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Determinants of drop-out in youth basketball: an interdisciplinary approach

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ABSTRACT

Using an interdisciplinary approach, we examined the baseline variation in biological maturity status, training experience, body size, functional capacities (Line Drill test and Yo-Yo Intermittent Recovery level 1 test) and motivation for achievement, competitiveness and deliberate practice of youth basketball players according to their participation status in the sport two years after assessment. Fifty-seven players were considered (10.5 to 15.5 years). Two years later we ascertained whether players discontinued participation (dropout), or remained playing engaged within a structured basketball training program. Taller adolescent players were more likely to be selected/promoted in youth basketball regardless of their lower functional capacity. Achievement and competitiveness motivation (will to excel and competitiveness) were related to dropping out or persisting in this sample of youth basketball players. Overall, there is a need to consider the interaction between physical growth, biological maturation, functional capacities and behavioural characteristics, specifically among players on the path to sport expertise.

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Introduction

Talent identification, selection and development are a major focus of youth sports programs. Within applied contexts, such as sports federations or professional clubs, there has been a generalization of providing youth sports programs using an "elite academies" model (e.g., Peek, Gatherer, Bennett, Fransen, & Watsford, 2018), focused on the development of high performance athletes, where children and adolescents can develop in a highly targeted, athlete-centred environment built around early specialization (Baker, Schorer, & Wattie, 2018). These youth sports programs generally assume that talent is a fixed capacity which consequently, can be identified and predicted early (Baker et al., 2018; Gonçalves, Rama, & Figueiredo, 2012). However, the

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paths to adult expertise in sports are both highly selective and nonlinear (Abbott, Button, Pepping, & Collins, 2005). Accordingly, the mechanisms that may predict future success or dropping out from organized sports are multifactorial and highly complex (Gonçalves, Figueiredo, & Silva, 2009), especially in sports like basketball, where structured training systems start at early ages (Gonçalves, Silva, Carvalho, & Gonçalves, 2011).

Basketball performance is influenced by physical, physiological, and behavioural characteristics (Carvalho, Gonçalves, Collins, & Paes, 2018; Clemente et al., 2018; Dragonea et al., 2019), perhaps even more so with young players (Carvalho et al., 2018). Body size and physiological performance are particularly valued in the selection process for youth basketball (Drinkwater, Pyne, & McKenna, 2008). Indeed, coaches may well be overvaluing these factors as available data in youth basketball, albeit scarce, shows an overrepresentation of early maturing boys (Carvalho et al., 2018; Carvalho, et al., 2013, 2011; Torres-Unda et al., 2016). Furthermore, studies tend to focus on selected characteristics of young players, considering unidisciplinary perspectives from either biological, psychological *or* behavioural variables (Carvalho et al., 2018). These studies also appear to favour those who remain in the sport, often labelled "elite youth players", rather than considering a more balanced and comprehensive data set from successes *and* failures across *several* interacting variables.

When considering young athletes, particularly during pubertal growth, coaches and researchers need to consider the possible interacting influence of chronological age, biological maturation and accumulated experience in the sport on body dimensions, functions and behaviours (Carvalho et al., 2018). Maturation is a major confounding variable to interpret young players´ performance, given the numerous hormonal changes during puberty resulting in important physical, physiological and behavioural changes (Pearson, Naughton, & Torode, 2006). Therefore, early prediction of adult performance from adolescent data is difficult and likely to be unreliable, although it remains the typical *modus operandi* in high-performance sport (Baker et al., 2018).

Behavioural dimensions have been sparsely considered in studies of young athletes (Carvalho et al., 2018; Figueiredo, Goncalves, Silva, & Malina, 2009), where the focus is mostly based on biological and performance characteristics (Till et al., 2016). Particularly in youth sports programs focused on the development of high performance athletes, it is generally assumed that expertise development is positively associated with an accumulated amount of training hours, and that the age of specialization is a particularly decisive moment to lift an athlete's skill level, readiness, and commitment (de Bruin, Smits, Rikers, & Schmidt, 2008; Gonçalves et al., 2011). Although psychological characteristics play a central role in the development of sport expertise (Baker et al., 2018), there are limited studies considering interactions of behaviour characteristic with physical growth, function and experience in youth sports (Figueiredo et al., 2009; Gonçalves et al., 2009).

Reflecting these various issues, we examined the baseline variation in biological maturity status, training experience, body size, functional capacities and motivation for achievement, competitiveness and deliberate practice of youth basketball players according to their participation status in the sport two years later. Specifically, we were interested in baseline differences between those who discontinued or continued to participate in the sport.

Methods

Experimental approach to the problem

The present study considers 57 male basketball players aged 10.5 to 15.5 years, measured in 2015. When measured, players were engaged in formal training and competition within a local club in Campinas metropolitan region and competed at the state level supervised by *Federação Paulista de Basketball (FPB)*. Players were part of the under-11 and under-12 teams that trained six hours per week, and the under-13 to under-15 teams that trained 8 hours per week. No participant was suffering from lower extremity musculoskeletal injury at the time of testing or during 6 months before testing.

All players were contacted again in 2017 to follow up their current status in the sport, i.e. whether they remained engaged in basketball structured training and competition or abandoned basketball. Hence, two groups of playing status were defined: *drop-outs*, players who discontinued (abandoned) basketball; and *persisters*, players who remained engaged in basketball structured training and competition, at least at same the level of baseline measurement.

The study was approved by the *Research Ethics Committee of the University of Campinas*. Participation in this study was voluntary; players and their parents or legal guardians provided informed written consent.

Procedures

Details about procedures and reliability estimates are presented elsewhere (Carvalho et al., 2018), as the present study re-examines the data at baseline, considering the players within status at follow-up two years later.

Briefly, we considered anthropometry measures, taken by a single and experienced observer following standardized procedures, including stature, sitting height, body mass and the triceps, subscapular, suprailiac and medial calf skinfolds, which were summed as a measure of relative body fat distribution. Intra-observer technical errors of measurement were 0.25 cm for stature, 0.38 cm for sitting height, 0.42 kg for body mass, and 0.68–0.91 mm for skinfolds.

Chronological age was calculated to the nearest 0.1 year by subtracting birth date from the date of testing. We used the maturity offset protocol (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002) to derive age at peak height velocity (PHV). Prediction of time before or after PHV considers chronological age, stature, body mass, sitting height and estimated leg length (stature minus sitting height). The assumptions and limitations of the offset equation applied to the sample of the present research project were recognized elsewhere (Carvalho et al., 2018).

We used two protocols of functional capacity for basketball: a short-term maximal effort protocol, the *Line Drill test* (Carvalho, Gonçalves, Grosgeorge, & Paes, 2017) and an intermittent endurance test, the Yo-Yo Intermittent Recovery level 1 test (Yo-Yo IR1) (Bangsbo, Iaia, & Krustrup, 2008). Each functional performance variable was standardized to a z-score; z-scores were reversed for the Line drill performance; as lower times indicate better performance. The respective z-scores were summed to provide composite functional performance indicators for each player.

To evaluate psychobehavioural factors, we used the Work and Family Orientation Questionnaire (Helmreich, Beane, Lucker, & Spence, 1978) and the Deliberate Practice Motivation Questionnaire (de Bruin et al., 2008). The former has 19 items, rated on a 5-point Likert scale (1 = completely disagree to 5 = completely agree), and assesses four dimensions of achievement: personal unconcern, work, mastery and competitiveness. We only used the last three subscales in the present study, consistent with previous observations with similar samples of youth basketball (Carvalho et al., 2018; Gonçalves et al., 2011). The Deliberate Practice Motivation Questionnaire (DPMQ), originally designed for chess (de Bruin et al., 2008), was adapted for basketball, translated and validated to Portuguese (Gonçalves et al., 2011). Two dimensions of deliberate practice are considered: will to compete and will to excel. The questionnaire is composed of 18 items, similarly rated in a 5-point Likert scale. The adapted Portuguese version showed good reliability in previous data in youth basketball from the same age range of the present study (Gonçalves et al., 2011).

Finally, years of experience in formal basketball training and age when players first took part in organized basketball practice were obtained by interview of the players, and confirmed with their coaches and parents.

Statistical analysis

Modelling approach. We used a multilevel linear regression model, in this case a null model, which is the simplest two-level model that includes only the random parameters, to measure the proportion of total variance which fell between players grouped by playing status two years after initial observation players (i.e., intraclass coefficient). As expected based on previous observations in youth male basketball (Carvalho et al., 2018, 2011; Drinkwater, Hopkins, McKenna, Hunt, & Pyne, 2007; Torres-Unda et al., 2016), we observed substantial nesting on the dependent variables by age groups (Supplementary table 1). Thus, we assumed players (level-1) nested by age group category (level-2) in the following steps of the analysis.

A series of multilevel linear regression models were fitted to explore whether body dimensions, functional capacities, achievement motivation dimensions and motivation for deliberate practice varied for players grouped by playing status two years after initial observation (dummy variable: drop-outs coded as 0; persisters coded as 1). We accounted for age by alignment with estimated age at PHV (maturity offset) and aggregation between age group at level-2.

We used allometric scaling to partition the influence of body size on the interpretation of functional capacities. Through analysis of the validity of allometric models, based on residual analysis, we only considered Yo-Yo IR1 performance scaled for body mass. Finally, for computational convenience and for interpretation when variables have different scales (McElreath, 2015), we used z-score transformations on both dependent and independent variables.

Priors. Variables standardization allowed us to use weakly informative prior distributions for population-level, normal priors (0,10), and for group-level effects, cauchy priors (0,2). As such, we intend that results reflected the knowledge available from the original data.

Model checking and inference. We used posterior predictive checks to confirm that we did not omit relevant interactions (Gelman et al., 2013). We used the widely applicable information criteria to compare models and to ensure we did not overfit our data (Gelman et al., 2013; McElreath, 2015).

Computation. For each model, we ran a chain for 2,000 iterations with a warm-up length of 1,000 iterations. The models were implemented with Bayesian methods via Markov Chain Monte Carlo (MCMC) simulation and using Hamiltonian Monte Carlo and its extension, the No-U-Turn Sampler, using Stan (Stan Development Team, 2015), and obtained using "brms" package (Burkner, 2017), available as a package in the R statistical language.

Results

Baseline characteristics of drop-outs and persisters, and the comparison between groups are summarized in Table 1. Positive intraclass coefficients indicate the need to consider aggregation at level-2, hence estimates based on single-level regressions become inaccurate (Gelman et al., 2013). There was substantial aggregation by playing status two years after initial observation. This related to chronological age, maturity status, age at the start of basketball training, years of training experience, functional performance score and motivation for achievement, competitiveness and deliberate practice.

Players considered in the present study ranged from under-11 to under-15 yearly competitive age groups. Substantial age-related variation between age groups was present (Supplementary Table 1). Thus, we accounted for variation between players grouped at level-2 within the Bayesian multilevel models to compare baseline characteristics of drop-outs and persisters. Comparisons of body dimension between drop-outs and persisters are summarized in Table 2, partitioning the influence of both maturity status and years of training in basketball, and aggregation at level-2 for an age group. Players who persisted playing basketball were taller, heavier and somewhat larger. As expected, the substantial influence of somatic maturity status was present, regardless of playing status two years later.

Functional performance characteristics of young players who dropped-out or persisted in basketball two years after the measurements are summarized in Table 3. These data partition the influence of both maturity status and years of training in basketball, and aggregation at level-2 for age group partitioning. There was no variation between persisters and drop-outs for Line Drill performance. Also, accounting for differences by playing status two years later and age group variation as a level-2 unit, no influence of maturity status or training experience was apparent. Notably, however, drop-outs had better Yo-Yo IR1 performance, even when the influence of body mass was partitioned using allometric scaling. This scaling removed the influence of maturity status on intermittent endurance performance, independent of playing status two years later and age group variation, as a level-2 unit. Also, a positive influence of experience on intermittent endurance was observed, independent of playing status two years later. When we considered the score of functional capacities, which ranks players with better performance in both tests, persisters were better on overall performance compared to dropouts. Also, more advanced maturity status and years of experience were positively related to the score of functional capacities, when accounting for playing status two years later and age group variation, as a level-2 unit.

Achievement motivation and motivation for deliberate practice characteristics of young players who dropped-out or persisted in basketball two years after the measurements are summarized in Table 4. These data partition the influence of both maturity status and years

Table 1. Descriptive statistics (posterior mean and 90% credible intervals) for players within status at follow-up two years later and corresponding intraclass coefficients.

	All sample (n = 57)	Drop-outs (n = 22)	Persisters (n = 35)	Intraclass coefficient
Chronological age (yrs)	13.2 (12.8 to 13.6)	13.4 (12.7 to 14.0)	13.1 (12.6 to 16.6)	0.12 (0.00 to 0.50)
Maturity offset (yrs)	−0.34 (−0.78 to 0.08)	−0.34 (−1.04 to 0.36)	−0.35 (−0.91 to 0.21)	0.09 (0.00 to 0.45)
Age at the start of basketball training (yrs)	10.1 (9.5 to 10.6)	10.9 (10.1 to 11.7)	9.6 (8.9 to 10.2)	0.23 (0.01 to 0.57)
Years of experience (yrs)	3.1 (2.5 to 3.7)	2.5 (1.6 to 3.6)	3.5 (2.8 to 4.2)	0.13 (0.00 to 0.44)
Stature (cm)	167.9 (164.0 to 171.8)	166.3 (160.0 to 172.7)	168.9 (163.8 to 173.9)	0.00 (0.00 to 0.02)
Body mass (kg)	60.2 (55.8 to 64.8)	56.8 (49.6 to 64.0)	62.4 (56.7 to 68.2)	0.00 (0.00 to 0.02)
Sitting height (cm)	83.5 (81.6 to 85.5)	83.1 (80.0 to 86.3)	83.8 (81.3 to 86.3)	0.01 (0.00 to 0.7)
Sum of skinfolds (mm)	59.0 (53.6 to 64.4)	52.5 (44.0 to 60.9)	63.2 (56.4 to 70.0)	0.00 (0.00 to 0.02)
Line Drill test (s)	34.79 (34.07 to 35.52)	34.84 (33.67 to 36.03)	34.76 (33.82 to 35.70)	0.05 (0.00 to 0.28)
Yo-Yo IR1 (m)	578.2 (515.4 to 641.1)	628.2 (527.5 to 728.9)	546.9 (467.0 to 626.7)	0.00 (0.00 to 0.00)
Scaled Yo-Yo IR1 ($m \cdot kg^{0.61}$)	48.5 (44.0 to 53.0)	54.7 (47.7 to 61.8)	44.6 (38.9 to 50.2)	0.00 (0.00 to 0.03)
Performance composite score (z-score)	0.00 (−0.45 to 0.45)	0.19 (−0.55 to 0.93)	−0.12 (−0.71 to 0.46)	0.24 (0.00 to 0.69)
Achievement motivation				
Work (1–5)	4.47 (4.32 to 4.60)	4.42 (4.21 to 4.64)	4.49 (4.31 to 4.66)	0.86 (0.00 to 0.87)
Mastery (1–5)	4.17 (3.99 to 4.35)	4.08 (3.79 to 4.37)	4.23 (4.00 to 4.46)	0.31 (0.00 to 0.81)
Competitiveness (1–5)	3.64 (3.44 to 3.83)	3.37 (3.07 to 3.67)	3.80 (3.57 to 4.04)	0.45 (0.01 to 0.85)
Deliberate practice motivation				
Will to excel (1–5)	4.21 (4.00 to 4.42)	3.85 (3.53 to 4.17)	4.43 (4.18 to 4.69)	0.48 (0.03 to 0.83)
Will to compete (1–5)	4.34 (4.19 to 4.49)	4.31 (4.06 to 4.55)	4.36 (4.16 to 4.56)	0.32 (0.00 to 0.84)

Table 2. Comparison between persisters and dropouts for body size, accounting for between player associated variation in training experience and maturity status, and aggregation by age group at level-2 using Bayesian multilevel models.

	Stature	Body mass	Sitting height	Sum of skinfolds
Population-level effects (90% credible interval)				
Intercept	−0.12 (−0.45 to 0.18)	−0.18 (−0.56 to 0.26)	−0.06 (−0.61 to 0.53)	−0.41 (−1.45 to 0.60)
Persisters/drop-out category *	0.16 (−0.02 to 0.35)	0.30 (0.09 to 0.51)	0.04 (−0.04 to 0.12)	0.51 (0.09 to 0.92)
Maturity offset	1.09 (0.90 to 1.29)	1.14 (0.85 to 1.45)	1.42 (1.32 to 1.53)	0.58 (−0.12 to 1.25)
Years of experience	−0.10 (−0.19 to −0.01)	0.02 (−0.10 to 0.14)	−0.04 (−0.08 to 0.01)	−0.00 (−0.24 to 0.23)
Group level estimates (90% credible interval)				
Level 2, between age group effects				
Intercept standard deviation	0.35 (0.08 to 0.78)	0.50 (0.06 to 1.18)	0.75 (0.35 to 0.41)	1.17 (0.18 to 2.46)
Level-1 standard deviation	0.36 (0.30 to 0.40)	0.44 (0.37 to 0.53)	0.17 (0.14 to 0.20)	0.90 (0.76 to 1.08)

* Persisters/drop-out category: dummy category with dropout coded 0, persisters coded 1; hence intercept is the estimate for the drop-outs and Persisters/drop-out category estimate represents the difference magnitude for the persisters players.

Table 3. Comparison between persisters and dropouts for functional capacities, accounting for between player variation in training experience and maturity status, and aggregation by age group at level-2 using Bayesian multilevel models.

	Line Drill test	Yo-Yo IR1	Scaled Yo-Yo IR1	Performance composite score
Population-level effects (90% credible interval)				
Intercept	−0.02 (−0.57 to 0.50)	0.31 (−0.08 to 0.76)	0.44 (−0.02 to 0.92)	0.22 (−0.20 to 0.63)
Persisters/drop-out category*	0.01 (−0.44 to 0.44)	−0.49 (−0.87 to −0.14)	−0.72 (−1.17 to −0.30)	−0.31 (−0.70 to 0.09)
Maturity offset	−0.30 (−0.61 to 0.10)	0.49 (0.18 to 0.78)	0.12 (−0.31 to 0.44)	0.48 (0.12 to 0.77)
Years of experience	−0.08 (−0.31 to 0.17)	0.21 (0.02 to 0.39)	0.22 (−0.01 to 0.45)	0.18 (−0.05 to 0.40)
Group level estimates (90% credible interval)				
Level 2, between age group effects				
Intercept standard deviation	0.52 (0.08 to 1.27)	0.36 (0.04 to 0.89)	0.39 (0.03 to 1.07)	0.34 (0.04 to 0.92)
Level-1 standard deviation	0.89 (0.75 to 1.06)	0.73 (0.63 to 0.86)	0.92 (0.77 to 1.09)	0.77 (0.65 to 0.91)

* Persisters/drop-out category: dummy category with dropout coded 0, persisters coded 1; hence intercept is the estimate for the drop-outs and Persisters/drop-out category estimate represents the difference magnitude for the persisters players.

Table 4. Comparison between persisters and dropouts for achievement motivation and deliberate practice motivation, accounting for between player variation in training experience and maturity status, and aggregation by age group at level-2 using Bayesian multilevel models.

	Achievement motivation			*Deliberate practice motivation*	
	Work	Mastery	Competitiveness	Will to Excel	Will to compete
Population-level effects (90% credible interval)					
Intercept	−0.07 (−0.52 to 0.40)	−0.02 (−0.39 to 0.38)	−0.32 (−0.74 to 0.11)	−0.37 (−0.95 to 0.19)	−0.05 (−0.58 to 0.45)
Persisters/drop-out category *	0.13 (−0.36 to 0.64)	0.07 (−0.37 to 0.51)	0.53 (0.06 to 0.98)	0.59 (0.12 to 1.06)	0.08 (−0.42 to 0.59)
Maturity offset	0.12 (−0.21 to 0.47)	0.23 (−0.04 to 0.51)	−0.04 (−0.38 to 0.26)	−0.12 (−0.54 to 0.22)	0.16 (−0.19 to 0.52)
Years of experience	0.01 (−0.27 to 0.28)	0.36 (0.11 to 0.58)	0.13 (−0.14 to 0.39)	0.25 (0.02 to 0.51)	0.09 (−0.19 to 0.38)
Group level estimates (90% credible interval)					
Level 2, between age group effects					
Intercept standard deviation	0.29 (0.02 to 0.40)	0.23 (0.01 to 0.69)	0.24 (0.01 to 0.72)	0.48 (0.06 to 1.23)	0.42 (0.05 to 1.09)
Level-1 standard deviation	1.05 (0.89 to 1.23)	0.91 (0.77 to 1.06)	1.01 (0.86 to 1.20)	0.91 (0.78 to 1.08)	1.01 (0.84 to 1.20)

* Persisters/drop-out category: dummy category with dropout coded 0, persisters coded 1; hence intercept is the estimate for the drop-outs and Persisters/drop-out category estimate represents the difference magnitude for the persisters players.

of training in basketball, and aggregation at level-2 for age group partitioning. Overall, both groups of players showed high scores for the dimensions of the Work and Family Orientation Questionnaire. All players had high scores for work, independent of playing status two years later, maturity status, experience or aggregation at level-2 for the age group. As for mastery, there was a positive influence on the scores of maturity status and years of experience in basketball, regardless of playing status two years later, accounting for aggregation for age group at level-2. Perhaps unsurprisingly, persisters had higher scores of competitiveness compared to dropouts, independent of maturity status and years of experience in basketball. The Deliberate Practice Motivation Questionnaire scores were high in the present basketball sample. For will to excel, persisters had higher scores than drop-outs, independent of maturity status. Also, years of experience in basketball had a positive influence, accounting for variation in playing status two years later. The scores of will to compete were high for all players, when accounting for variation in all variables and levels in the model.

Discussion

In this study we used an interdisciplinary approach to examine the baseline variation in biological maturity status, training experience, body size, functional capacities and motivation for achievement, competitiveness and deliberate practice of youth basketball players according to their participation status in the sport two years later (i.e. discontinued their participation in the sport, drop-out; or continued to participate in the sport, persisters). Drop-outs were slightly older but had less accumulated training experience than those who remained in the training programs two years after initial observation. Considering variation between players for chronological age, maturity status and training experience, those retained in the youth basketball training programs had higher body dimensions and worse functional capacity but notably, had higher values for competitiveness (achievement motivation), will to excel and will to compete (deliberate practice motivation) compared to those who dropped out. Overall, coaches appear to have selected those who were taller, heavier and motivated to compete and excel, even if they had worse functional performance compared to those who were not retained in the youth basketball program.

We acknowledge the limitations of the maturity offset equation to estimate individual maturity status (Carvalho et al., 2018; Malina & Koziel, 2014). However, the range of predicted ages at PHV and uncertainty estimates by age group (see Supplementary Table 1) were within the ranges for age at PHV derived from longitudinal studies which modelled individual stature data for young athletes (Carvalho, Lekue, Gil, & Bidaurrazaga-Letona, 2017; Philippaerts et al., 2006), as well as the longitudinal studies where the maturity offset protocol was used (Mirwald et al., 2002). Cautiously, we may infer that the players in the present sample, on average, were "on time" in maturation, but substantial between-player variability was present (Table 1). Hence, the need to appropriately account for variation on predicted age at PHV when interpreting body size, functional capacities and motivation for achievement, competitiveness and deliberate practice. Considering the athletes by playing status two years after observation, persisters were slightly advanced in maturity status.

Concerns about the risks and potential impacts of early specialization in youth sports have been raised (Baker, Cobley, & Fraser-Thomas, 2009; Pasulka, Jayanthi, McCann, Dugas,

& LaBella, 2017). However, the current practices in youth sports programs often referred as "elite academies" are generally focused on early specialization (Baker et al., 2009, 2018). As stated earlier, this approach is based on several assumptions, such as talent is a fixed capacity than can be identified early, or beliefs about talent (e.g., talent as a gift) (Baker et al., 2018). On the other hand, the perspective is also supported with the argument that expertise attainment needs a deliberate engagement (Ericsson, 2007) in practice during the specialization years, spending time wisely and always focusing on tasks that challenge the current performance (Gonçalves et al., 2011). In the present study, persisters started their formal training in basketball earlier. Consequently, they had more accumulated experience than their dropout peers two years after observation. Similar observations were reported in youth soccer (Figueiredo et al., 2009). Therefore, although the body of evidence is sparse, it appears to confirm that young athletes starting early in organized training may have advantages in the selection process in youth team-sports.

When comparing body dimensions of players by playing status two years after observation, there were no apparent differences for body dimensions (see Table 1). However, as reported earlier (Carvalho et al., 2018), there was substantial variation in body dimension associated with contrasting maturity status (Table 2). Hence, we re-modelled body dimensions by playing status, aligning for maturity-associated and chronological age-variations in the sample. The results of the Bayesian multilevel revealed that taller and heavier players were likely to be retained two years after the observations (see Table 2). These findings are consistent with the limited observations in youth basketball. For example, in a sample of 84 Portuguese players aged 12 to 15 years, retained players (n = 52) were also taller and heavier than dropouts (n = 32) two years after observations (Gonçalves et al., 2009).

Results also highlight the need to be cautious when interpreting the functional performance of adolescent basketball players. A naive interpretation of the comparisons between drop-out and persisters (i.e., without considering variations in age, maturity status and training experience – Table 1) would suggest that persisters were better on Line-drill performance than drop-out players whilst, on overall performance composite score, drop-outs were better than persisters. Also, this simple picture would suggest that there were no differences on intermittent endurance performance between players by playing status. However, after aligning the influence of age, maturity indicator and training experience in the Bayesian multilevel models the initial interpretations differ. Consequently, dropouts showed higher intermittent endurance performance, even when allometric scaling was performed, and substantially better overall functional performance. Also, the differences in the Line drill performance between players by playing status were explained by age-related variation (note the substantial group-level estimate for age group effects, and the large uncertainty estimates for maturity offset and years of experience at population-level effects). The preceding observations add to the need for appropriate analytical approaches to examine the interactions between age, maturity status and years of experience in sport with performance.

Consistent with the observations with a Portuguese youth basketball sample (Gonçalves et al., 2009), persisters appear to have lower levels of functional capacity during pubertal years compared to those who are not retained in basketball. Of course, these interpretations are limited to the data available and lack the prospective of repeated measures across pubertal years. For example, it has been noted in a longitudinal study in youth soccer that the rate of changes within a competitive season should also be considered to interpret functional capacities of young players (Bidaurrazaga-Letona, Lekue, Amado, & Gil, 2017).

These concerns notwithstanding, it is likely that the present sample already reflects a highly selected group of young basketball players. This may contribute to the high scores observed for both achievement and competitiveness motivation, and deliberate practice motivation in the present study. A naive interpretation (Table 1) would suggest that players that persisted in youth basketball training programs had substantially higher values in all dimensions of motivation in both questionnaires used. However, considering the substantial influence of chronological age and years of experience in basketball, but not maturity status, persisters were more motivated for excel and for competitiveness, and similarly high in the other dimensions compared to dropouts. These results are consistent with observations where will to excel was the main predictor identified to classify under-16 players by competitive level in both male (Gonçalves et al., 2011) and female (Gonçalves, Carvalho, & Gonçalves, 2015) youth basketball. The results add to the calls for further consideration of behavioural characteristics in the study of young athletes' development and progression in sport (Carvalho et al., 2018; Figueiredo et al., 2009; Macnamara & Collins, 2013).

Finally, the present study is limited by its sample size, and may reflect particular characteristics of context of the study, warranting caution when generalizing interpretations. Also, we were not able to track information about growth, performance and behaviour characteristics after the baseline observation. Nevertheless, the present data add valuable insights for the study of youth basketball selection and progression, particularly considering a multidimensional approach, particularly given the increase in t call for interdisciplinary studies in sports research (Carvalho et al., 2018; Piggott, Muller, Chivers, Papaluca, & Hoyne, 2018).

In summary, we used an interdisciplinary approach to examine whether variation in biological maturity status, training experience, body size, functional capacities and motivation for achievement, competitiveness and deliberate practice of youth basketball explained differences between players according to their participation status in the sport two years after the assessment. The present study highlights the need to consider Bayesian multilevel modelling to deal with the interactions among physical growth, biological maturity status, functional capacities and behavioural characteristics; specifically, among players on the path to sport expertise. On a simpler level, it became apparent that taller adolescent players are more likely to be selected/promoted in youth basketball, regardless of their lower functional capacity, particularly intermittent endurance. Finally, achievement and competitiveness motivation is apparently linked to the process of dropping out or persisting in this sample of youth basketball players. The need to consider the complex interactive pattern between variables is perhaps the clearest applied implication of the study.

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