC_{bu} (r = .72), and slightly lower for SC_{off} (r = .56). Tab. 10 presents an overview of the decision-making scores (i.e., SC_{bu} and SC_{off}). Kruskal-Wallis-test identified significant differences in decision-making competence with regards to age in SC_{off} ($H(2) = 21.10$, $p < .01$, $\omega = 1.78$), but just failed significance for SC_{bu} ($H(2) = 5.95$, $p = .051$, $\omega = .50$). Post-hoc analysis revealed U19 and U17 players scored significantly higher in SC_{bu} (U17 > U16: $Z = 2.35$, $p < .01$, $\Phi = .24$; U19 > U16: $Z = 1.88$, $p < .05$, $\Phi = .41$) and SC_{off} (U17 > U16: $Z = 3.82$, $p < .01$, $\Phi = .39$; U19 > U16: $Z = 4.17$, $p < .01$, $\Phi = .46$) compared to U16 players. However, there were no significant differences between U19 and U17 players in the SC_{bu} (U17 > U19: $p = .483$) category nor in SC_{off} (U19 > U17: $Z = 0.04$, $p = .244$). In relation to playing time of competitive matches in the current season, FTRP performed significant better than RP in both scores, with low to moderate effect sizes (SC_{bu}: $Z = 2.57$, $p < .01$, $\Phi = .22$; SC_{off}: $Z = 1.69$, $p < .05$, $\Phi = .14$).

With respect to the stepwise logistic regression, only SC_{bu} showed significance and therefore remained in the model (SC_{bu}: $H(1) = 8.00$, $p < .01$). The ORs e^{β} from the logistic regression model indicated that one standard deviation ($SD_{SCbu} = 0.153$) increase in SC_{bu}, improved the

chance of being a FTRP by a factor of 1.65 (= $(e^{\beta})^{0.153} = 26.69^{0.153}$). Regarding the prognostic validity, there was a trend for drafted players to have a higher decision-making accuracy than non-drafted players in SC_{bu} (Z = 1.82, $p < .05$, $\Phi = .20$) and SC_{off} (Z = 0.78, $p = .217$), however only SC_{bu} provided a significant difference. Analyzing the prediction of future youth national team status with regard to the logistic regression models led to the same result as for the playing status variable. Only SC_{bu} demonstrated significance and therefore remained in the model (SC_{bu}: H(1) = 4.14, $p < .05$). With respect to future youth national team member, a one standard deviation increase in SC_{bu} improved the chance of being drafted by a factor of 1.89 (= $(e^{\beta})^{0.153} = 64.20^{0.153}$).

Regarding playing position the Kruskal-Wallis-test did not reveal significant differences in any decision-making competence (SC_{bu}: H(2) = 5.26, $p = .072$; SC_{off}: H(2) = 1.81, $p = .404$).

Tab. 10: Descriptive and inferential statistics for criterion-related validity with regards to age group, playing status, future youth national team players and the explorative analysis of playing position[#]

Variables	Decision accuracy score	Descriptive statistics ($M \pm SD$)			Effect size: Kruskal-Wallis-test	Post-Hoc Analysis/ Mann-Whitney U-test		
Age group		U16	U17	U19		U16 vs. U17	U16 vs. U19	U17 vs. U19
		(N=41)	(N=55)	(N=44)				
					ω		Φ	
	SC_{bu}	66 ± 14	73 ± 14	71 ± 18	.50[†]	.24*	.41*	.00
	SC_{off}	63 ± 11	74 ± 13	75 ± 14	1.78*	.32**	.46**	.00
Playing status		FTRP	RP			FTRP vs. RP		
		(N=70)	(N=68)					
						Φ		
	SC_{bu}	74 ± 13	67 ± 17			.21**		
	SC_{off}	73 ± 13	69 ± 15			.14*		
Youth national team		Drafted	Non-drafted			Drafted vs. Non-drafted		
		(N=16)	(N=70)					
						Φ		
	SC_{bu}	73 ± 11	65 ± 16			.20*		
	SC_{off}	69 ± 11	66 ± 13			.08		
Playing position		DF	MF	FW		DF vs. MF	DF vs. FW	MF vs. FW
		(N=55)	(N=61)	(N=24)				
					ω		Φ	
	SC_{bu}	71 ± 16	72 ± 13	63 ± 17	.44[†]	.00	.21	.25*
	SC_{off}	70 ± 16	73 ± 13	69 ± 9	.15	.07	.07	.15

Note: **p < .01, *p < .05; [†] p< .10, FTRP = First team regular player; RP = Reserve player; DF = Defenders, MF = Midfielders, FW = Forwards

Discussion

The aim of this study was to develop a reliable and valid video-based decision-making diagnostic which presented footage from a first-person perspective and incorporated soccer-specific perceptual-coupling movements. In particular, the diagnostic was developed as a measure to discriminate decision-making competence within a high performing youth group. Results showed the diagnostic, which included realistic soccer video-scenes, is a suitable

instrument for discriminating age and playing status. A further aim was to examine the predictive value of the new video-based decision-making diagnostic, with the findings indicating a trend for future youth national team players to be better decision-makers. Finally, when considering playing position, midfielders performed better than defenders or forwards, with the results indicating there is a trend for participants from specific playing positions to perform better in their respective categories on the diagnostic.

This study advances the current sport-based decision-making literature by demonstrating the ability to develop a decision-making diagnostic which couples the sport-specific visual perception of in-game video-scenes (i.e., first person perspective) with sport-specific movement response. Traditional video-based instruments which assess decision-making performance generally present footage from a broadcast (i.e., Television broadcast) or third person perspective coupled with non-sport specific decision response methods such as written, verbal or button responses. However, it has been suggested the lack of sport-specific responses may limit the correlation between video-based perceptual cognitive tests and actual in-game decision-making performance (e.g., van Maarseveen et al., 2016). This is further supported by Travassos et al. (2013) who indicated perceptual-cognitive assessments need to consider the task representativeness when developing sport-specific diagnostics. By developing assessments, which consider representative task constraints, such as presenting decision-making situations from a first person perspective, coupled with a sport-specific response, enhances the validity of the assessment measure and data (Travassos et al., 2013).

Using reliable diagnostics instruments is fundamental to scientific work. The implications associated with using a diagnostic instrument with a lack of, or unknown, reliability is whether the participant performance differences are due to random test error or actual performance changes of the participants (Gadotti, Vieira & Magee, 2006). In comparison to the assessment of manifest variables (e.g., time, height, distance), the measurement of latent

variables such as decision-making competence poses a much larger challenge. Therefore, it is essential the measures used to assess latent variables have established reliability. For the current study, results indicated a satisfactory value for SC_{bu} and slightly lower for SC_{off}, when assessing the separate performance aspects of the diagnostic. Overall, this represents an adequate level of reliability for the video-based diagnostics. By establishing the reliability of 60 decision-making situations in this study, future investigations assessing soccer players' decision-making ability, using a perception-action coupling diagnostic can use these clips and protocol to reliably and accurately monitor decision-making performance changes.

To assess the diagnostic validity of the decision-making test, analysis was conducted across three different age groups (i.e., U16; U17; U19) within the academy. The finding was consistent with previous studies which have demonstrated incremental improvement in performance with age (e.g., Höner, 2005). However, it should be noted only the U16 group demonstrated significantly lower decision-making accuracy when compared with the older age groups. A possible explanation as to why there was no significant difference between the U17 and U19 players could be due to two possible reasons. From the perspective of the U19 team, the best players from the squad had already played for the senior professional team (i.e., in either the first or reserve/second team) and therefore were not able to participate in the investigation. In relation to the U17 group, two of the three U17 cohort squads in this study were very successful and participated in the finals of the German U17 championship (i.e., the highest level of competition at this age). Therefore, it could be safe to assume that despite the age difference with respect to U19 group, both groups were of a very similar performance level. This finding supports other studies to investigate age-related soccer-specific performance skill differences. For example, Borgmann, Fiedler, Lanwehr, Kraus and Mayer (2016) revealed in the Vienna Determination Test, which measures inhibition and

cognitive flexibility, only significant differences between U19 and U17 players in comparison to U15 players. However, there were no differences between U19 and U17 age groups. Furthermore, Huijgen, Elferink-Gemser, Post and Visscher (2010) highlighted no improvements from ages 16 to 19 in dribbling and sprinting, which the authors attributed to the end of the puberty. At this stage, further research is needed to explore whether there are peak developmental phases for cognitive factors. While the current study demonstrated the ability to differentiate U16 and older adolescent athletes (i.e., U17 and U19), developing a decision-making diagnostic sensitive enough to differentiate performance of high-performing late adolescent athletes (i.e., U17 and U19) requires further investigation.

A strength of this study is the sample consisted of participants from one of the most successful youth soccer academies in Germany, thus resulting in a very high-level homogeneous group. This is not a common approach used by researchers investigating soccer-specific decision-making skills as they have generally conducted cross-sectional studies comparing and identifying skill differences between groups of elite and non-elite participants (i.e., sub-elite; intermediate; novice participants; Diaz del Campo et al., 2011; Roca et al., 2012). Therefore, while the findings of the current study indicated only a slightly significant result for discriminating playing status, the possible reason for this may be attributed to the high sensitivity when comparing athletes within a high-skilled group. This supports previous findings by van Maarseveen et al. (2016) who also failed to detect significant differences in perceptual-cognitive skills between talented female soccer players of a comparable highly skilled level (i.e., national soccer talent team). Nevertheless, the logistic regression models demonstrated that players with good decision accuracy on the diagnostic will have a higher probability of being a first team regular player (SC_{bu}: OR = 1.65; see Fig. 8). Therefore, providing initial evidence of the potential benefit associated with the use of this new diagnostic to potentially identify more skilled individuals within a homogenous youth group.

A further aim of the study was to determine the prognostic validity of new decision-making test by understanding the ability of the instrument to predict future soccer success. While previous studies have aimed to predict future selection using a video-based test (O' Connor et al., 2016), the current study extended the literature by using the novel approach of incorporating perception-action coupling within the assessment measures to predict future success. Further, in comparison to other previous investigations which only assessed performance using a cross-sectional design, the current investigation implemented a longitudinal design, to allow for a greater understanding of potential future soccer success. The logistic regression model for SC_{bu} indicated that players who performed well on the assessment improved the chance of being drafted (i.e., selected to participate in a German youth national team training course) by a factor of 1.89. The probability curve (Fig. 8) increased more rapidly for higher SCbu values and therefore results proved the diagnostics prognostic relevance for participants who perform better on the assessment are also more likely to be drafted. This finding supports other video-based research which has demonstrated the ability to predict selection into high performing youth soccer programs (O' Connor et al., 2016). This indicates the possibility for a perception-action coupling video-based diagnostic to be used within talent identification process to assist with the assessment of players' decision-making performance. While the non-parametric analysis demonstrated only small significant effect sizes for SC_{bu} and even failed to identify a significant difference for SC_{off} between drafted and non-drafted future youth national team players, this finding may have been limited by the relatively low number of participants selected into national youth programs (n = 16). Therefore, future research should consider increasing the number of national youth players in the sample to fully understand the potential decision-making skill differences between these high performing players (i.e., drafted; non-drafted for youth national team; Ackerman, 2014).

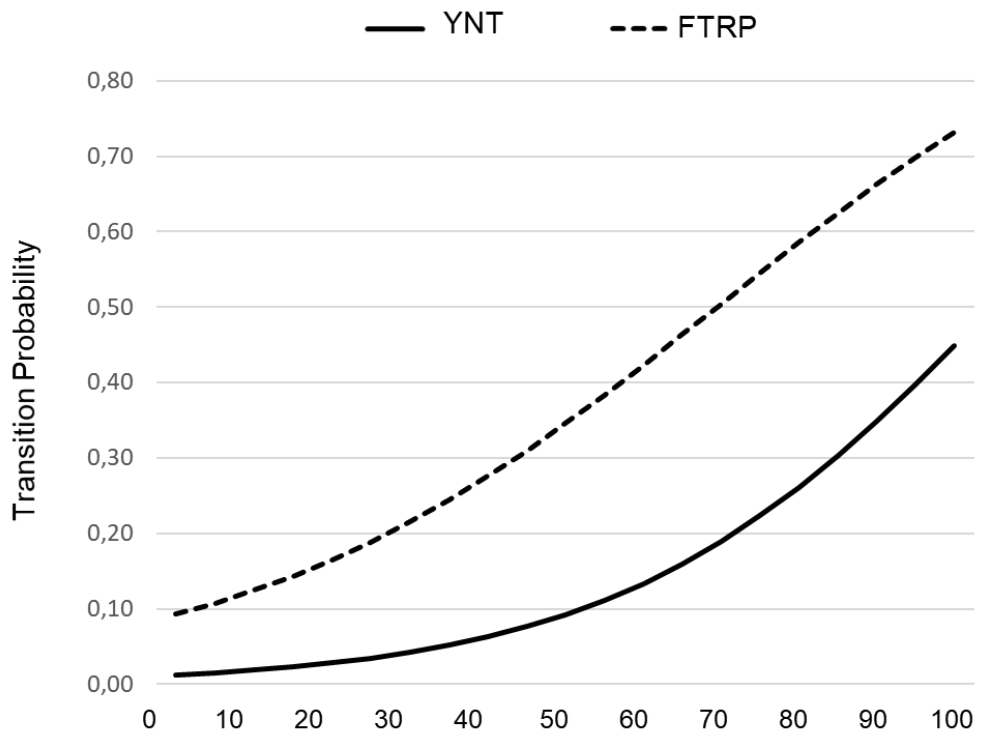

Fig. 8: Selection probabilities obtained from the logistic regression for reaching FTRP and YNT status depending on the significant SCbu[#]

The present study extended the current research knowledge related decision-making assessments by developing a diagnostic which incorporated decision situations from defense, midfield and forward scenarios. However, while it was explored whether there would be differences based on playing positions, the findings only indicated a trend for midfielders to demonstrate higher decision-making performance levels. This outcome reflects, to some extent, the results of previous investigations relating to decision-making performance differences between playing positions (e.g., Höner, 2005). In the current study there was a trend for better performances by defenders and midfielders in comparison to forwards. This reflects the build-up game situations these two positions are more involved in during actual games. Despite the lack of significant differences between playing positions, the novel approach used by the current study may enable more detailed comparisons between playing positions in future. Future research should divide playing positions in a stricter manner, for instance when considering the position of a forward, there exists differences between central

forwards and wide forwards (i.e., wingers). Another possible reason for why finding non-significant differences, is the potential influence of common tactical game facets which is incorporated into youth training programs during the players developing years. While this study was unable to demonstrate a significant difference between positions, this study provides a first insight about the potential influence of playing position on the decision-making performance of high-performing youth soccer players.

As this is one of the first studies to develop a decision-making diagnostic which couples sport-specific perception and action in the assessment, the findings should be considered with respect to several limitations. First, the execution-time of decision-making was not measured directly. It was only restricted by the length of the video scenes and a marked limiting line. In current literature, there are different opinions about the importance of execution time with respect to decision-making. Vaeyens, Lenoir, Williams, Mazyn and Philippaerts (2007) emphasized that experienced players make quicker and more accurate decisions compared to less skilled player. However, there are other assertions that experts admittedly decide faster than non-experts, but waited longer in their execution (Schorer, 2007). In context with a diagnostic using perceptual-action coupling it is of interest whether highly skilled players decide faster than less skilled players and if they are also faster in their execution or if they wait for the perfect moment to execute the appropriate response. Therefore, a further development of the diagnostics could include the measurement of execution-time. Second, the current sample was limited by the restrictions of testing within a professional sporting club environment. As such, several high performing U19 athletes were not included in the sample due to professional club commitments. As a result, it may be possible the lack of significant differences between U17 and U19 players may not fully describe the potential age related differences between these two groups. Therefore, future investigations should aim to sample all athletes from within an age group, to ensure a true representation of the

performance group. Finally, this study only assessed the performance of on-ball decision-making situations where players had to decide on the best passing option. Future studies should also consider the development of diagnostics which include other decision-making options, such as shooting and dribbling. Further, off-the-ball decision-making, such as offensive or defensive positioning or support play, which has not been assessed in the literature, should also be considered.

Conclusion

Sport-based decision-making is a cognitive process in which athletes use their knowledge about a (current) situation to select an appropriate decision based on their perceived ability to execute a sport-specific motor skill response (Causer & Ford, 2014). While the decision-making is defined by the ability to perceive appropriate stimuli and execute a sport-specific skill response, traditional diagnostic instruments used to examine decision-making, such as video-based tests, prompt non-sport specific responses such as verbal, written or button responses (e.g., Roca et al., 2012). This study addressed this limitation by developing a reliable and valid video-based diagnostic, which couples perception and action by presents video situations from a first-person perspective, which require sport-specific skill responses (i.e., passing to a player in the video). The results indicate the video-based decision-making diagnostic can discriminate decision-making competence within a high performing youth group, in particular, age and playing status. Further, trends associated with national youth team participation demonstrate the potential predictive value of the new video-based decision-making diagnostic. Therefore, this study provides initial evidence to suggest a perception-action coupling video-based diagnostic can be used within talent identification process to assist with the assessment of players' decision-making performance. Finally, future decision-making assessment studies can also use similar procedures to those employed in the

current investigation to develop a valid and reliable video-based decision-making diagnostic in other sports/domains.

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3.2.2 Relevance of Motor Talent Predictors in Elite Girls' Soccer: A Five-year Prospective Cohort Study within the German Talent Development Program

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Abstract

While recent research has provided valuable information about talent predictors, there is a gap regarding female youth soccer. This study analyzed the prognostic relevance of technical skills and speed abilities for future success in female soccer and assessed the role of sex as a moderator variable.

Within the German talent identification and development program, N = 499 U12 girls participated in motor diagnostics (sprint, agility, dribbling, ball control, shooting). Five years later, 14.2% of these girls made the youth national team [NT], 18.8% the regional association team [RA], and 66.9% were not further selected [NS]. The tests' predictive validity for achieving one of these levels was analyzed using ANOVAs with post-hoc tests and logistic regressions.

Participants' performances in the motor diagnostics significantly discriminated between all three selection levels. Future NT outperformed NS (d = 1.04) and RA players (d = 0.55), who, in turn, outperformed NS players (d = 0.47). Nearly all motor tests demonstrated predictive validity independent of sex. Only the prognostic relevance of dribbling was notably larger for girls than boys. Thereby, the dribbling test was most helpful for identifying the female NT players.

Although diagnostics are not sensitive enough to determine individual decisions for talent selection, motor test results provide objective information that can supplement coaches' daily work.

Keywords: Female youth football, motor tests, predictive validity, speed abilities, talent diagnostics, technical skills

Introduction

Only approximately 0.3% of all registered soccer players ultimately play for professional clubs (Kunz, 2007). Thus, talent identification and development (TID) programs in soccer are faced with the meaningful *challenge of selecting the most talented individuals* from millions of available players for further promotion within their systems. Furthermore, the selection typically occurs at an early age and often before individuals even reach adolescence. Moreover, the requirements for professional soccer players are complex (Unnithan et al., 2012) and include a multidimensional spectrum of potentially relevant aspects (i.e., physical, psychological, physiological, and environmental dimensions; Williams & Reilly, 2000) that need to be considered in the TID process.

Given the complexity of talent selection, players' potential for future success has traditionally been evaluated holistically and subjectively by experienced youth coaches (Christensen, 2009). To provide a more comprehensive evaluation of players, there has been a recent trend to complement this subjective selection practice with more objective measurements and many soccer TID programs have implemented diagnostics that measure a variety of talent predictors (Unnithan et al., 2012; Vaeyens et al., 2008). In the literature it is particularly youth players' motor performance that has received meaningful consideration, and multiple researchers have investigated the *prognostic relevance of motor talent predictors* (Elferink-Gemser & Visscher, 2012; Gonaus & Müller, 2012). In those studies, several results have been revealed in terms of predictive validity of factors such as endurance, sprint, agility, strength, flexibility, and dribbling. For example, Höner and Votteler (2016) used a prospective cohort design to examine the prognostic relevance of speed abilities (i.e., sprint and agility) and soccer specific-technical skills (i.e., dribbling, ball control, and shooting) for youth players within the German Soccer Association's (Deutscher Fußball-Bund) TID program. More specifically, the motor performance of 22,843 male players from the age group

Under-12 (U12) was assessed and, subsequently, used to significantly distinguish U16-U19 players with respect to four selection levels in middle-to-late adolescence (i.e., youth national team [NT], regional association [RA], youth academy, and non-selected [NS]).

One core issue concerning talent prognosis based on motor predictors is that empirical findings are meaningfully influenced by the methodological design features (e.g., development stage, sample size) of the respective research (Murr et al., 2018b). Participants' *biological sex may represent such an important moderator variable* for the empirical evidence of talent predictors. For example, sex-based differences in maturation (e.g., girls are younger than boys at peak height velocity; Granados, Gebremariam & Lee, 2015), socialization (e.g., adolescent girls show relatively less engagement in sports than boys; Kausmann, Vogel, Hagen & Simonson, 2017), or the TID selection process (i.e., fewer girls compete for positions on the NT; DFB, 2017b) may influence the prognostic relevance of motor predictors. This assumption is supported by Williams and Reilly (2000) in their fundamental narrative review on TID in soccer, who stated that "it is by no means clear that conclusions about young talented male players can be generalized to females" and that it is important "that research into talent identification and development is extended to address issues related to young female soccer players" (p. 664).

Over the last two decades, researchers have provided a variety of new insights to TID across different sports (e.g., Mann et al., 2017). However, Johnston et al. (2018) concluded in their recent systematic review of talent identification in sport that there is an *overrepresentation of studies with male samples* and, therefore, argued for greater diversity in TID research. Moreover, soccer-specific systematic reviews indicated, that there are no prognostic studies investigating physiological characteristics (Murr et al., 2018b) or psychomotor skills (Murr et al., 2018, accepted) of female athletes. The limited number of studies in which researchers

have examined motor characteristics of female soccer players have predominantly been conducted utilizing cross-sectional designs. That is, researchers either descriptively reported the abilities of elite athletes (e.g., Jensen & Larsson, 1992; Tumilty & Darby, 1992) or compared the motor performance of different individuals based on age groups, competitive levels, or playing positions (e.g., Manson, Brughelli & Harris, 2014; Vescovi, Brown & Murray, 2006; Vescovi, Rupf, Brown & Marques, 2011). Despite the value of such studies, their implications for TID are limited as they offer insufficient insight into the predictive validity of diagnostics. More specifically, the existing research cannot provide sound insight about valid motor indicators that could support TID programs in identifying the female players who have the highest potential for future success.

The present study

The lack of prospective studies in female soccer TID research is surprising given the growing interest in female soccer in recent decades (Gledhill & Harwood, 2015; UEFA, 2015). For example, in Germany, there are over 1.1 million female soccer players, which includes approximately 339,000 girls below the age of 16 (DFB, 2017b). The present study was conducted within the DFB's TID program. Every year over 14,000 youth players in the age groups U12 to U15 are selected for this TID program and get promoted in one of the 366 regional training centers (see Höner et al., 2015). In 2016, this also included over 900 of the most talented young female players in Germany. To monitor individuals' motor development, all TID players participate in biannual diagnostics assessing speed abilities and technical skills.

Methods

The purpose of the current research was to provide empirical insights into the *prognostic relevance of these motor predictors* for future success in female soccer over a five-year period (from U12 to U17). This was done by exploring mean differences in players' motor

performances based on different future selection levels (providing information about the diagnostics' prognostic relevance at the group level) and by estimating players' individual selection probabilities relative to their test scores (providing information about the diagnostics' prognostic relevance at the individual level). Furthermore, the data from male TID players (Höner & Votteler, 2016) was reanalyzed to address *sex as a potential moderator variable* regarding the prognostic relevance of motor predictors.

Participants

The *study sample* consisted of N = 499 female U12 players from the German TID program who were born between 1993 and 1998 (M = 11.4 years old; SD = 0.3) and who participated in the motor diagnostics between 2004 and 2009. On average, these girls were 148.5 (± 6.6) cm tall and weighed 38.5 (± 6.0) kg. All players' parents provided informed consent for the collection and scientific use of the data. In addition, this research was approved by the ethics committee of the Faculty of Economics and Social Sciences at the University of Tübingen and the scientific board of the DFB.

Design and measures

In German soccer, the nationwide TID program starts with the age group U12. U17 represents the oldest age group in female youth soccer before players' transition to the adult level. Using a *five-year prospective cohort study design*, this study assessed the girls' motor performance at U12 to predict their future success in terms of the achieved selection level at U17.

The motor diagnostics consisted of five motor tests assessing players' performance in sprint (time for a 20-meter linear 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 (eight shots at different target fields rated for precision and speed by the coach). These *motor predictors* were all negatively coded (i.e., less time and fewer points indicate better

performance). Based on all tests, a positively coded motor score was calculated. Except for shooting (α = .41 and r_{tt} = .31), each test (.68 ≤ α ≤ .95 and .50 ≤ r_{tt} ≤ .76) as well as the score (α = .89 and r_{tt} = .74) demonstrated sufficient internal consistencies and test-retest reliabilities (for details see Höner et al., 2015).

Players' future success at U17 was operationalized as *criterion* by three selection levels. Analysis of rosters for the U17 of the German NT and the 21 RAs in Germany for the years 2008-2016 revealed that the current sample included 71 players who reached the NT (14.2%), 94 players who made the RA (18.8%), and 334 players who were not selected further (66.9%). Regarding the motor score, a two-way ANOVA revealed a non-significant interaction between the selection levels and the examined cohorts (F(10; 481) = 1.22, p = .27), thus the cohort variable was not further considered as a confounding variable in the following procedures.

To enable comparisons between female and male players, it was imperative to control for potential features in the research design other than sex (e.g., the motor tests, players' developmental phase and performance level). Therefore, reanalyzed data from a recent study (Höner & Votteler, 2016) was chosen as the point of comparison. This limits the potential influence of other moderator variables, since Höner and Votteler's (2016) sample comprised male U12 players from the German TID program (birth cohorts 1993 – 1997) and used the same test battery and procedures. The N = 22,843 boys were 11.4 (± 0.3) years old, 148.5 (± 6.7) cm tall, and weighed 38.0 (± 5.7) kg, which are similar characteristics to the female sample from the current study (t_{age}(23340) = 0, p > .99; t_{height}(23340) = 0, p > .99; t_{weight}(23340) = -1.94, p = .05). Furthermore, it was deemed appropriate to compare female U12 players born between 1993 and 1998 with male U12 players born between 1993 and 1997, because Höner and Votteler (2016) did not find any cohort effect. As part of the reanalysis, the four selection levels (i.e., NT, RA, youth academy, and NS) investigated in that

recent study were recoded to match the current research's criterion variable (i.e., NT, RA, and NS). All boys who did not achieve at least the RA level were considered as NS.

Data analysis

Data were analyzed using SPSS version 25. One-way ANOVAs were conducted to analyze the *prognostic relevance of motor predictors* for female youth soccer players. The single test performances and overall score were utilized as dependent variables in order to determine the significance of mean differences between participants based on their future selection levels (i.e., NT, RA, and NS). Subsequently, post-hoc tests were computed and differences between players based on the three future selection levels were classified by effect sizes (η^2, Cohen's *d*). To compare effect sizes for girls in the present study with those calculated for boys, the effect sizes reported by Höner and Votteler (2016) were recomputed according to the three recoded selection levels. To investigate the significance of the *moderator variable sex,* the 95% confidence intervals [CIs] of the effect sizes for the female sample were utilized.

In addition, multinomial logistic regressions were computed to determine players' *individual selection probabilities* for NT and RA based on their respective motor performance score at U12. This was done separately for two models: (1) comparing players who reached the NT to participants who made the RA or were not further selected (i.e., NT vs. RA/NS) and (2) comparing those who reached at least the RA level to NS players (i.e., NT/RA vs. NS). The overall model fit was analyzed with the likelihood ratio chi-squared test. Regression coefficients and the odds ratio coefficients e^{β} (including their 95% CI) were calculated with reference to RA and NS players in model 1 and NS players in model 2. The score's regression coefficients were used to calculate participants' statistical transition probabilities for reaching higher selection levels. Additionally, to enhance the applied value of the current findings, score results were transformed into percentile ranks (PRs) and thresholds were defined for

participants with “average” and “top” performances (PR50 and PR90, respectively). Subsequently, the score values corresponding to these thresholds were used to estimate the selection probabilities for reaching the NT or RA level. Furthermore, the relative chances (odds ratios, [ORs]) of being selected for a higher selection level were investigated by comparing the chances for players with better and worse score results than the defined thresholds.

Results

Prognostic relevance of motor talent predictors

Descriptive and ANOVA statistics for all motor talent predictors indicated that girls who reached the NT at U17 performed better at U12 than girls who made it to the RA level or were not further selected (see Fig. 9). Similarly, future RA players outperformed individuals who were not further selected. Except for the predictor shooting (F (2; 496) = 2.31, p = .10), one-way ANOVAs revealed significant mean differences across all variables between participants’ motor performance at U12 based on their future selection level at U17 (each $p <$ .001). Whereas small effect sizes were found for sprint, agility and ball control ($.04 \leq \eta^2 \leq .05$), medium effect sizes could be detected for dribbling ($\eta^2 = .10$) and the overall score ($\eta^2 = .12$).

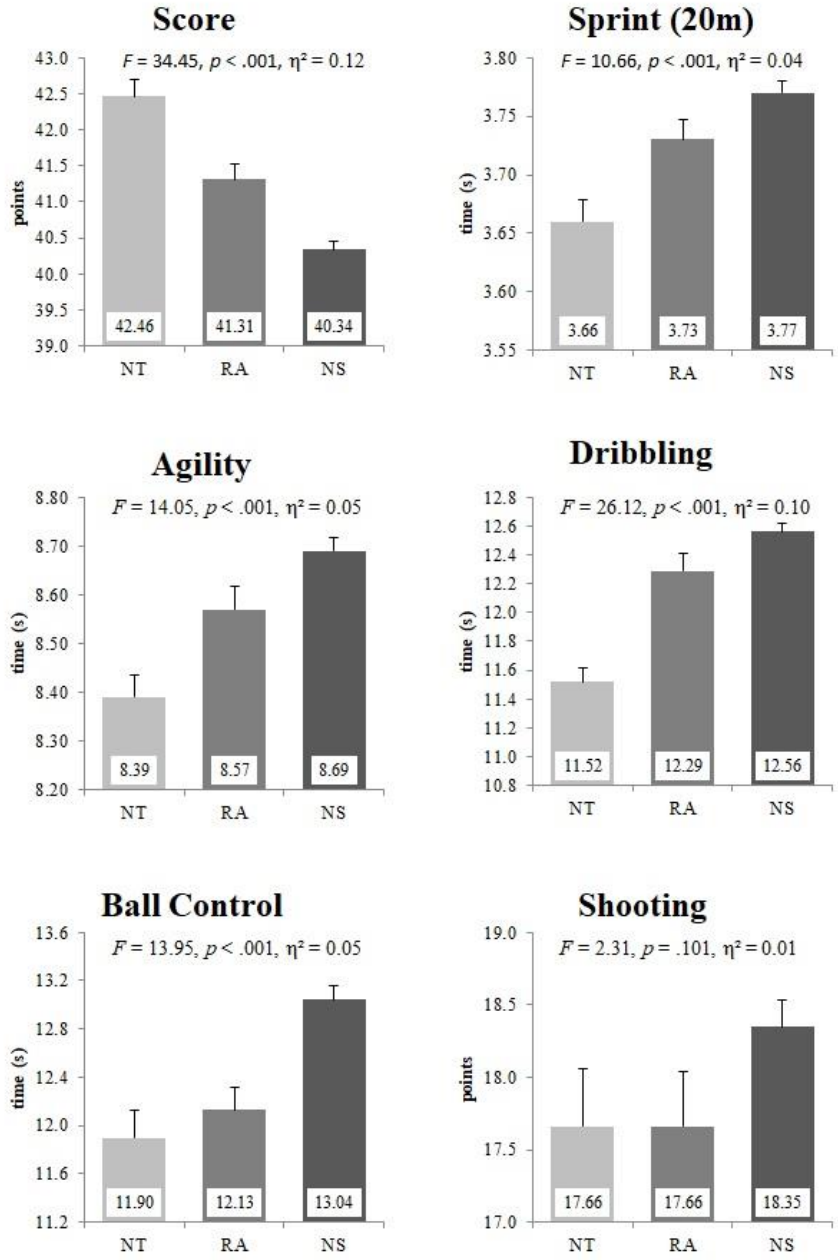

Fig. 9: Descriptive and ANOVA statistics for all motor talent predictors at U12 between girls who reached the NT at U17, who made it to the RA level or were not further selected[#]

Table 1 provides the results for the post-hoc multiple group comparisons. The motor score significantly discriminated between participants from all three selection levels, respectively (i.e., NT vs. RA, NT vs. NS, and RA vs. NS; $p < .001$). Regarding the individual motor predictors, there were significant mean differences in all measured variables (except for shooting) between NT and NS players. Effect sizes for these significant mean differences

ranged from $d = 0.55$ for ball control to $d = 0.95$ for dribbling ($p < .001$). When comparing the motor performance of NT and RA players, sprint ($d = 0.41$; $p < .05$), agility ($d = 0.42$; $p < .05$), and foremost dribbling ($d = 0.76$; $p < .001$) were sensitive enough to significantly discriminate between the respective selection levels. Similarly, a significant difference between RA and NS players was found for agility ($d = 0.27$; $p < .05$), dribbling ($d = 0.23$; $p < .05$), and ball control ($d = 0.45$; $p < .001$).

Tab. 11: Sample sizes and multiple group comparisons for the U12 motor diagnostics of female and male players separated by selection level in middle-to-late adolescence[#]

Sample	Performance Variables	Future selection levels within examined sample[†]				Post-hoc Analyses		
		Total	NT	RA	NS	NT vs. NS	NT vs. RA	RA vs. NS
		M ± SD (n)				d [CI 95%][#]		
Females	Score (points)	40.83 ± 2.19 (499)	42.46 ± 2.06 (71)	41.31 ± 2.12 (94)	40.34 ± 2.04 (334)	1.04*** [0.77; 1.30]	0.55** [0.24; 0.86]	0.47*** [0.24; 0.70]
	Sprint (s)	3.75 ± 0.19 (499)	3.66 ± 0.17 (71)	3.73 ± 0.17 (94)	3.77 ± 0.19 (334)	0.58*** [0.33; 0.85]	0.41* [0.10; 0.72]	0.21 [-0.01; 0.45]
	Agility (s)	8.63 ± 0.47 (499)	8.39 ± 0.38 (71)	8.57 ± 0.46 (94)	8.69 ± 0.47 (334)	0.67*** [0.40; 0.92]	0.42* [0.11; 0.73]	0.27* [0.03; 0.49]
	Dribbling (s)	12.36 ± 1.17 (499)	11.52 ± 0.79 (71)	12.29 ± 1.17 (94)	12.56 ± 1.15 (334)	0.95*** [0.69; 1.21]	0.76*** [0.43; 1.07]	0.23* [0.01; 0.46]
	Ball Control (s)	12.17 ± 2.08 (499)	11.90 ± 1.93 (71)	12.13 ± 1.85 (94)	13.04 ± 2.09 (334)	0.55*** [0.29; 0.81]	0.12 [-0.19; 0.43]	0.45*** [0.22; 0.68]
	Shooting (points)	18.12 ± 3.37 (499)	17.66 ± 3.37 (71)	17.66 ± 3.69 (94)	18.35 ± 3.26 (334)	0.21 [-0.05; 0.47]	0.00 [-0.31; 0.31]	0.20 [-0.02; 0.44]
Males	Score (points)	41.96 ± 2.04 (19,638)	43.70 ± 2.08 (178)	43.11 ± 2.03 (655)	41.90 ± 2.04 (18,805)	0.88***	0.29***	0.59***
	Sprint (s)	3.70 ± 0.18 (22,026)	3.58 ± 0.17 (190)	3.64 ± 0.17 (710)	3.70 ± 0.18 (21,126)	0.67***	0.35***	0.33***
	Agility (s)	8.55 ± 0.46 (21,893)	8.35 ± 0.43 (189)	8.45 ± 0.43 (706)	8.55 ± 0.46 (20,998)	0.44***	0.23***	0.22***
	Dribbling (s)	11.80 ± 1.01 (21,894)	11.18 ± 0.87 (190)	11.38 ± 0.88 (706)	11.82 ± 1.02 (20,998)	0.63***	0.23**	0.43***
	Ball Control (s)	11.83 ± 1.79 (21,332)	10.84 ± 1.46 (186)	10.99 ± 1.49 (699)	11.87 ± 1.78 (20,447)	0.58***	0.10	0.50***
	Shooting (points)	17.74 ± 3.69 (21,371)	16.71 ± 4.10 (188)	16.76 ± 3.80 (693)	17.78 ± 3.68 (20,490)	0.29***	0.01	0.28***

Note. * = $p < .05$, ** = $p < .01$, *** = $p < .001$, NT = Youth national team, RA = Regional association team, NS = Not selected. For the sprint, agility, dribbling, ball control and shooting tests, lower results indicate better performance; [†]To enable adequate comparisons between the present study's data for female players and the data analyzed by Höner & Votteler (2016), the selection levels within the boys' sample (i.e., NT, RA, youth academy, and NS) were recoded to match the current study's criterion variable (i.e., NT, RA, and NS). All boys who did not achieve at least the RA level were captured in one group as NS. [#]In order to compare the effect sizes between female and male athletes, 95% CIs for effect sizes for the female athletes were utilized to investigate whether these cover the effect sizes detected in the male sample by Höner and Votteler (2016).

The respective effect sizes for the male study sample are presented in the lower part of Tab. 11. With one exception, the 95% CI for the effect sizes of the female sample covered the values of the effect sizes for boys. Only for dribbling, the effect sizes fell below the lower thresholds of the 95% CIs of the girls' sample (i.e., 0.69 and 0.43 respectively), thus, suggesting that the prognostic validity for discriminating future NT players from NS (d = 0.63) and from RA players (d = 0.23) was significantly larger for girls than for boys.

Individual selection probabilities based on score results

The coefficients, estimated selection probabilities, and ORs for being selected with respect to the two logistic regression models are shown in Tab. 12. For both investigated models the overall fit was significantly better compared to the null model: (1) NT vs. RA/NS (χ^2 (1) = 49.47, $p < .001$) and (2) NT/RA vs. NS (χ^2 (1) = 52.69, $p < .001$). The coefficients e^{β} from the logistic regression models indicated that a one standard deviation (SD_{Score} = 2.19) increase in score performance improved players' likelihood of being selected for the NT by a factor of 2.72 (= $1.58^{2.19}$) and for at least reaching the RA by a factor of 2.12 (= $1.41^{2.19}$). The corresponding 95% CI provided evidence for the significance of the ORs.

The analysis of the ORs at the PR50 and PR90 score thresholds, which were used to discriminate between the dummy coded score groups, showed that the highest relative chances of being selected were found for NT players when compared to RA/NS players (model 1). For example, the value $OR_{PR>90}$ = 4.95 indicated that U12 players belonging to the best 10% of their age group regarding score performance were almost five times more likely to reach the NT than the remaining 90% of players.

Tab. 12: Logistic regression coefficients, estimated selection probabilities and odds ratios (ORs) based on the dummy-coded prediction variable score dichotomized at PR50 and PR90[#]

Selection level	Logistic regression coefficients			Estimated selection probabilities		ORs for being selected (group A vs. group B)	
	constant	b	e^{β} [95%-CI]	P(PR50)	P(PR90)	$OR_{PR>50}$	$OR_{PR>90}$
NT	-20.829	0.458	1.58 [1.37; 1.82]	0.11	0.31	5.48	4.95
NT or RA	-14.849	0.344	1.41 [1.28; 1.56]	0.32	0.55	3.13	4.66

Note. NT = Youth national team, RA = Regional association team.

The curves of the individual selection probabilities based on the U12 score performance are displayed in Fig. 10. By definition, the probability of being selected for at least the RA (i.e., NT and RA combined) was higher than the likelihood of making the NT. With an average test result for score (i.e., PR50), the estimated probabilities (i.e., 11% for NT and 32% for at least RA) closely resembled the actual selection rates within the examined sample (14.2% and 33%, respectively). Also, the selection probabilities increased with an improvement in score values, confirming the prognostic validity of the motor diagnostics. For example, a girl who performed better than 90% of her peers at U12 (i.e., score value at PR90) had a distinctly higher probability of being selected (i.e., the chance of being selected at the U17 age group would be 31% for NT and 55% for at least the RA level).

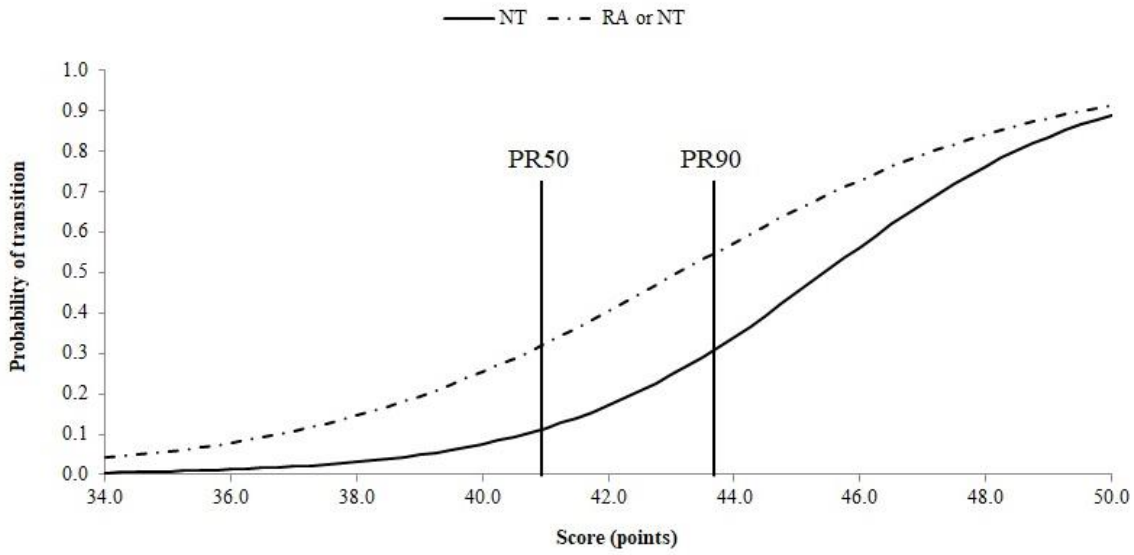

Fig. 10: The curves of the individual selection probabilities based on the U12 score performance[#]

Discussion

Recently, there have been several large-scale prospective studies in which researchers have provided valuable information with respect to the prognostic relevance of potential talent predictors (Mann et al., 2017; Sarmento et al., 2018). However, there is a meaningful gap in the literature with respect to female sport in general (Johnston et al., 2018), and researchers have yet to explore the prognostic relevance of motor predictors with female soccer players in particular (Murr et al., 2018b). Accordingly, the present results provide initial insights to this prognostic relevance from the beginning (U12) to the end (U17) of the development process within a nationwide female soccer TID program. Overall, despite a large sample size and sufficient statistical power, the results for the shooting test revealed no significant insights. Therefore, in addition to the comprehensive motor score, further discussion of the results is focused on the speed abilities sprint and agility as well as the technical skills dribbling and ball control.

The *group-based comparisons* demonstrated the prognostic validity of the motor diagnostics for girls' future performance level. More specifically, participants' performances in the motor score were significantly associated with all three future selection levels. Future NT

players outperformed those who were selected for the RA, who, in turn, outperformed NS players (each by approximately half a standard deviation). As a result, the diagnostics can provide relevant information for coaches that can help them in their selection of players within a TID program.

Further interpretation of the results must consider that the current study comprised a preselected sample (players chosen for the TID program), which limits the variance of the investigated variables and, accordingly, the expected statistical effect sizes ("restriction of range of talent"; Ackerman, 2014). Therefore, effect sizes from studies with different “ranges of talent” (i.e., samples with considerably more or less variability in relevant variables) are difficult to compare. Moreover, previous research that has explored the role of motor predictors within female TID programs was not conducted in soccer. Instead, recent studies in female athletics were primarily conducted in individual sports, such as gymnastics (e.g., Pion, Lenoir, Vandorpe & Segers, 2015; Vandorpe et al., 2012) and, thus, likely provide inadequate information for the TID process in soccer due to the unique demands of those sports. There are a few exceptions in which researchers have explored the prognostic relevance of motor performance in sports that are more comparable to soccer. For example, Lidor et al. (2005) examined the predictive value of motor performance factors sprint, agility and dribbling for 12-13 years old female handball players who were either selected or not selected for the NT two years later. They only found significant differences between the two groups' dribbling skills. Similarly, in their longitudinal study, Elferink-Gemser, Visscher, Lemmink and Mulder (2007) indicated that elite female hockey players (12-16 years old) performed better on technical skills (i.e., slalom dribbling) than their sub-elite counterparts. In contrast, no significant difference was found for participants’ speed abilities (i.e. linear

sprinting and agility). Overall, the results from these studies are in line with the present findings as dribbling represented the most relevant motor predictor (i.e. speed [$.04 \leq \eta^2 \leq .05$] vs. dribbling [$\eta^2 = .10$]).

By applying the same research design as Höner and Votteler (2016), the current study also provides initial insight about the role of *biological sex as a moderator variable*. Overall, the motor diagnostics possesses predictive validity independent of sex. Even within an already selected sample, the future NT girls and boys performed approximately one standard deviation better in the motor score than NS players. Regarding the individual motor tests, the effect sizes found for the male sample generally did not meaningfully deviate from the effect sizes reported in the present study. However, there was one striking exception as the prognostic relevance of players' dribbling skills was notably larger for girls than boys. This was particularly evident for the discrimination between future NT and RA players ($d = 0.76$). The discriminative power between RA and NS players was considerably lower ($d = 0.23$) and, therefore, the dribbling test appears to be especially valid for the selection of the most talented female players and less for the deselection process. These findings might serve as a suggestion for female soccer TID programs, in that they may want to emphasize the development of dribbling in order to reduce the variability in this skill and increase the "density" of talent (for insights regarding a greater variability of physical capacities in female compared to male elite soccer see Cardoso de Araújo, Baumgart, Jansen, Freiwald & Hoppe, 2018). However, due to the lack of prognostic studies in female youth soccer, the current results should be used as an initial insight into the important role of dribbling skills in female youth soccer that needs to be replicated in further research.

Although the group-based results demonstrated predictive validity of the motor diagnostic for future success, the analyses of the *individual selection probabilities* supported the conclusion of other researchers (Emmonds, Till, Jones, Mellis & Pears, 2016; Höner et al.,

2017) who argued that motor diagnostics are not sensitive enough to be used as the sole determining factor in the selection of players. That is, there are several girls in the present study who made the U17 NT despite relatively weak motor performances in U12. In contrast, there were also players who performed well in the diagnostics and ended up not being further selected at U17. Indeed, diagnostics always provide "false negatives" and "false positive" (for a detailed discussion of sensitivity and specificity in TID programs see Höner & Votteler, 2016). Nevertheless, the motor diagnostics for female U12 players revealed to some extent powerful predictions for reaching the NT level. Girls who belonged to the best 10% in the diagnostics (i.e., PR > 90) had nearly five times better chances of becoming a NT player than other female TID players, and nearly every third girl with a PR = 90 achieved the NT level (P[PR90] = 31 %). Based on the results of Höner and Votteler (2016), the relative chance to become a NT was comparable for males ($OR_{PR>90}$ = 4.53), whereas the absolute probability (P[PR90] = 2 %) considerable differed between the girls and boys within the TID program. However, it is noteworthy that the selection rates within the female TID program are higher because a meaningfully larger number of boys are promoted in the TID program, while the available number of roster spots on the NT are equal (for a diagnostic concept considering the selection rate see Taylor & Russell, 1939).

In addition to general information about diagnostics' predictive validity, coaches are often interested in an evidence-based prioritization of the most relevant motor variables. Regarding the *relevance of single motor tests*, the results of the present study are in line with previous studies (Murr et al., 2018, accepted; Schorer et al., 2012), that have found it almost impossible to provide consistent predictions for future success using a fixed ranking of variables, due to the complex nature of performance demands. Even within a clearly defined research design (i.e., focus on speed abilities and technical skills, homogeneous, elite study sample, constant prognostic period from U12 to U17), dribbling (followed by agility) was

by far the most powerful factor in distinguishing between players at the highest selection levels (NT vs. RA players), whereas ball control (followed by agility) was the only powerful predictor in discriminating between the two lower selection levels (RA vs. NS). These findings indicate that the decisive parameters for the selection of players for the next higher level might differ from those for the deselection of players.

Limitations and future directions

This study provides an initial insight into the predictive validity of motor tests regarding future success in female soccer TID programs. Future research must cross-validate these findings. Especially the relevance of shooting skills should be an objective. Although the shooting test revealed the lowest predictive value in this study (see also Höner et al., 2017), this result should not be interpreted to mean that girls' shooting skills are irrelevant for future success. It seems far more appropriate to ascribe the low predictive value to the limited reliability of the shooting test. Several studies have pointed out the problems of assessing shooting skills with reliable measurements (Ali, 2011; Höner et al., 2015; Kurz, Hegele & Munzert, 2018) and it is a relevant challenge for future research to develop scientifically sound assessment for these complex skills.

Another relevant topic in current TID research refers to the validity of the predictor and criterion variables in prospective studies. This study investigated motor tests as predictors that are applied in a nationwide TID program with thousands of players. Therefore, features such as economical test procedures and high standardization in terms of reliable nationwide reference values are important strengths of this motor diagnostics. However, recent TID research has developed more ecologically valid assessments of complex skills in more realistic game situations (e.g., Fenner, Iga & Unnithan, 2016; van Maarseveen, Oudejans & Savelsbergh, 2017). Furthermore, Bergkamp, Niessen, den Hartigh, Frencken und Meijer (2018) argued for a continuous variable quantifying (soccer-specific) performance as

criterion. Although such variables would obviously possess more statistical information, the current study used a categorical variable with three ordered levels. In doing so, the study focused more on future success in youth soccer and not directly on the future performance or playing abilities. However, these different approaches regarding the predictor and criterion variables in TID research should be further examined and compared with each other to identify the corresponding strengths and weaknesses in supporting TID programs.

Finally, it should be mentioned that other relevant variables were not considered in this study. For instance, only chronological age was assessed, but not indicators of maturity such as age of peak height velocity or the percentage of adult height (Lloyd, Oliver, Faigenbaum, Myer & De Ste Croix, 2014). Moreover, this study did not address the intra-individual development of the motor predictors (Leyhr et al., 2018) or the interaction of the motor predictors with other relevant predictors such as personal dispositions (Höner & Feichtinger, 2016) or perceptual-cognitive skills (Forsman et al., 2016; O' Connor et al., 2016; Zuber et al., 2015).

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4. Zusammenfassende Interpretation und Ausblick

Als primäres Ziel verfolgte diese Dissertationsschrift eine kritische Auseinandersetzung mit dem aktuellen Forschungsstand zur Prognoserelevanz von personbezogenen (d. h. physiologischen, anthropometrischen und psychologischen) Talentprädiktoren im Fußball. Dabei standen zwei zentrale Schwerpunkte im Mittelpunkt der Betrachtung: Erstens die systematische Aufarbeitung existierender Studien zur Prognoserelevanz sowie zur empirischen Evidenz einzelner Prädiktoren aus den verschiedenen Merkmalsbereichen und zweitens die Analyse verwendeter Studiendesignmerkmale und deren potentiellen Einfluss auf die prognostische Relevanz.

Aufbauend auf zentralen Erkenntnissen der systematischen Reviews (Murr et al., 2018a; Murr et al., 2018b) war ein dritter Schwerpunkt dieser Arbeit, bisher defizitäre Forschungsbereiche zur Prognoserelevanz personbezogener Talentprädiktoren in zwei Einzelstudien zu erweitern. Hierzu wurde ein fußballspezifisches Diagnostikinstrument zur Entscheidungskompetenz entwickelt und hinsichtlich Reliabilität sowie diagnostischer und prognostischer Validität geprüft. Darüber hinaus wurde die Prognoserelevanz technomotorischer Prädiktoren im Mädchenfußball untersucht, um eine weitere Lücke des Forschungsstandes zu schließen.

4.1 Forschungsstand und empirische Evidenz zur Prognoserelevanz personbezogener Talentprädiktoren

Übergreifend wurden 21 Prognosestudien in die beiden publizierten Reviews eingeschlossenen und deckten jeweils mindestens einen der drei personbezogenen Merkmalsbereiche Physiologie, Anthropometrie, Psychologie ab, wobei jeweils diverse Prädiktoren hinsichtlich ihrer prognostischen Validität geprüft wurden. Angesichts des regen Interesses der Ta-

lentforschung hinsichtlich prognostisch valider Talentprädiktoren, hält sich die Fülle des aktuellen Forschungsstands in Grenzen. Ein wesentlicher Grund dafür ist gewiss das für prospektive Studien notwendige längsschnittliche Design, welches in Anbetracht prognostischer Aussagen eine lange Zeitspanne von Erhebung der Daten bis zur Auswertung der Ergebnisse erfordert.

In den vorliegenden Studien überprüften verschiedene Autoren in 16 Studien[4] die Prognoserelevanz von psychologischen Prädiktoren, wohingegen im Merkmalsspektrum der physiologischen (9) und anthropometrischen (7) Bereiche deutlich weniger Studien aufzufinden waren. Besonders für die anthropometrischen Prädiktoren, die hinsichtlich ihrer Gütekriterien reliable, valide und ökonomisch vertretbare Erhebungsverfahren vorweisen können (WHO Multicentre Growth Reference Study Group, 2006), scheint die Anzahl an Prognosestudien vergleichbar gering. Auf der Ebene einzelner Talentprädiktoren wurden in Anbetracht einer Analyse zur Prognoserelevanz die Technik (10), Ausdauer (9) und Schnelligkeit (8) am zahlreichsten eruiert. Dabei erwiesen sich alle drei Prädiktoren in der Großzahl ihrer untersuchten Effekte als prognostisch valide (vgl. Tab. 3 und 6). Aktuelle Studien, die aufgrund ihres späteren Publikationsdatums nicht in einem der Reviews eingeschlossen wurden, kamen hinsichtlich der prognostischen Güte der Prädiktoren Technik, Ausdauer und Schnelligkeit zu übereinstimmenden Ergebnissen. Beispielsweise konnten Emmonds et al. (2016) feststellen, dass zukünftige Profispieler bessere Ausdauer- und Schnelligkeitsleistungen im U16- und U18-Alter gegenüber ihren damaligen Mitspielern, die den Profistatus nicht erreichten, erzielten. Ferner identifizierten Höner et al. (2017) im Rahmen einer technomotorischen Diagnostik mit DFB-Stützpunkt-Spielern der Altersgruppe U12 für den zukünftigen Erfolg im Erwachsenenalter (Profispieler aus der Bundesliga, 2. Bundesliga und 3. Liga vs.

[4] Da in einigen Studien Prädiktoren aus verschiedenen Merkmalsbereichen erfasst wurden, ist die Gesamtanzahl der einzelnen Merkmalsbereiche höher als die insgesamt 21 eingeschlossenen Studien.

Amateurspieler aus Verbandsliga und niederen Ligen) sowohl die Schnelligkeitskomponenten 20m-Linearsprint und Gewandtheit, als auch die technischen Fertigkeiten Dribbling und Ballkontrolle als prognostisch valide Prädiktoren.

Zudem zeigte die systematische Aufarbeitung des Forschungsstands, dass die anthropometrischen Prädiktoren Größe und Gewicht in den vorliegenden Studien nur ein sehr schwaches Maß an Prognoserelevanz darboten. Dabei waren lediglich 15-25% der untersuchten Effekte signifikant. Diesen Ergebnissen folgend, eignen sich temporäre körperliche Vorteile wie Größe und Gewicht eher wenig, um Prognosen für den zukünftigen Erfolg eines Spielers abzugeben.

In der weiteren Analyse zeigte die Prüfung auf empirische Evidenz in jeweils sieben Studien geringe Prognoserelevanz für Kraft und psychologische Persönlichkeitsdispositionen bzw. mentale Fertigkeiten. Für den Prädiktor Kraft, der überwiegend in Form von Schnellkraft über den Vertikalsprung Counter-Movement-Jump gemessen wurde, konnten nur in gut 26% der untersuchten Effekte signifikant bessere Leistungen bei zukünftig erfolgreichen Spielern festgestellt werden. Dennoch stoßen Vertikalsprünge oftmals innerhalb der Leistungsdiagnostik in Leistungszentren auf großen Anklang. Mögliche Gründe für eine Überprüfung des vertikalen Sprungkraftvermögens liegen zum einen daran, dass dieses die Schnellkraftleistungsfähigkeit der Beinstreckerkette abbildet, es zum anderen eine spezifische Leistungsvoraussetzung für den Sprung zum Kopfball darstellt (Schlumberger, 2006). Trotz der inkonsistenten Befundlage für die Prognoserelevanz psychologischer Persönlichkeitsdispositionen und Fertigkeiten stellten sich in den Ergebnissen des zweiten systematischen Reviews Prädiktoren heraus, die bei zukünftig erfolgreicheren Spielern in größerem Maße ausgeprägt sind (z. B. Hoffnung auf Erfolg, geringere Furcht vor Misserfolg; Höner & Feichtinger, 2016). Zu einer wissenschaftlichen Fundierung der empirischen Evidenz innerhalb des psy-

chologischen Merkmalsspektrums sind weitere Prognosestudien von Nöten, die eine zuverlässige Aussage über die Relevanz einzelner persönlichkeitsbezogener Faktoren liefern können. Besonders Analysen zur prognostischen Validität mentaler Fertigkeiten, die aufgrund instabiler Eigenschaften deutlich schwieriger zu erfassen sind als psychologische Persönlichkeitsdispositionen, erfordern zukünftig größere Beachtung, da sie wichtige Faktoren vor allem im Wettkampf abbilden (Morris, 2000).

Hinsichtlich kognitiver Faktoren zeigte sich durch die geringe Anzahl von lediglich vier Studien wie auch durch deren unterschiedliche Ergebnisse eine bisher unzureichende Überprüfungsmöglichkeit der Prognosekraft. Eine Erklärung könnte darin liegen, dass es schwierig ist, geeignete Diagnostikinstrumente zu finden, die latente Konstrukte wie Entscheidungskompetenz oder Antizipation reliabel und valide messen (Ackerman, 2014). Während drei von vier der analysierten Studien (Forsman et al., 2016; Huijgen et al., 2014; Kannekens et al., 2011) unter Verwendung von Selbsteinschätzungsfragebögen zu widersprüchlichen Ergebnissen kamen, erwies sich die vierte Studie (O' Connor et al., 2016) unter Einsatz einer videobasierten Diagnostik für die Entscheidungsfähigkeit als prognostisch relevant. Um zukünftig konkrete Aussagen zur Prognosekraft kognitiver Prädiktoren treffen zu können, besteht auch an dieser Stelle ein Bedarf an weiteren Untersuchungen, optimaler Weise unter Verwendung von Diagnostiken, die eine Wahrnehmungs-Handlungskopplung beinhalten und somit näher an dem realen Fußballspiel sind als bisher eingesetzte Verfahren (Hagemann et al., 2008). Travassos et al. (2013) unterstreichen in ihrer Meta-Analyse zur Antworterfassung bei Entscheidungsaufgaben, dass eine sportspezifische Antwort eine höhere Konsistenz aufweist, wenn es darum geht, Spieler hinsichtlich ihres Leistungsniveaus zu trennen. Die im Rahmen dieser Arbeit durchgeführte empirische Studie zum Entscheidungshandeln zielte auf eine Wahrnehmungs-Handlungs-Kopplung ab (vgl. Kapitel 4.2.1).

In jeweils nur zwei Studien berücksichtigt, zeigten die in der Analyse des Reviews 2 zu den psychologischen Prädiktoren dazugehörende Jonglierfähigkeit und die für das Erzielen eines Tores essentielle Torschussfähigkeit eine geringe prognostische Validität. Sowohl die geringe Anzahl an vorliegenden Untersuchungen, als auch die mangelnde Prognoserelevanz des Torschusses, kann auf die Komplexität dieser Fähigkeit und eine damit verbundene Problematik bei der Entwicklung zuverlässiger Testverfahren zurückgeführt werden (Ali, 2011; Russell et al., 2010). Die bereits oben beschriebene aktuelle Studie von Höner et al. (2017), zeigte zwar für den Torschuss eine prognostische Validität, jedoch betonen die Autoren auch den niedrigen Wert der instrumentellen Reliabilität des Torschusstests ($\alpha = .41$). Zwei weitere bisher kaum in der Forschung berücksichtigten Prädiktoren waren die Sprintwiederholungsfähigkeit und die Beweglichkeit. Während für die Sprintwiederholungsfähigkeit zwei Studien eine hohe prognostische Güte feststellten und diese demnach in weiteren Studien überprüft werden sollte, konnte die einzige Studie zur Beweglichkeit keine signifikanten Effekte finden.

Neben der in dieser Arbeit gefundenen empirischen Evidenz zur Prognoserelevanz bestimmter Prädiktoren wie der Technik, ist im Rahmen zukünftiger Identifikations- und Selektionsprozesse aufgrund der schwachen prognostischen Validität von Körpergröße und Gewicht eine Berücksichtigung des biologischen Entwicklungsstandes erstrebenswert. Gerade aber jene Prädiktoren werden in Zusammenhang mit physiologischen Faktoren in der Praxis bei Trainern für die Auswahl von Talenten oftmals stärker berücksichtigt als die technischen Fertigkeiten (Carling, Le Gall, Reilly & Williams, 2009). Trainer, die nur auf die aktuelle Leistungsfähigkeit wertlegen und dabei nicht den biologischen Entwicklungsstand eines Spielers betrachten, übersehen, dass in diesem Kontext bereits stark ausgeprägte körperliche Merkmale in jungen Jahren Vorteile im Wettkampf mit sich bringen (Unnithan et al., 2012).

Infolge dieser Tatsache, sind Spieler mit physiologischen und anthropometrischen Entwicklungsrückständen trotz überdurchschnittlich guten technischen Fertigkeiten oft nicht mit gleichaltrigen Konkurrenten wettbewerbsfähig. Dies kann wiederum dazu führen, dass diese Spieler nicht weiter selektiert und dementsprechend nicht bestmöglich weiter gefördert werden (vgl. Matthäus-Effekt; Wormhoudt, Savelsbergh, Teunissen & Davids, 2017 S. 51). Ungeachtet dessen, dass die körperlichen Defizite in Bezug auf das individuelle Größenwachstum in naher Zukunft ausgeglichen werden können, gehen somit viele spät entwickelte Spieler in der Talentförderung verloren (Figueiredo et al., 2009).

Um verantwortliche Personen in der Nachwuchsförderung für diese Thematik zu sensibilisieren, sollen im folgenden Abschnitt Ursachen für existierende Unterschiede hinsichtlich des biologischen Entwicklungstandes und der damit verbundenen Problematik andiskutiert werden.

4.2 Der biologische Entwicklungsstand als Störgröße im Selektionsprozess

Die Einteilung in Altersklassen erfolgt im Nachwuchsfußball auf Basis eines jährlichen Stichtages (in Deutschland 1. Januar; DFB, 2018, S. 8) in Altersgruppen (U10, U11, U12, usw.). Diese Einteilung impliziert, dass der chronologische Altersunterschied von Spielern innerhalb einer Altersgruppe bis zu knapp einem Jahr betragen kann. Demzufolge ist davon auszugehen, dass beispielsweise im ersten Jahresquartal geborene Spieler in der Regel gegenüber im vierten Jahresquartal geborenen Spielern einen physischen Entwicklungsvorsprung besitzen können, da sie innerhalb ihrer Altersgruppe chronologisch relativ älter sind (Deprez et al., 2013). Die Existenz von ungleich weit entwickelten Spielern zeigt sich in der Tatsache, dass relativ ältere Spieler auf verschiedensten Ebenen im Nachwuchsfußball (Junioren-Amateurbereich, vgl. Lovell et al., 2015; Stützpunkte, vgl. Votteler & Höner, 2014; Juniorennationalmannschaft, vgl. Williams, 2010) öfter vertreten sind (für einen

Überblick vgl. Sierra-Díaz, González-Víllora, Pastor-Vicedo & Serra-Olivares, 2017). Diese Überrepräsentation an frühgeborenen Spielern bildet das im Sport generell weit verbreitete Phänomen des relativen Alterseffekts (RAE) ab (Cobley, Baker, Wattie & McKenna, 2009). Diese Ungleichverteilung bedeutet für relativ jüngere Spieler, dass sie öfters aufgrund ihrer im Vergleich zu relativ älteren Spielern limitierten (körperlichen) Fähigkeiten aus den Fördersystemen fallen (Müller, Gehmaier, Gonaus, Raschner & Müller, 2018).

Während dem RAE inzwischen formell in manchen Bereichen der Praxis versucht wird, z. B. durch Quotenregelungen in Sichtungsturnieren oder Stützpunkten entgegenzuwirken (DFB, 2015), besteht weiterhin das Problem, dass dem individuellen biologischen Entwicklungsstand eines Spielers unabhängig vom chronologischen Alter wenig Beachtung geschenkt wird. Dieser kann innerhalb einer Altersgruppe sehr stark abweichen. Besonders in der Pubertät, in der häufige, intensive und facettenreiche Selektionsprozesse ablaufen, kann der Unterschied bis zu vier Jahre betragen (Malina, Bouchard & Bar-Or, 2004). Johnson, Farooq und Whiteley (2017) betonen, dass der biologische Entwicklungsstand an sich einen zehnfach höheren Einfluss bei der Selektion von Talenten hat als das relative Alter. Zur Bestimmung des biologischen Entwicklungsstands geben Lloyd et al. (2014) einen Überblick über verschiedene Indikatoren, die sowohl mittels invasiver als auch non-invasiver Methoden erhoben werden. Häufig eingesetzte non-invasive Methoden sind die subjektive Einschätzung zur biologischen Reife von erfahrenen Nachwuchstrainern (Romann, Javet & Fuchslocher, 2017) oder die Berechnung des Alters zum Zeitpunkt des schnellsten Längenzuwachses (Age at Peak Height Velocity) basierend auf verschiedenen Parametern (Chronologisches Alter, Körpergröße, Gewicht, Beinlänge; Fransen et al., 2017; Mirwald, Baxter-Jones, Bailey & Beunen, 2002).

Welchen Einfluss der biologische Entwicklungsstand konkret auf die aktuelle Leistungsfähigkeit bei Nachwuchsspielern hat, überprüften Vandendriessche et al. (2012). Basierend

auf der subjektiven Trainereinschätzung wurden belgische Juniorennationalspieler innerhalb ihrer Altersgruppen als normal- oder spätentwickelt eingestuft. Hierbei wiesen Spieler, die nach Einschätzung ihrer Trainer altersgemäß normalentwickelt sind, in physiologischen Prädiktoren wie z. B. Linearsprint, Gewandtheit und Vertikalsprünge signifikant bessere Leistungen auf als Spätentwickler, während bei technischen Fertigkeiten wie Dribbling kein Unterschied zu erkennen war. Zu vergleichbaren Ergebnissen kamen auch Rommers et al. (2018), die den biologischen Entwicklungsstand der Spieler mittels einer objektiven Methode (Mirwald et al., 2002) in früh, normal und spät einteilten. Dabei zeigte die Gruppe der frühentwickelten Spieler bessere Leistungen gegenüber den spätentwickelten Spielern im Linearsprint, jedoch ergaben sich keine Leistungsunterschiede bei der Überprüfung des Dribblings. Demnach sollten in der Talentförderung die Selektion von Spielern nicht nur anhand der aktuellen Leistungsfähigkeit festgemacht werden. Auf Basis dieser Erkenntnisse ist, wie von Baker et al. (2018) bereits berichtet, eine sorgfältige Analyse des biologischen Entwicklungsstands notwendig, damit nicht viele Talente frühzeitig verloren gehen.

Bezüglich der in den Reviews eingeschlossenen Analysen, wurden in vier erwähnten Studien (Deprez et al., 2015; Figueiredo et al., 2009; Le Gall et al., 2010; Zuber et al., 2016) der biologische Entwicklungsstand in prospektiver Weise untersucht und mit zukünftigen Erfolgen der Spieler in Verbindung gebracht. Die Ergebnisse von Figueiredo et al. (2009) zeigten, dass bei 11- bis 14-Jährigen die spät entwickelten Spieler systematisch bei der Selektion in Leistungszentren benachteiligt wurden. Hingegen kamen Deprez et al. (2015) in einem ähnlichen Studiendesign für 10- bis 17-Jährige hinsichtlich ihres biologischen Entwicklungsstands nur in der höchsten Altersgruppe zu einem signifikanten Unterschied zwischen Spielern, die für die nächste Altersklasse selektiert bzw. nicht selektiert wurden. Dagegen fanden Le Gall et al. (2010) in ihren Untersuchungen heraus, dass zukünftige Spieler auf internationalen Niveau gegenüber Spielern, die im Erwachsenenbereich auf Amateurniveau spielen,

im Alter von 15 bis 16 Jahren signifikant später entwickelt waren. Zudem konnten Zuber et al. (2016) in einem personenorientierten Untersuchungsansatz belegen, dass spät entwickelte Spieler im Alter von 12 bis 13 Jahren anhand starker Kompetenzen in Technik und der Persönlichkeitsdisposition Hoffnung auf Erfolg ihren körperlichen Nachteil kompensieren konnten und höhere Chancen auf eine zukünftige Berufung in die Juniorennationalmannschaft hatten. Zusammengefasst zeigt sich, dass einerseits spät entwickelte Spieler bei der Selektion benachteiligt wurden (Figueiredo et al., 2009), während bei Deprez et al. (2015) der biologische Entwicklungsstand keinen Einfluss auf den Selektionsprozess hatte. Anderseits konnten Le Gall et al. (2010) und Zuber et al. (2016) zeigen, dass Spieler die es trotz körperlicher Entwicklungsrückstände schafften, in einem Talentförderprogramm zu bleiben, zukünftig erfolgreicher waren. Infolgedessen gilt es auch bei Studien zur Prognoserelevanz personbezogener Prädiktoren, in denen oftmals nur eine einmalige Erhebung des Prädiktors stattfindet, zu berücksichtigen, dass vor allem in der pubertären Phase potenziell gute Spieler aufgrund noch nicht ausgereifter körperlicher Merkmale in physiologischen Faktoren mit Leistungsnachteilen zu rechnen haben (Meylan et al., 2010; Morris et al., 2018).

4.3 Studiendesigns in der prospektiven Talentforschung

4.3.1 Die Heterogenität der Merkmale

Die in den beiden Reviews eingeschlossenen 21 Studien demonstrierten die Verwendung sehr heterogener Studiendesigns. Eine damit verbundene große Vielfalt an unterschiedlichen Merkmalen des Studiendesigns erschwert die Vergleichbarkeit der Studien.

Auffallend für die untersuchten Personenstichproben war, dass bis zum Jahr 2016 keine Studien zur prognostischen Relevanz personbezogener Prädiktoren bei Juniorinnen vorlagen. Dies überrascht, da nach einem ausführlichen Report der UEFA das Interesse für den Frauenfußball stetig gestiegen war (Gledhill & Harwood, 2015; UEFA, 2015). Diese Erkenntnis

war auch der Anlass dafür, in einer empirischen Studie die prognostische Relevanz von den physiologischen Prädiktoren 20m-Linearsprint und Gewandtheit sowie den psychologischen Prädiktoren Ballkontrolle, Dribbling und Torschuss für Mädchen zu überprüfen (vgl. Kapitel 4.4.2). Die Analyse der Studiendesignmerkmale zeigte weiterhin, dass mit Ausnahme der Studie von O' Connor et al. (2016) innerhalb eines australischen Talentförderprogramms, alle Studien im europäischen Raum durchgeführt wurden. Überraschend an dieser Stelle waren fehlende Studien aus England, wenn man den hohen Stellenwert betrachtet, den die Talentforschung im Mutterland des Fußballs einnimmt (Johnston et al., 2018). In Bezug auf die Entwicklungsphase bildeten drei Untersuchungen zu jüngeren Altersgruppen (< U12) die Ausnahme im Vergleich zu Studien mit älteren Altersgruppen (16 Studien in der U12-U15, 10 in der U16-U19). Eine Ursache für die verhältnismäßig geringe Betrachtung jüngerer Altersgruppen könnte darin liegen, dass die Mehrzahl der Talentstudien an Leistungszentren (9 Studien) bzw. im Rahmen von Talentförderprogrammen (10 Studien) durchgeführt wurden. Allerdings beginnen viele Vereine oder Talentförderprogramme die Ausbildung erst ab der Altersgruppe U12 (z. B. DFB-Talentförderprogramm; DFB, 2009). Demnach sollte für zukünftige Prognosestudien auch der Fokus auf jüngere Jahrgänge gerichtet werden.

Nach Vaeyens et al. (2008) ist das Hauptziel in der Talentförderung, junge Spieler mit dem größtmöglichen Potenzial für den Erfolg im Herrenfußball zu identifizieren und zu selektieren. In diesem Sinne verfolgten sechs Autoren das erreichte Leistungsniveau im Erwachsenenfußball, indem sie dieses als Selektionskriterium wählten. Weiter wurden die Selektion in die nächste Altersklasse sowie die Berufung in eine Juniorennationalmannschaft als Kriterium jeweils sechsmal angewandt. Im Rahmen eines begrenzten Zeitumfangs bei der Durchführung einer Studie sowie in bestimmten Entwicklungsphasen können auch diese Selektionskriterien wertvolle Erkenntnisse hinsichtlich der Prognoserelevanz von einzelnen

Prädiktoren liefern. Konsequenterweise hängen die Wahl des Selektionskriteriums und die Länge des Prognosezeitraums voneinander ab. Die in den Reviews eingeschlossenen Studien variierten in den Prognosezeiträumen von weniger als einem Jahr bis hin zu 15 Jahren. Kürzere Prognosezeiträume können für bestimmte Übergänge in die nächste Stufe im Talentfördersystem (z.B. vom Stützpunkt in ein Leistungszentrum) von Bedeutung sein, sind jedoch auch anfälliger für Störfaktoren (z. B. dem biologischen Entwicklungsstand). Zukünftig würden Untersuchungen, die sowohl (halb-) jährliche Erhebungen der Prädiktoren sowie eine Selektion in verschiedenen Altersklassen (z. B. U15, U17, U19 und Herrenbereich) durchführen, einen großen Mehrwert bezüglich einer Prognosekraft innerhalb verschiedener Talentstufen liefern (Leyhr et al., 2018).

Ein weiteres Resultat der beiden Reviews war die größtenteils unidimensionale Untersuchung von Prädiktoren (14 Studien). In nur sieben Studien wurden Prädiktoren aus mehr als einem Merkmalsbereich erhoben. Carling und Collins (2014) stehen Aussagen über zukünftige Erfolge von Spielern auf Basis der Erhebung einzelner Prädiktoren sehr kritisch gegenüber. Folgerichtig wäre im Rahmen der komplexen Leistungsanforderungen im Fußball die Überprüfung der prognostischen Validität in einem multidimensionalen Ansatz sinnvoll (Till et al., 2016). Solch eine multidimensionale Untersuchung eröffnet im statistischen Kontext die Möglichkeit, Prädiktoren und deren prognostische Güte isoliert von anderen Prädiktoren zu betrachten.

Verständlicherweise erforderten die vielen unterschiedlichen Prädiktoren innerhalb der drei Merkmalsbereiche den Einsatz spezifischer Messinstrumente. Ackerman (2014) unterstreicht die Relevanz der eingesetzten Diagnostiken bei der Durchführung von Talentstudien und plädiert für eine gründliche Prüfung der Gütekriterien, um den gewünschten Prädiktor zuverlässig und valide zu messen. Zu guter Letzt kann die Größe der Stichprobe indirekt

einen Einfluss auf eine gefundene Prognoserelevanz nehmen (Ali, 2011), da diese Auswirkung auf die statistische Aussagekraft der Analyse hat (Ackerman, 2014). Die Stichprobengrößen in den vorliegenden Studien reichten von N = 66 (Gravina et al., 2008) bis hin zu N = 22.843 (Höner & Votteler, 2016). Letztere ist innerhalb einer bereits selektierten Gruppe (Spieler gehören zu den besten 4% ihres Jahrgangs) einzigartig.

Aufgrund der bisher relativ geringen Anzahl an Studien und der zugleich vielen unterschiedlichen Studiendesigns ist es nahezu unmöglich, generelle Aussagen zu treffen, in welchem Maße Merkmale der Studiendesigns im Sinne von Moderatoren einen Einfluss auf die Prognoserelevanz einzelner Prädiktoren haben. Es steht jedoch außer Frage, dass je nach verwendetem Studiendesign, die Ergebnisse im Rahmen einer prospektiven Studie kritisch betrachtet und eingeordnet werden müssen. Daher soll im folgenden Beispiel veranschaulicht werden, welche Auswirkungen bestimmte Merkmale bei der Analyse von Ergebnissen haben können:

In Review 1 (Murr et al., 2018a) konnte gezeigt werden, dass bei einer Eingrenzung auf Studien, die bei der Überprüfung der Ausdauerleistungsfähigkeit intermittierende Testverfahren einsetzten (Krustrup et al., 2003), eine deutliche Steigerung signifikanter Effekte von 48% auf 82% (vgl. Tab. 4) bezüglich der prognostischen Relevanz des Prädiktors Ausdauer ergab. Des Weiteren kann das Leistungsniveau, auf dem der Prädiktor erhoben wird, Auswirkungen auf die Prognosekraft haben. Dies zeigt sich beispielsweise in einem Vergleich zwischen den Studien von Figueiredo et al. (2009) und Deprez et al. (2015). Beide verwendeten mit Ausnahme der Stichprobengröße (N = 33 bzw. N = 214) und des Leistungsniveaus (regionaler Verein vs. Leistungszentrum) vergleichbare Merkmale im Studiendesign (Personenstichprobe: U12/U13 Spieler, Prognosezeitraum: 2 Jahre, Selektionskriterium: weitere Förderung im bzw. Ausschluss aus dem Verein, Erhebungsverfahren: intermittierende Aus-

dauerdiagnostik) zur Überprüfung der prognostischen Relevanz der Ausdauer. Die Ergebnisse zeigten, dass bei der bereits stärker selektierten Gruppe der Leistungszentrumsspieler deutlich kleinere Effekte bezüglich der Prognosekraft vorzufinden waren ($0.48 <= d <= 0.66$) als im Vergleich zum Gruppenunterschied bei Figueiredo et al. (2009) ($d = 1.56$). Eine Vermutung daraus könnte abgleitet werden, dass innerhalb bereits selektierter Leistungsgruppen die Sensitivität der Diagnostik nicht hoch genug ist, während auf niedrigem Leistungsniveau sehr starke Effekte gefunden werden können.

4.3.2 Methodologische Qualität prospektiver Studien

Unabhängig davon, wie die Merkmale in den Studiendesigns prospektiver Untersuchungen gewählt werden, sollte die methodologische Qualität einer Studie gewährleistet sein. Um diese zu bewerten bzw. mit anderen Studien in ein Verhältnis zu setzen, dienen systematische Reviews. Sportwissenschaftler behelfen sich beim Anfertigen systematischer Reviews erfahrungsgemäß mit bewährten Bewertungsskalen aus der Medizin (z. B. Physiotherapy Evidence Database Scale; de Morton, 2009). Jedoch erweisen sich diese Skalen meist für die Anwendung auf Talentstudien als problematisch, sofern diese nicht im sportmedizinischen Kontext oder in Trainingsinterventionen ihren Schwerpunkt haben. In der Talentforschung wird dabei oft auf eine narrative Form des Reviews (vgl. Ali, 2011; Johnston et al., 2018; Meylan et al., 2010) zurückgegriffen, in der Ergebnisse sehr detailliert, jedoch überwiegend deskriptiv analysiert werden. Auf eine Bewertung der methodologischen Qualität der einzelnen Studien etwa in Form eines Scores, wird jedoch weitgehend verzichtet. Während im Review für die physiologischen und anthropometrischen Merkmalsbereiche (Murr et al., 2018b) ebenfalls eine Bewertung der methodologischen Qualität der Studien ausblieb, wurde sich für die Übersichtsarbeit zu psychologischen Talentprädiktoren an einer im Review von Sarmento et al. (2018) modifizierten Skala zur Bewertung von quantitativen Studien orientiert (vgl. supplemental tab. 3.). Diese Skala basiert auf der „Critical Review Form

for quantitative studies“ nach Law (1987), die ursprünglich für Studienbewertungen in der ergotherapeutischen Forschung entwickelt wurden. Jedoch zeigte sich in ähnlichem Maße wie bei Sarmento et al. (2018), dass unter Anwendung der modifizierten Skala eine sehr hohe Erfüllung der Kriterien bei fast allen Studien vorlag (Murr et al., 2018a). Demzufolge ist diese Skala bis zu diesem Zeitpunkt nur bedingt für die Bewertung der methodologischen Qualität in Talentstudien geeignet.

Infolge einer in dieser Arbeit ausführlichen Analyse der Studiendesignmerkmale, haben sich relevante Kriterien herauskristallisiert, denen bei der Veröffentlichung einer prospektiven Studie zukünftig Beachtung geschenkt werden sollte. Für einzelne empirische Studien, die einen prospektiven Ansatz verfolgen, sollen diese Kriterien bzw. Empfehlungen als eine Art Leitfaden für eine präzise Beschreibung des methodischen Vorgehens bei der Veröffentlichung eines Manuskriptes dienen. Ein erster Entwurf solch eines Leitfadens liefert Tab. 13 Abgeleitet aus diesem Leitfaden wäre ein weiterer Schritt die Entwicklung einer Bewertungsskala bezüglich der methodologischen Qualität bei prospektiven Studien, die zukünftig in systematischen Reviews für die Bewertung der Studien eingesetzt werden kann.

Tab. 13: Leitfaden zur Beschreibung des methodischen Vorgehens für die Veröffentlichung prospektiver Studien im Fußball

Merkmal	*Empfehlung für Autoren*	*Darstellungsmöglichkeit im Manuskript*
Personenstichprobe		
Geschlecht	Angaben des untersuchten Geschlechts	Junioren
Altersklasse (Jahrgang)	Untersuchung getrennter Altersklassen unter Angabe des jeweiligen Jahrgangs	U12 (2002), U13 (2001), U14 (2000)
Leistungsniveau zum Zeitpunkt der Erhebung	Exakte Benennung und Einordnung des Leistungsniveaus der Spieler(innen) im untersuchten Land mit Referenzwerten (Prozentangaben)	Stichprobe stammt aus einem Talentförderprogramm des DFBs, Spieler gehören zu den besten 5% ihres Jahrgangs
Untersuchungsdesign		
Stichprobengröße	Exakte Angabe der Gesamtstichprobe sowie der Einzelstichproben bezüglich der Altersklassen	$N_{Ges} = 450$, $N_{U12} = 100$, $N_{U13} = 150$, $N_{U14} = 200$
Prognosezeitraum	Präzise Angabe des Zeitpunkts der Erhebung (Z1) sowie des Zeitpunkts der ausgewählten Selektion (Z2)	Z1: in den ersten beiden Wochen der Saisonvorbereitung (01.-14. Juli) in der Saison 2017/2018 Z2: Spieler, die zu Beginn der Saison 2019/2020 (1. Juli) der auserwählten Gruppe angehören Prognosezeitraum: 2 Jahre

Selektionskriterium	Exakte Angabe des Leistungsniveaus und der Bedingung, wann das Kriterium erfüllt ist	Spieler, die in der U15 an der Diagnostik teilnahmen und mindestens ein Spiel in der 1. oder 2. Bundesligasaison 2017/2018 bestritten haben.
Diagnostik		
Erhobenes Merkmal	Benennung des anhand der Diagnostik gemessenen Merkmals	Schnelligkeit über linearen 10- und 20 Meter Sprint
Erhebungsinstrument	Exakte Beschreibung des eingesetzten Erhebungsinstruments sowie der Durchführung und Auswertung der Diagnostik (Alternativ: Verweis auf andere Studien).	Beschreibung: Messung durch drei Doppellichtschranken (Start, 10m, 20m) von der Marke Browers. Durchführung: Start aus Schrittstellung ohne Auftaktbewegung, vorderer Fuß 50 cm hinter der Startlinie, kein Startsignal, sondern nach Ermessen des Spielers, zwei Durchgänge pro Spieler mit 60 Sekunden Pause. Auswertung: Die schnellere der beiden Zeiten wird gewertet. Alternativ: Für eine genaue Beschreibung und Durchführung der Diagnostik vgl. DFB-Testmanual (2013).
Gütekriterien	Angaben über die Reliabilität des Erhebungsinstruments (Alternativ: Verweis auf andere Studien).	Cronbachs $\alpha = .95$ Alternativ: Vgl. Höner et al., (2015)

<table>
<tr><td colspan="6">Statistik</td></tr>
<tr><td>Auswertungssoftware</td><td>Angabe der verwendeten Auswertungssoftware mit zugehöriger Version</td><td colspan="4">SPSS Version 25

Mplus Version 7.0</td></tr>
<tr><td rowspan="4">Deskriptive Statistik</td><td rowspan="4">Angabe deskriptiver Größen (Mittelwerte M, Standardabweichungen SD)</td><td></td><td>Profispieler</td><td>Amateure</td><td>U17-Junioren</td></tr>
<tr><td></td><td colspan="3">M ± SD</td></tr>
<tr><td>30m (s)</td><td>4.01 ± 0.13</td><td>4.17 ± 0.16</td><td>4.18 ± 0.11</td></tr>
<tr><td>Dribbling (s)</td><td>11.53 ± 0.77</td><td>12.29 ± 1.07</td><td>12.56 ± 1.15</td></tr>
<tr><td>Inferenzstatistik</td><td>Beschreibung der durchgeführten uni- bzw. mulitvariaten Auswertungs-verfahren unter Angabe von Effektstärken</td><td colspan="4">Einfaktorielle Varianzanalyse mit Post hoc Tests für multiplen Gruppenvergleich.

Cohens d und η^2 wurden als Effektgrößen berechnet.</td></tr>
</table>

4.4 Empirische Studien als Folge von Ergebnissen der Reviews

4.4.1 Entscheidungskompetenz als kognitiver Talentprädiktor (Manuskript 3)

Das bezüglich kognitiver Talentprädiktoren vorliegende Forschungsdefizit war der Anlass für die Durchführung einer empirischen Studie zur Entscheidungskompetenz von Juniorenspielern auf hohem Leistungsniveau (U16-U19 Spieler aus dem Nachwuchsleistungszentrum des Bundesligavereins VfB Stuttgart)[5]. Die im Rahmen einer Pilotstudie (Dieze, 2015) erstellte videobasierte Diagnostik zur Überprüfung der Entscheidungskompetenz in verschiedenen Spielsituationen (Spielaufbauszenen in der Abwehrreihe und Angriffsszenen in Mittelfeld und Sturm) wurde innerhalb einer hochselektierten Stichprobe auf Reliabilität sowie diagnostische und prognostische Validität geprüft. Über der Evaluation der Diagnostik hinaus wurde zudem in einem weiteren Schritt der Einfluss der Spielposition auf die Entscheidungskompetenz explorativ untersucht.

Die Analyse zur instrumentellen Reliabilität ergab für die Spielaufbauszenen einen zufriedenstellenden (r = .72), für die Angriffsszenen einen gerade noch vertretbaren Wert (r = .56). Trotz einer für die Erhebung akzeptablen Reliabilität, sollten für einen zukünftigen Einsatz dieser Diagnostik einzelne Videoszenen mit schwachen Reliabilitätskennziffern aus der Gesamtdiagnostik eliminiert, um somit die Reliabilität der Diagnostik weiter erhöhen. Bezüglich der diagnostischen Validität zeigte sich, dass die Diagnostik, unabhängig von den Spielsituationen, hinsichtlich Alter und Anzahl der eingesetzten Spielminuten im Wettkampf die Spieler innerhalb eines hohen Leistungslevel trennen kann. Die Ergebnisse der prognostischen Validität lieferten zudem für die Spielaufbauszenen signifikant bessere Werte für zu-

[5] Die Nachwuchsabteilung des VfB Stuttgart 1893 e.V. gehört seit Jahrzehnten zu den erfolgreichsten im Jugendbereich. Sowohl bei den U19 Junioren als auch bei den U17 Junioren ist der VfB Stuttgart mit insgesamt 17 Titeln Rekordsieger (Transfermarkt, 2018a, 2018b)

künftige DFB-Juniorenauswahlspieler. Die in diesem Zusammenhang gefundene kleine Effektgröße für die Spielaufbauszenen könnte an der bisher geringen Anzahl der Auswahlspieler (N=16) sowie der sehr homogenen Stichprobe liegen. Um prognostisch validere Aussagen über das eingesetzte Diagnostikinstrument treffen zu können, besteht der Bedarf an weiteren Untersuchungen mit größeren Stichproben und einer Betrachtung des Erfolgs im Erwachsenenalter als Selektionskriterium.

Der explorative Ansatz in dieser Studie, diverse Spielerpositionen hinsichtlich ihrer Entscheidungskompetenz in unterschiedlichen Spielsituationen zu überprüfen, ergab bisher keine signifikanten Unterschiede. Dennoch ergaben sich Tendenzen auf deskriptiver Ebene, dass Spieler auf denen für sie vorhergesehen, positionsspezifischen Videoszenen (Verteidiger im Spielaufbau, Stürmer in Angriffsszenen) ihre besten Leistungen abrufen können.

Eine große Stärke dieser Studie liegt in der elitären Stichprobe (Spieler gehören zu den besten 1% ihres jeweiligen Jahrgangs), mit der die Untersuchung durchgeführt wurde, zum anderen bilden die Videos aus der Sicht des ballführenden Spielers zusammen mit einer fußballspezifischen Antwortreaktion zur Ermittlung der Entscheidung (Pass aus dem Dribbling heraus zum Mitspieler auf der Videoleinwand) ein experimentelles Setting, das die Wahrnehmung der Spieler mit der auszuführenden Handlung koppelt. Da in dieser Studie nur auf die Entscheidungskorrektheit Wert gelegt wurde, gilt es für weitere Untersuchungen der Entscheidungskompetenz, die benötigte Entscheidungszeit der Spieler in Betracht zu ziehen. Zudem bietet die mittlerweile fortgeschrittene Technik die Möglichkeit, sich zum Beispiel in virtueller Umgebung weiter an die reale Wettkampfsituation im Spiel anzunähern und eventuell auch zukünftig solche Diagnostiken als Trainingsinstrument einzusetzen.

4.4.2 Prognostisch relevante Talentprädiktoren im Mädchenfußball (Manuskript 4)

In einer zweiten empirischen Studie wurde das Ziel verfolgt, erste Ergebnisse zu der bis dato unzufriedenen Forschungslage hinsichtlich der Untersuchung zur Prognoserelevanz personbezogener Talentprädiktoren im Mädchen- und Frauenbereich zu liefern. Dabei wurden im Rahmen der technomotorischen Leistungsdiagnostik des DFB-Talentförderprogramms (DFB, 2013; Höner et al., 2015) bei U12 Stützpunkt-Spielerinnen schnelligkeits- sowie technikbezogene Prädiktoren erhoben, um auf Basis dieser Leistungen das Selektionslevel in der U17 (Juniorinnennationalmannschaft, Verbandsauswahl bzw. nicht selektiert) vorherzusagen. Die Ergebnisse zeigten im Extremgruppenvergleich (Juniorennationalmannschaft vs. nicht selektiert) eine hohe prognostische Güte der Prädiktoren Schnelligkeit, Gewandtheit, Dribbling und Ballkontrolle (vgl. Tab. 11) und sind demnach vergleichbar mit der gefundenen empirischen Evidenz dieser Prädiktoren bei Junioren in Review 1 und 2. Unter Verwendung des gleichen Studiendesigns wie bei Höner und Votteler (2016), die exakt die gleichen Prädiktoren für Junioren erhoben, zeigte sich, dass die technomotorische Leistungsdiagnostik unabhängig vom Geschlecht eine gute prädiktive Validität liefert. In Betrachtung der einzelnen Prädiktoren ergaben sich mit Ausnahme des Dribblings keine größeren Abweichungen der Effektstärken zwischen Mädchen und Jungen. Der schon bei den Junioren als bedeutsam identifizierte Prädiktor Dribbling erwies sich für Mädchen noch in deutlich größerem Maße als prognostisch relevant, besonders in der Unterscheidung zwischen den höchsten Leistungslevel Junior(inn)ennationalmannschaft und Verbandsauswahl (Mädchen: d=0.76; Jungen: d=0.23). Diese prospektive Studie lieferte erste Ergebnisse für die prognostische Relevanz von Prädiktoren aus dem physiologischen und psychologischen Merkmalsbereich. Es besteht der Bedarf an weiteren Untersuchungen bezüglich anderen Prädiktoren.

4.5 Ausblick

Angesichts der kritischen Prüfung existierender prospektiver Studien ist eine wichtige Erkenntnis dieser Arbeit, dass die objektive Erhebung von Ausdauer, Schnelligkeit und den technischen Fertigkeiten Dribbling und Ballkontrolle im Juniorenalter eine Prognosekraft besitzt. Demnach sind diese Prädiktoren nicht nur im Profifußball als diskriminierende Eigenschaften zwischen erfolgreichen und weniger erfolgreichen Spielern von Bedeutung, sondern besitzen auch im Juniorenbereich eine gewisse prognostische Validität in Zusammenhang für zukünftigen Erfolg. Für weitere wissenschaftlich fundierte Aussagen über die prognostischen Relevanz personbezogener Talentprädiktoren bedarf es zusätzliche prospektive Studien, bei denen die bisher weniger berücksichtigten Prädiktoren (z. B. Sprintwiederholungsfähigkeit, Torschuss, Entscheidungskompetenz) bzw. Prädiktoren, für die inkonsistente Befunde vorliegen (z. B. Persönlichkeitseigenschaften, mentale Fertigkeiten), untersucht werden. Die fehlende empirische Evidenz für die prognostische Relevanz anthropometrischer Prädiktoren führt zu der Erkenntnis, dass in der Talentförderung Spieler nicht aufgrund ihrer aktuellen körperlichen Vorteile eine Bevorzugung erhalten sollen, wenn es um Spieleinsatzzeiten oder Selektionsprozesse geht. Die damit in Verbindung stehende und aufgegriffene Diskussion zum biologischen Entwicklungsstand der Spieler, soll einen Anstoß zur stärkeren Berücksichtigung des Potenzials der Spieler für zukünftige Leistungen geben, anstatt sich zu sehr auf den aktuellen Leistungsstand zu beziehen.

Eine weitere zentrale Erkenntnis dieser Arbeit zeigt sich in der heterogenen Befundlage der analysierten Studien hinsichtlich ihrer Studiendesigns. In diesem Zusammenhang ist davon abzuraten, empirische Befunde generell auf unterschiedliche Leistungsniveaus oder auf verschiedene Entwicklungsphasen zu übertragen. Hinsichtlich der Erhebungsmethoden spezifischer Prädiktoren ist für die Talentförderung in der Praxis der Einsatz von reliablen und

validen Messinstrumenten unerlässlich. Für eine objektive und standardisierte Testdurchführung sollten zudem geschulte Testleiter eingesetzt werden.

Für eine bessere Einordnung in den wissenschaftlichen Kontext sollten darüber hinaus für zukünftige Studien zur Prognoserelevanz personbezogener Talentprädiktoren eine hohe methodologische Qualität gewährleistet sein. Dabei tragen präzise Angaben der Merkmale des Studiendesigns zu einem besseren Verständnis der Studie, sowie zur angemessenen, studienübergreifenden Vergleichbarkeit bei. An dieser Stelle dient der Prototyp eines Leitfadens als Anstoß zur expliziten Beschreibung des methodischen Vorgehens. Verwendung soll dieser im Rahmen hoher wissenschaftlicher Standards für die Veröffentlichung prospektiver Studien finden.

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Anhang

Zusätzliches Onlinematerial für Murr et al., (2018)

Supplemental tab. I: Overview of the 95% confidence interval for Cohen's d

Dimensions of predictor			Physiology								Physique	
		Predictor	Endurance	Speed				Strength		Flexibility	Anthropometry	
			Endurance	Sprint (≤ 20m)	Sprint (> 20m)	COD	RSA	Power	Maximum	Full-Body	Height	Weight
Study	Sample	Age group	CI [95%]	CI [95%]	CI [95%]	CI [95%]	CI [95%]	CI [95%]	CI [95%]	CI [95%]	CI [95%]	CI [95%]
Deprez et al.	147	U10	[-0.16; 1.10]	[0.06; 0.80]	[0.24; 0.95]	[-0.34; 0.63]		[-0.16; 0.63]			[-0.31; 0.39]	[-0.71; -0.02]
(2014)	132	U11	[-0.07; 1.35]	[0.04; 0.84]	[-0.08; 0.72]	[0.23; 1.39]		[-0.14; 0.78]			[-0.26; 0.51]	[-0.52; 0.25]
	112	U12	[0.21; 1.11]	[-0.27; 0.61]	[0.17; 1.07]	[-0.04; 1.03]		[-0.03; 0.97]			[-0.33; 0.54]	[-0.50; 0.37]
	102	U13	[0.01; 0.95]	[-0.12; 0.81]	[0.09; 1.02]	[-0.71; 0.43]		[0.01; 1.04]			[-0.53; 0.37]	[-0.32; 0.59]
	108	U14	[0.22; 1.41]	[0.17; 1.11]	[0.56; 1.52]	[-0.27; 0.76]		[0.50; 1.47]			[-0.12; 0.74]	[0.08; 0.95]
	97	U15	[0.24; 1.41]	[0.48; 1.51]	[0.54; 1.58]	[-0.24; 1.04]		[0.53; 1.64]			[0.02; 0.98]	[0.11; 1.07]
	87	U16	[-0.22; 0.93]	[-0.38; 0.67]	[0.04; 1.11]	[-0.47; 0.81]		[-0.36; 0.71]			[-0.18; 0.84]	[-0.27; 0.75]
	79	U17	[0.31; 1.39]	[0.33; 0.63]	[0.04; 1.11]	[0.08; 1.34]		[-0.58; 0.58]			[-0.11; 0.82]	[-0.20; 0.72]
Figueiredo et al.	33	U12/U13	[0.75; 2.36]		[0.29; 1.80]	[0.26; 1.76]	[0.45; 2.00]	[-0.04; 1.43]			[0.27; 1.78]	[-0.31; 1.12]
(2009)	36	U14/U15	[0.03; 1.40]		[0.32; 1.74]	[0.92; 2.47]	[0.48; 1.92]	[0.35; 1.77]			[0.93; 2.48]	[0.49; 1.94]
Gil et al.	48	U15	[0.08; 1.27]		[0.27; 1.48]	[-0.16; 1.01]		[-0.45; 0.71]			[0.20; 1.40]	[-0.16; 1.01]
(2007a)	53	U16	[0.50; 0.66]		[-0.52; 0.63]	[-0.04; 1.13]		[-0.08; 1.09]			[-0.79; 0.36]	[-0.27; 0.89]
	41	U17	[-0.92; 0.43]		[-0.57; 0.77]	[0.16; 1.56]		[0.30; 1.06]			[-0.39; 0.96]	[-0.45; 0.90]
	52	U18	[-0.16; 0.97]		[0.48; 0.64]	[-0.43; 0.68]		[-0.69; 0.43]			[-0.45; 0.66]	[-0.54; 0.58]
Gil et al. (2014)	85	U10/U11	[0.11; 1.22]	[-0.06; 1.04]	[-0.07; 1.03]	[0.11; 1.22]		[-0.48; 0.61]	[0.03; 1.13]		[-0.72; 0.37]	[-0.41; 0.68]
Gonaus & Müller	410	U15	[0.09; 0.48]	[0.09; 0.48]		[0.29; 0.68]		[0.11; 0.50]	[0.51; 0.91]	[0.02; 0.41]		
(2012)	504	U16	[0.09; 0.44]	[-0.02; 0.33]		[0.21; 0.56]		[0.24; 0.59]	[0.28; 0.64]	[0.03; 0.38]		
	456	U17	[0.10; 0.47]	[0.27; 0.65]		[0.13; 0.50]		[0.10; 0.47]	[0.24; 0.61]	[-0.03; 0.34]		
	272	U18	[-0.15; 0.33]	[0.26; 0.74]		[0.12; 0.60]		[-0.02; 0.45]	[0.35; 0.83]	[-0.22; 0.25]		
Gravina et al. (2008)	66	U11-U14	[-0.62; 0.40]		[0.82; 1.95]	[0.24; 1.30]		[-0.51; 0.51]	[-0.37; 0.65]		[-0.25; 0.78]	[-0.22; 0.81]
Huijgen et al. (2014)	113	U16-U19	[-0.32; 0.46]			[0.02; 0.81]	[0.07; 0.86]				[-0.54; 0.25]	[-0.32; 0.47]
Le Gall et al.	105	U14	[-0.31; 0.76]	[-0.53; 0.53]	[-0.43; 0.64]			[-0.35; 0.71]	[-0.48; 0.59]		[-0.20; 0.87]	[-0.35; 0.72]
(2010)	92	U15	[-0.17; 0.91]	[-0.26; 0.82]	[0.09; 1.18]			[-0.03; 1.06]	[-0.30; 0.79]		[-0.26; 0.83]	[-0.49; 0.59]
	86	U16	[-0.06; 1.03]	[-0.15; 0.94]	[0.04; 1.14]			[-0.01; 1.09]	[-0.99; 0.10]		[0.31; 1.42]	[0.16; 1.26]
Roescher et al.	26	U15	[-1.06; 0.50]									
(2010)	59	U16	[-0.66; 0.46]									
	55	U17	[-0.36; 0.85]									
	55	U18	[0.01; 1.08]									
	53	U19	[0.22; 1.34]									

According to Döring and Bortz (Döring, N. & Bortz, J. (2016). Forschungsmethoden und Evaluation in den Sozial- und Humanwissenschaften, 5th edition.. Berlin, Heidelberg: Springer.), confidence intervals were computed using the statistic software SAS (SAS university edition).

Supplemental tab. 2: List of all measurements and instruments that were analyzed in the systematic review

		Physiology								Physique	
		Endurance	Speed				Strength		Flexibility	Anthropometry	
Study		Aerobic/anaerobic capacity	Sprint (≤ 20m)	Sprint (> 20m)	COD	RSA	Power	Maximum	Full-body	Height	Weight
Deprez et al. (2014)	Item (measure)	Endurance (covered distance)	5m linear sprint (best time)	30m linear sprint (best time)	Soccer-specific motor coordination (best time)		Vertical jump (CMJ, best height)			Height (cm)	Weight (kg)
	Instrument	*Yo-yo IR1*	*Electronic timing lights*	*Electronic timing lights*	*Ugent dribbling test*		*Jump mat*			*Portable stadiometer*	*Total body composition analyser*
Figueiredo et al. (2009)	Item (measure)	aerobic performance (covered distance)		34,2m linear sprint (best time)	5 x 10m shuttle sprint (best time)	7 x 34,2m linear sprint with 25s recovery (mean time)	Vertical jump (CMJ, best height)			Height (cm)	Weight (kg)
	Instrument	*Yo-yo-IE1*		*Electronic timing lights*	*Electronic timing lights*	*Electronic timing lights*	*Jump mat*			*Anthropometric standardization reference manual*	*Anthropometric standardization reference manual*
Gil et al. (2007a)	Item (measure)	Aerobic capacity (VO2max)		30m linear sprint with 15m acceleration (best time)	30m flat sprint with 10 cones and 15m acceleration (best time)		Vertical jump (CMJ, best height)			Height (cm)	Weight (kg)
	Instrument	*Astrand's test*		*Electronic timing lights*	*Electronic timing lights*		*Jump mat*			*No information provided*	*No information provided*
Gil et al. (2014)	Item (measure)	Endurance (covered distance)	15 m linear sprint (best time)	30m linear sprint (best time)	30 m flat sprint with 10 cones (best time)			Strength upper extremities (maximum isometric effort)		Height (cm)	Weight (kg)
	Instrument	*Yo-yo IR1*	*Electronic timing lights*	*Electronic timing lights*	*Electronic timing lights*			*Dynamometer*			*Seca beam balance*

		Physiology								Physique	
		Endurance	Speed				Strength		Flexibility	Anthropometry	
Study		Aerobic capacity	Sprint (≤ 20m)	Sprint (> 20m)	COD	RSA	Power	Maximum	Flexibility	Height	Weight
Gonaus & Müller (2012)	Item (measure)	aerobic endurance (speed corresponding to 4mmol)	5m linear sprint (best time)		5 x 10m shuttle sprint (best time)		Vertical jump (CMJ, best height)		Whole-body flexibility (cm)		
	Instrument	*20m multi-stage endurance test*	*Electronic timing lights*		*Electronic timing lights*		*Force plate applying piezoelectric sensors*		*Sit-and-reach*		
Gravina et al. (2008)	Item (measure)	aerobic capacity (VO2max)		30m linear sprint with 15m acceleration (best time)	30m flat sprint with 10 cones and 15m acceleration (best time)		Vertical jump (CMJ, best height)	No information given		Height (cm)	Weight (kg)
	Instrument	*Astrand's test*		*Electronic timing lights*	*Electronic timing lights*		*Jump mat*			*International Society for the Advancement of Kineanthropometry*	*International Society for the Advancement of Kineanthropometry*
Huijgen et al. (2014)	Item (measure)	Intermiitent endurance capacity (ISR-score)			30m flat sprint with 12 cones (best time)	3 x 30m peak shuttle sprint (total time)				Height (m)	Weight (kg)
	Instrument	*Interval Shuttle Run Test*			*Electronic timing lights*	*Shuttle SDT*					
Le Gall et al. (2010)	Item (measure)	Aerobic capacity (VO2max)	10m linear sprint (best time)	40m linear sprint (best time)			Vertical jump (CMJ, best height)	Strength knee flexors and extensors (peak concentric torque)		Height (cm)	Weight (kg)
	Instrument	*Progressive track run test*	*Electronic timing lights*	*Electronic timing lights*			*Jump mat*	*Dynamometer*		*Fixed stadiometer*	*Seca beam balance*
Roescher et al. (2010)	Item (measure)	Intermiitent endurance capacity (ISR-score)									
	Instrument	*Interval Shuttle Run Test*									

Zusätzliches Onlinematerial für Murr et al., (2018, akzeptiert)

Supplemental tab. 3: - Criteria used to analyse the methodological quality of studies (adapted from Sarmento et al., 2018)

	Quality Criteria (QC)	Decision	*Study* [1]	[20]	[46]	[47]	[48]	[50]	[51]	[52]	[53]	[54]	[55]	[56]	[57]	[58]	[59]	[60]	Total
QC1	Was the design appropriate for the research question?		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
QC2	Was the sample described in detail?		1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15
QC3	Was sample size justified?		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
QC4	Was informed consent obtained?*		1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	13
QC5	Were the outcome measures reliable?*	1=Yes 0=No	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	15
QC6	Were the outcome measures valid?*		1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	1	13
QC7	Was method described in detail?		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
QC8	Were results reported in terms of statistical significance?		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
QC9	Were the analysis methods appropriate?		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
		Total	9	9	8	6	9	9	8	8	9	9	9	9	9	8	9	8	

Note. * (if not described, assume No), the numbers in squared brackets present the studies as they are named in the original PLoS One manuscript