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A proposed conceptualization of talent in sport: The first step in a long and winding road

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A B S T R A C T

Objectives: The validity of sporting talent is hotly contested by those working, watching, and participating in sport in its variety of forms. Despite considerable research attention to understanding talent development in sport settings, the overall utility of this concept is not known. One of the reasons for this is that sporting talent has not been adequately conceptualized. This paper aims to provide a broad foundation for exploring talent in sport.
Design: Critical review.
Methods: Prior work from psychology, sport psychology and sport science more generally are reviewed to develop a new conceptualization of talent in sport.
Results and conclusions: We propose a multi-faceted conceptualization of talent as: innate (i.e., originating in biological elements present at birth), multi-dimensional (i.e., consisting of capacities from a range of broad cognitive, physical, and psychological categories), emergenic (i.e., involving interactions among factors that combine multiplicatively), dynamic (i.e., evolving across developmental time due to interactions with environments and random gene expression) and symbiotic (i.e., cultural and social factors will determine the ultimate value of an individual's talent). We also suggest several avenues for future research to determine the validity of talent in sport.

> "Those of us who believe that talent exists should be trying to document as clearly as we can, with as much rigor as we can muster, that it can be defined and assessed, but putting things in either/or terms is not likely to move beyond simplistic accounts of what is manifestly a subtle and complex process"
>
> Feldman & Katzir (p. 414; 1998)

Few concepts in sport are as divisive as the notion of 'natural talent'. Talent has been a popular topic for sport scientists; a recent systematic review highlighted nearly 1700 articles on talent (or talent-related topics) over the past 25 years (Johnston, Wattie, Schorer & Baker, 2018). Unfortunately, this systematic review highlighted that the quality of evidence in this area is generally limited and that those working in high performance sport settings have very little high quality evidence with which to make decisions about talent, despite the reality that selection decisions are made regularly in the athlete development pathway. In this review we want to take initial steps to generating a clearer conceptualization of the term talent.

There are many reasons for the lack of high quality evidence testing the notion of talent, most notable the scarcity of longitudinal studies on athlete development, which are expensive and administratively complex compared to cross-sectional and/or qualitative investigations. However, development of a solid evidence base for or against talent may also be limited by another critical limitation of research in this area, specifically, the lack of clarity regarding what talent is and what it means for researchers and practitioners in sport (see Dohme, Backhouse, Piggott & Morgan, 2017 for more on the need for clarity in sport and exercise psychology). As noted in the quote above, researchers have not examined the concept of talent with appropriate vigor or methodological complexity. In this paper, we have tried to provide a roadmap for beginning this examination.

1. The need for a sport-specific approach to talent

While the field of athlete development is ripe with theoretical and conceptual models describing the progression from novice to elite performer (e.g., *Long-Term Athlete Development*, Balyi, Way, & Higgs, 2013; *Developmental Model of Sport Participation*, Côté & Vierimaa, 2014; *Foundations, Talent, Elite and Mastery*, Gulbin, Croser, Morley & Weissensteiner, 2013) as well as reviews of the factors influencing this process (e.g., Gledhill, Harwood & Forsdyke, 2017), there are no comprehensive models of what talent means in sport. The notion of talent and its development has been explored in other domains (e.g., gifted education, Gagné, 2003; psychology, Simonton, 1999, 2001), and

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while providing some intriguing and relevant elements for those working in sport settings (e.g., see the application of Gagné's Differentiated Model of Giftedness and Talent in Gulbin, Oldenziel, Weissensteiner, & Gagné, 2010; Gulbin, Weissensteiner, Oldenziel, & Gagné, 2013), these domains may be insufficient to capture the complexity of talent in sport. Sport is unique; it encapsulates other domains and extends beyond them. Primarily, this is because physical and motor elements of performance and constraints related to an athlete's body play a greater role than in traditional talent models derived from cognitive psychology. Like chess, it requires complex decision-making, pattern recognition and performance under pressure, but regularly requires the execution of these skills while an opponent is actively working to resist this execution. Like music, it requires the successful demonstration of highly complex motor skills, but also typically involves executing these movements while moving through an environment that is, to varying degrees, dynamic and unpredictable. Moreover, the perceptual-cognitive and complex motor skills seen in sport occur with performers actively engaged in sophisticated, and often fast-paced, deception to disrupt their opponents' performance (Walsh, 2014).

1.1. What does talent mean in sport?

For good or ill, talent remains a central element of sport science and athlete development. The assumption of models of talent development or talent environments (e.g., Henriksen, Stambulova, & Roessler, 2010) is that *there is something to be developed* (i.e., that talent exists and is waiting to be developed in the proper environment). However, while the importance of talent is emphasized in models and frameworks of athlete development, our understanding of what talent is remains muddled. In 2013, Ross Tucker of the Science of Sport website used their Facebook page to conduct an open-ended survey to get sport practitioners (e.g., coaches, athletes, scientists, spectators) to respond to the question "What is talent?" resulting in a range of responses and a lack of clear descriptive characteristics (Tucker, 2013). The sport science research community has not been much clearer. For instance, Cobley, Schorer, and Baker (2012) suggested "talent refers to the quality (or qualities) identified at an earlier time that promotes (or predicts) exceptionality at a future time" (p. 3), which seems to generally reflect how talent is conceptualized by many researchers and practitioners in sport. However, this definition makes it impossible to delineate whether a current level of performance is the result of innate predispositions, learning through experiences and training or some combination of these factors. Similarly, Issurin (2017) defined talent as "a special ability that allows someone to reach excellence in some activity in a given domain" (p. 1994) and noted a range of prerequisites and precursors of talent. Again, this definition results in a conceptualization of talent that does not demarcate how it is different from current performance and/or level of acquired skill. Davids, Güllich, Shuttleworth, and Araujo (2017) grounded their discussion of talent in ecological psychology and suggested talent represents the "functional relationship developed between a performer and a specific performance environment" (pp. 193). Although this definition adequately emphasizes that an individual's performance ultimately reflects the complex interaction between performer, task and environment, the practical utility of this definition to those working in high performance sport environments could be more straightforward. Nebulous definitions make it difficult to test the validity of this concept and/or the strength of relationships between it and other important elements of athlete development. This is particularly true in sports where exceptional performance can result from different permutations and combinations of skills and abilities.

In their seminal review, Howe, Davidson, and Sloboda (1998) set up five criteria in order to explore the validity of talent:

> 1) It originated in genetically transmitted structures and hence is at least partly innate. 2) The full effects may not be evidenced at an early stage, but there will be some advance indications, allowing trained people to identify the presence of talent before exceptional levels of mature performance have been demonstrated. 3) These early indications of talent provide a basis for predicting who is likely to excel. 4) Only a minority are talented, for if all children were, there would be no way to predict or explain differential success. Finally, 5) talents are relatively domain-specific (p. 399–400).

In a recent review and update of these five criteria as they relate to talent in sport, Baker and Wattie (2018) concluded that while the concept of talent may be reasonable from a conceptual perspective, it has limited utility because of a lack of valid and reliable measures for practitioners and researchers. It is also likely the sport models describing what talent is, and equally importantly, is not, are too simple.

To most working in high performance sport and athlete development talent refers, very broadly, to potential for success at some future level of competition (e.g., adult success). In its simplest form, this may reflect a direct relationship between some factor (e.g., height) and an adult-level outcome (e.g., basketball performance). However, given the extended time course for athlete development, potential is likely also reflected in the possession of the necessary qualities to be able to stay in the pathway through development (e.g., having 'coachability', perseverance, resilience, etc.). Measuring this potential is immensely difficult; selecting late means measures are likely confounded by experience as noted above. However, given the multitude of influences on an athlete's development and research emphasizing the limited accuracy of talent selection decisions (e.g., Koz, Fraser-Thomas & Baker, 2012), selecting early means lower accuracy (Güllich, 2014).

One of the reasons for this is that coaches and administrators do not have valid measures of potential and are commonly left making assumptions about potential based on current performance on a test (or tests) of interest. However, the relationship between current performance and future potential is, at best, imperfect and, at worst, meaningless. Performance on a given test usually reflects a limited number of skills/capacities (e.g., physiological capacities or cognitive skill but rarely both), which inevitably presents a reductionist view of talent in the domain of interest. Performance evaluations occur regularly across development, which in later stages of development is increasingly problematic given the likelihood of learning/experience affecting the validity of these tests as measures of talent. Moreover, the variables that correlate with performance at young ages may not necessarily be the same factors explaining adult performance.

Waiting until later in development is useful because it decreases the time between when an athlete is evaluated and the future event being predicted (e.g., predicting whether an 18 year old will succeed as an elite athlete may be more accurate than predicting whether a 9 year old will be because the time course of prediction is shorter). However, this process is far from precise. For instance, professional sports in the United States use a battery of tests in 'scouting combines' to evaluate athletes relative to indicators that arguably have some relevance to performance at the professional level. However, sports 'drafts' have limited accuracy (Koz et al., 2012), especially when considering these selections are made relatively late in the athlete development pathway (i.e., generally in early adulthood).

Research in this area would be improved by clear operational definitions of key terms. For instance, in Figure 1 we distinguish terms that are commonly used in talent and related research (Hodges & Williams, 2012). Here, talent is positioned initially as an antecedent to processes such as learning and development, affecting outcomes such as skill, performance and expertise. However, this also reflects a far too simplistic view of talent since it may evolve/emerge as an individual interacts with their learning and training environments. In the current article, we focus on conceptualizing talent in sport, in an effort to improve our understanding of this concept, and the research that informs this understanding. Below, we discuss five qualities that relate to sport-related talent drawn from models from mainstream psychology (Howe

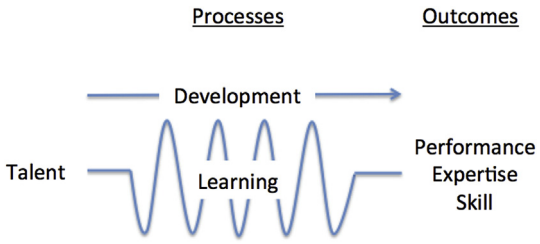

Figure 1. The relationship between terms used in talent and skill acquisition research. From this perspective, talent reflects the 'starting point' (i.e., those antecedents of skill development and potential present at birth) for the processes of learning and development. This perspective also distinguishes talent from outcomes such as skill, performance and expertise.

et al., 1998; Simonton, 1999, 2001), education (Gagné, 2004) and ecological dynamics (Davids et al., 2017). Our intention is to provide a working framework, with falsifiable components, that can be used as the basis to determine the ultimate value of talent as a concept in the domain of sport.

2. Qualities of sporting talent

2.1. Innate

As we noted earlier, there is a lack of clarity regarding what talent actually is and how it relates to athlete development. In many models (e.g., Long-Term Athlete Development, Way et al., 2016, see also Bailey & Collins, 2013 discussion of the Standard Model of Talent Development), talent simply refers, rather nebulously, to *the thing being developed.* This is inadequate and confusing because it is indistinguishable from words such as skill or functional capacity, which are easier to define. Howe et al. proposed that talent be situated firmly in genetically transmitted structures and therefore partly innate, which differentiates it from Gagné's (2004) conceptualization of talent as "outstanding systematically developed skills" (p. 119) reflecting both genetically- and experience-based elements. We also advocate talent as representing 'innate' qualities (i.e., present at birth), which reflects standard dictionary definitions of talent as "existing in, belonging to, or determined by factors present in an individual from birth" (Merriam-Webster Dictionary) or "an innate quality or ability is one that you were born with, not one you have learned" (Cambridge English Dictionary). We propose that talent is *that component of development that is present at birth* differentiating it from skills, which reflect learned behaviours that may be confounded by talent.[1] This does not mean that talent is static and incapable of interacting with diverse environmental stimuli. The concept of heritability illustrates the non-static and interactive property of innate talent. Heritability is a measure of the variation in a characteristic (phenotype) within a population that results from genetic variation. Take, for example, IQ, where heritability scores in high socioeconomic vs. low socioeconomic groups (median split) can be approximately 70% and 10%, respectively (Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman, 2003). This example illustrates how genetic factors interact with the environment, and that developmental environments can significantly constrain full expression of genetic capability.

In fact, sensitivity to different environments (e.g., as seen in athletes who are able to respond positively to negative events during development; see Collins & MacNamara, 2012; Hardy et al., 2017) may be positioned as an indicator of talent. In this view, models of talent development should be more correctly called models of *skill* development, with talent as an antecedent of skill-based outcomes. Conceptualizing talent in this way is clearer for practitioners (e.g., for designing skill development models) as well as for researchers (e.g., to create research designs where hypotheses are easier to articulate and examine).

2.2. Multi-dimensional

This qualification is largely uncontroversial, at least with practitioners in sports where athlete development relates to the improvement of skills and capabilities in a range of areas (e.g., such as the physical, technical, tactical, emotional, mental skills outlined in the Canadian Sport for Life Long-Term Athlete Development framework; Way et al., 2016). It is worth emphasizing, however, since researchers continue to focus on uni-dimensional approaches to talent (Johnston et al., 2018). Johnston et al. (2018) noted that the majority of research in this area has focused on physical (e.g., anthropometric, physiological) variables with few studies considering the interaction of variables from different disciplines (e.g., physical and cognitive variables). In part, the uni-dimensional and reductionist approach to innate talent may simply reflect the reality that talent is difficult to define and conceptualize. Indeed, the term 'talent' is itself often implicitly singular, which may also contribute to reductionist approaches and conceptualizations.

2.3. Emergenic

One thing that makes talent selection so difficult is that athletes can usually take multiple pathways to achieve elite performance. Simonton (2001) argued researchers see talent in an overly simplistic fashion, such as reflecting stable traits similar to how we consider eye or hair colour. This simplistic view situates talent-related qualities as easy to identify early and stable across development. Lykken and colleagues (1982; 2006; Lykken, McGue, Tellegen, & Bouchard, 1992) proposed that most complex traits reflect combinations of genes, or partly genetic traits, that work through multiplicative interactions. Emergenic elements reflect this relationship and are defined as:

> Arising as a novel or emergent property resulting from the interaction of more elementary and partly genetic properties. An emergentic trait may be determined by a configuration of independently segregating polygenes interacting in a multiplicative rather than an additive fashion … In some instances, situational factors may figure as configural components. The distinctive feature of emergenesis is the notion of configurality, which implies that a change of any one component may result in a qualitative, or a large quantitative, change in the emergenic trait (Lykken et al., 1992; p. 1569).

For instance, several variables associated with athletic performance appear to be emergenic, such as creativity (Simonton, 2003), leadership (Simonton, 2009), personality traits (Keller, Coventry, Health, & Martin, 2005), and recreational interests (Lykken, Bouchard, McGue, & Tellegen, 1993). The relationship between genetic properties and height is a useful illustration of an emergenic property. Research has identified *hundreds* of genetic variants, in approximately 180 loci, that constrain human height (Allen, Estrada, Lettre et al., 2010). Adult height, which is important to performance in many sports, and is relatively straightforward to measure and forecast, results from a complex pattern of polygenic inheritance (i.e., DNA sequence variants at many genetic loci) and environmental interaction (e.g., proper nutrition). The full implication of the emergenic property becomes evident, and daunting, when we consider the multi-dimensional nature of talent and more complex traits than simply adult height.

2.4. Dynamic

A simple view of genes is that their effects are expressed at birth and

[1] It is important to note that genetic factors are not immutable or fixed prior to birth. The fetal programming hypothesis proposes that intrauterine stressors (e.g., compromised nutrition, exposure to influenza and other viruses) can permanently re-program an individual's development, with lasting health and growth-related consequences (Brutsaert & Parra, 2009).

therefore easy to identify. This reflects the approach that youth who are exceptional at throwing, catching, running and so on at early stages of development must have the genes required for adult success. This view is certainly too simplistic to capture current understanding of genetic action. Genes are expressed across developmental time, which results in unpredictable patterns of development. This is especially true when dealing with complex outcomes like sports performance where the traits are polygenic and multi-disciplinary. In Simonton's view, these qualities are seen as 'epigenetic', reflecting a start from an undifferentiated state and then moving to differentiation over time through subtle and not so subtle interactions with the environment. However, there have been recent calls to limit the use of 'epigenetic' to specific "phenomena and mechanisms that cause chromosome-bound, heritable changes to gene expression that are not dependent on changes to DNA sequence" in order to prevent confusion with the actual processes of epigenetic effect (Deans & Maggert, 2015). Ecological psychologists use the term 'dynamic' to refer to similar action. At the heart of both 'dynamic' and 'epigenetic' is the notion that the process of development evolves over time due to interactions with the environment:

> "Ask not what a gene does. Ask what it does in a particular environment and when expressed in a particular network of other genes … genes aren't about inevitability. Instead they're about context-dependent tendencies, propensities, potentials, and vulnerabilities. (Sapolsky, 2017; p. 265)"

As if the conceptualization of talent as a dynamic, multi-disciplinary phenomenon that emerges across an unpredictable time course was not complex enough, there is evidence indicating that complicated biological outcomes like sports performance are hostage to the effects of random gene expression. Some elements of development are random and unpredictable. As Davids and Baker (2007) noted in their deconstruction of the false dichotomy of nature versus nurture, interactions at the molecular level have a degree of randomness in biological processes such as transcription, protein synthesis and gene transmission. This means skill development will always have a degree of unpredictability.

2.5. Symbiotic

Skill development does not operate in a vacuum, and, as a result, the value of any given talent characteristic is determined by a host of other contextual factors such as cultural importance and relevance to elite sport performance at that specific point in time. For example, the cultural importance of bobsleigh in Germany is apparent (supported by a host of training facilities and human capital) and there is no reason to suppose that Germans are innately talented at sliding down a manmade chute of ice in a small torpedo. In a different culture such athletes (e.g., those with superior genetic potential for power-based sports; Calvo et al., 2002) might be sprinters, rugby players or American football players. The anthropometrics profiles of athletes from different sports have changed over time, altering the value of these variables for long-term development (Norton & Olds, 2001). In sports like men's soccer and football for example, players have become taller and heavier as these characteristics have become more valued (e.g., associated with longer careers, better performance; Norton & Olds, 2001). This suggests a symbiotic relationship between the talent-related characteristics of the individual athlete, the value of those characteristics by the developmental environment in which they find themselves and the task constraints of the sport.

3. Implications of this view on talent

3.1. Conceptualizing better research questions

Without a clear conceptualization of talent, it is not possible to design appropriate investigations to evaluate it. Having a solid conceptual foundation will allow researchers to utilize approaches such as twin and family studies to determine the long-term relevance of this concept. Twin and family designs, in particular, could be important for determining the role of other factors present at birth but not related to biological constraints (e.g., parental socioeconomic status, socio-cultural traditions) on the development of exceptional athletes. Moreover, a stronger conceptualization will allow for better modeling of relationships between talent and the developmental environment. In Figure 2, we note different types of interactions between talent related factors and athlete development outcomes. For instance, as we noted earlier, an individual's predicted adult height is directly related to their likelihood of becoming an elite performer in sports where height is seen as a critical variable for future performance (e.g., UK Sport's Tall and Talented national search program). In addition to this simple direct relationship, genetic factors may have moderating or mediating influences (Barron & Kenny, 1986). According to classic definitions, moderating variables affect the strength and/or direction of the relationship between a predictor variable and an outcome variable. For instance, identifying relationships between genetically-constrained indicators of personality (e.g., conscientiousness, Bergeman et al., 1993; selfishness, ruthlessness, Hardy et al., 2017) and important training-related outcomes (e.g., propensity and motivation to practice) might reflect a moderating role for talent-related factors on the relationship between training behaviours and attainment. Individuals with different profiles on these talent-related variables may have different training and competition experiences, which ultimately influence attainment. Conversely, talent-based factors may have mediating relationships as reflected in situations where the association between an independent variable and a dependent variable is partially or fully explained by a third (i.e., mediating) variable. For instance, in a study of physical activity time by Barnett, Morgan, van Beurden and Beard (2008) adolescents' beliefs in their sport competency mediated the relationship between skill proficiency in childhood and physical activity participation six years later. Similar relationships likely apply to talent development environments but have yet to be explored. For example, an individual's propensity to accumulate the considerable hours of training/practice required for optimal skill acquisition may be driven by genetically-constrained factors related to motivation (e.g., achievement motivation, Halvari & Kjormo, 1999). Our understanding of the psychological factors (e.g., motivation, personality) related to the long-term development of elite performers is still developing (see Hardy et al., 2017) but it is plausible that many of these factors are partially influenced by genetic factors, thereby reflecting talent-related qualities. This suggests several fruitful lines of future research such as determining the optimal developmental environments to facilitate the emergence of these factors.

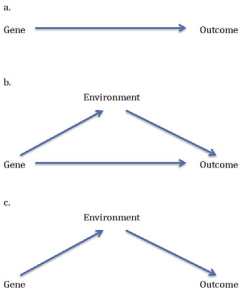

Figure 2. The different relationships between genes and talent-related outcomes Figure (a) shows the direct relationship where a gene directly affects a talent-related outcome (e g., genes for height) whereas Figure (b) shows a moderating relationship with the environment affects the strength and direction of the association between genes and outcome. Figure (c) reflects a mediating relationship where the environment accounts for the relationship between a gene and the outcome.

Importantly, better and clearer conceptualizations of talent will facilitate determining the long-term validity of this concept – if only to

eventually dismiss this conceptualization in favour of one that is more valid (e.g., adding, removing, or modifying some of the five qualities discussed above). Currently, the notion of talent in sport is so vague it makes testing its validity difficult.

3.2. Improving models of athlete development

Models of development are based on assumptions of stability and generalizability across development, which may violate some of the conditions noted above (e.g., that it is epigenetic). Current models that describe development relative to stages or phases, run the risk of impeding development by being too prescriptive. Moreover, these models assume that the nuances of athlete development are known and can be distilled to a few stages of development (for an exception, see the Athlete Skills Model developed by Wormhoudt, Savelsbergh, Teunissen and Davids, 2018). They also assume developmental environments are static across generations when the value of talent in a given domain likely changes over time as sports mature and level of competition increases or decreases. An important area of future research would be to evaluate long-standing models of athlete development to determine how they change as sports evolve. For example, in a sport that has become increasingly popular, the pathway to success may have stabilized due to a decrease in inter-individual developmental variability (i.e., flexibility in how an athlete develops is reduced). Conversely, given the range of genetic and developmental factors that have the potential to influence an athlete's development, it is possible there will always remain many ways athletes can traverse the pathway to expertise. Ultimately, there are inherent limitations to athlete development models that overly rely on aggregates, categorization and dichotomisations to prescribe athlete development. Such processes ignore intra- and inter-individual variability in the multidimensional nature of talent and athlete development. Importantly, these models suggest the factors underpinning talent and its emergence in various environments remain consistent across sports, which may be problematic. Individual sports may wish to consider talent more specifically as it relates to their domain and develop sport-specific models of talent development.

3.3. Challenging traditional methods in talent research

If innate talent is multidimensional, emergenic (the result of diverse multiplicative processes), dynamic (its expression evolves over time due to interactions with the environment), and symbiotic (subject to environmental constraints), we must rethink how we appraise evidence used to inform models of athlete development. Several researchers have cautioned against the exclusive use of uni-dimensional discrete measures, in favour of more longitudinal approaches (Johnson et al., 2018; Baker & Wattie, 2018; Abbott, Button, Pepping & Collins 2005). However, there may be other methodological implications to our characteristics of talent in sport.

In addition to the general criticisms around the reliance of the commonly used null hypothesis significance testing (NHST) and *p* values (see Cohen, 1994; Hopkins & Batterham, 2016; Wasserstein & Lazar, 2016), there may be specific reasons to consider other methodological paradigms in talent research (see also Büsch & Granacher, 2017). First, the characteristics of talent in sport (e.g., that talent is rare, Baker & Wattie, 2018) mean that studies of talent are predisposed to being underpowered and may have too much variation to detect small effects/differences. Second, if talent is as dynamic, complicated, symbiotic and rare as proposed then there are problems with the logic of NHST, specifically NHST's reliance on inferring trends to other hypothetical populations. If our qualities of talent in sport are accurate, then there are conceptual issues with 'inference'. There could be problems with inferring findings from a sample to a group of hypothetical athletes who may have different combinations of talent characteristics, or that may have performance-related characteristics that differ from current conceptualizations of talent (i.e., what is 'talent now' might not be what talent is later). There is simply too much variation, too many different ways of 'being talented', too many unique pathways to expert performance (and therefore roles for talent in that process) to make inferences using *only* NHST to be accurate and perhaps appropriate (both empirically and theoretically). There is also the problem of using discrete measures at one point in time to decide that something is or is not a statistically significant indicator of talent. This approach is not consistent with the multidimensional, dynamic and emergenic properties of talent. As such, it may be necessary for a continued and renewed call for methodological pluralism within talent research, and to triangulate evidence from multiple paradigms to form the most accurate evidence-base that is consistent with 'what talent is'.

A number of different methods and paradigms, including NHST. could be used to triangulate evidence related to talent in sport. Magnitude-based inference (see Hopkins & Batterham, 2016; Hopkins, Marshall, Batterham, & Hanin, 2009), while certainly controversial (see Bernards, Sato, Haff, & Bazyler, 2017; Saini, 2018; Hopkins & Batterham, 2018), would be one way to permit these types of more sensitive classifications of evidence for talent. This approach would have the benefit of providing probabilistic estimates to a probabilistic process (Abbott et al., 2005). It would allow estimates (with confidence intervals) to exist within categories of evidence (i.e., not reliable, reliable but trivial, or reliable and non-trivial) and to overlap across these categories (see Figure 3). For example, an estimate of talent could exist within the 'reliable and non-trivial' category, but with a small range of its confidence interval extending/overlapping into the 'reliable but trivial' category. In traditional NHST paradigms this type of trend would be classified as 'not statistically significant' when it actually indicates that the estimate may be reliable for many and trivial for some. Researchers could also employ a range of other quantitative approaches, such as decision-theoretic modeling, false discovery rates and more traditional Bayesian inference (see Mengersen, Drovandi, Robert, Pyne, & Gore, 2016), that also address the issue of probability and the importance of magnitudes in talent research (see Bernards et al., 2017; Wasserstein & Lazar, 2016). In addition, given the dynamic nature of talent, qualitative methods may be particularly useful for capturing the nuance and complexity of talent identification and development in sport. Such approaches, using longitudinal data or merging data from cross-sectional studies across ontogenic time, would provide scientists and practitioners with more accurate estimates of how the influences of talent characteristics/indicators change over time. Potentially, this would equip scientists and practitioners with additional tools to make more informed decisions about the likelihood of type I and II errors in talent identification and development. We then at least start to form a better picture of how our indicators of innate talent probabilistically fluctuate over time.

3.4. Improving the process of talent identification/selection

A key element of most athlete development systems is regular evaluation of developing athletes to determine their suitability for high performance sport. Regular 'identification' and/or 'selection' is a reality for the majority of high performance sports due to limitations in the resources available for high performance athlete development (e.g., governmental funding, elite coaches, etc.). However, research on the

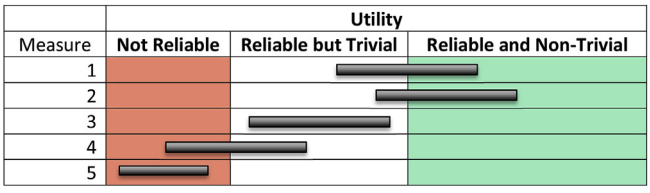

Figure 3. Example of a profile of talent-related measures and their effects using magnitude-based inference.

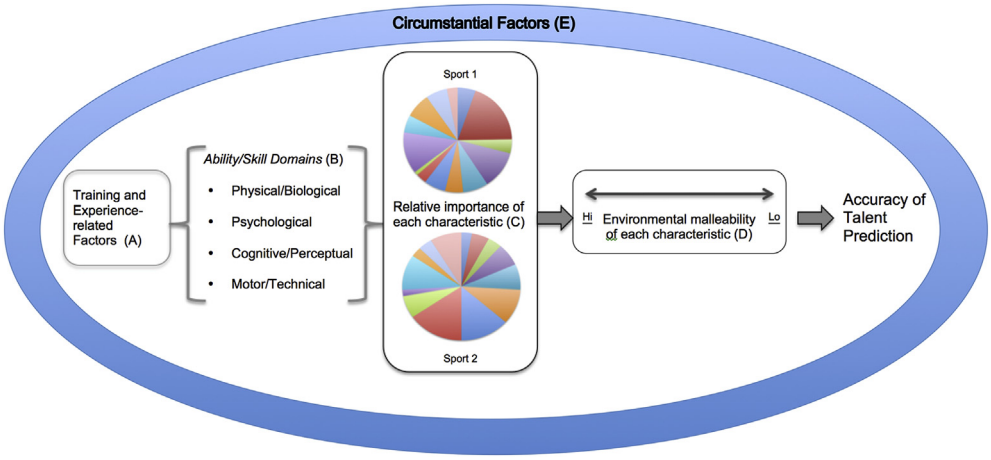

Figure 4. Relationships between different factors in determining the accuracy of talent predictions.

efficacy of identification and selection decisions is rare (Johnston et al., 2018), and existing examinations suggest the accuracy of these decisions is generally poor (e.g., Koz et al., 2012). Regardless, without a fundamental re-structuring of the delivery of high performance sport in most countries, resources for athlete development will continue to be limited thereby necessitating selection/de-selection from the high performance athlete pathway at some point.

Central to this discussion is how current approaches to selection might be improved. In Figure 4, the accuracy of talent selection decisions is constrained by a range of factors. For instance, coaches, scouts and recruiters generally consider athletes across a range of 'talent/skill domains' (B) (e.g., physical and technical test batteries, or taxonomies of skills and abilities; c.f. Fleishman, 1975). However, because these tests are largely confounded by prior exposure to athlete training and developmental opportunities, training and experience related factors (A) have to be considered. Furthermore, the overall relevance of each variable as a predictor of long-term potential relates to i) the relative importance of each variable to adult-level performance (C) and ii) the degree to which this variable is changeable by the developmental environment (D). For example, height is an important performance-related characteristic in many sports and future adult height can be predicted using sex-based maturity and height velocity curves (Kozieł & Malina, 2018; Sherar, Mirwald, Baxter-Jones, & Thomis, 2005). Therefore, height can be predicted relatively early and with reasonable precision suggesting the extent to which height is relevant to a sport will directly affect how accurate athlete selections will be. Importantly, even in sports where height is obviously critical (e.g., basketball), it is not the only relevant performance-related variable. In order to have high levels of accuracy, *all* of the performance-related variables would need to have similarly accurate and precise early indicators, which is unlikely (Johnston et al., 2018). Factors that may underpin skill and performance that are more predictable and/or stable over time (e.g., some measures of personality at some points in development, Penke, Denissen, & Miller, 2007; height, Yang, Benyamin, McEvoy, Gordon, Henders, et al, 2010) may be more accurately assessed than factors such as decision-making, anticipation and creativity that are more adaptable to training and instructional resources. The task then is to determine which indicators are drawn from talent elements that are more versus less stable across development. From this perspective, the more a sport is dependent upon elements that are generally stable, the more they lend themselves to accurate long-term prediction.

Making this process even more complex are the impacts of factors such as one's age compared to their peers (see Relative Age Effects; Wattie, Schorer & Baker, 2015), family socio-economic status (Fairclough, Boddy, Hackett, & Stratton, 2009; Lawrence, 2017) and characteristics of early developmental environments (Rossing, Stentoft, Flattum, Côté, & Karbing, 2017), which are largely random, circumstantial and unpredictable but nonetheless affect a person's likelihood of becoming an elite athlete (E). Collectively, this highlights the complexity of talent identification and selection processes and, perhaps, explains the low levels of accuracy in many identification initiatives.

4. Concluding thoughts

Our intention in this review was to clarify the notion of talent in sport as it relates to research and practice in athlete development, in order to inform an approach that is unique to this domain of human endeavour. We suggest that such clarification is important for designing superior research studies and stronger evidence-based policy. Importantly, as researchers who focus on the role of the environment in facilitating and optimizing athlete development, we do not wish to devalue the influence of the developmental environment; however, our definition of talent does position the environment in a different way. More specifically, the environment becomes an arena that is responsible for providing the varying stimuli necessary to facilitate the acquisition/emergence of key performance-related capacities. Ultimately, an individual's capacity for positively interacting with the environments in which they find themselves may be the most significant constraint to maximizing their potential. This requires a clear understanding of what optimal development entails and for whom, which is incomplete, especially at younger ages, given the dynamic, emergenic and multidimensional qualities of talent in sport. We would submit that this review provides an important starting point for the long and winding road ahead.

Declarations of interest

None.

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