AN ECOLOGICAL APPROACH TO SOURCES OF ENJOYMENT IN YOUNG FEMALE ATHLETES

UMA ABORDAGEM ECOLÓGICA ÀS FONTES DE PRAZER EM JOVENS ATLETAS DO SEXO FEMININO

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Abstract
The present study used a bioecological approach to investigate the factors influencing enjoyment sources among young female athletes. It focused on personal characteristics (maturity status), process (accumulated deliberate practice), and contextual factors (age group, competition level, sport type, and state), as well as the dynamic interactions of time with personal characteristics and process. The study included 243 young female athletes, with repeated measures collected from a sub-sample of 84 athletes across competitive seasons. We modeled the responses to the Sources of Enjoyment in Youth Sports Questionnaire (SEYSQ) using Bayesian hierarchical modeling. The results indicated that, in general, the young female athletes agreed with the statements in the SEYSQ. When considering cross-sectional data, there was no variation in the responses to SEYSQ factors associated with process, person, and context. When aligning chronological age, menarche age, and accumulated sport-specific deliberate practice, the sport context emerged as an important in shaping changes in sources of enjoyment across the development of young Brazilian female athletes between 12 and 18 years. The study highlights the importance of incorporating time in ecological approaches to youth sport research through a repeated-measures design to operationalize the bioecological approach

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properly. The findings do not support the argument that early specialization may lead to low enjoyment and a compromise in commitment and sustained participation in youth sport programs.
Keywords: Youth sport; Talent development; Adolescence; Bioecological theory; Bayesian multilevel modeling.

Resumo
O presente estudo utilizou uma abordagem bioecológica para investigar os fatores que influenciam as fontes de prazer entre jovens atletas. Concentrou-se em características pessoais (estado de maturidade), processo (prática deliberada acumulada) e fatores contextuais (faixa etária, nível de competição, tipo de esporte e estado), bem como nas interações dinâmicas do tempo com características pessoais e processo. O estudo incluiu 243 jovens atletas, com medidas repetidas coletadas de uma subamostra de 84 atletas ao longo de temporadas competitivas. Modelamos as respostas ao Questionário de Fontes de Prazer em Esportes Juvenis (SEYSQ) usando modelagem hierárquica bayesiana. Os resultados indicaram que, em geral, as jovens atletas concordaram com as afirmações do SEYSQ. Ao considerar dados transversais, não houve variação nas respostas aos fatores do SEYSQ associados a processo, pessoa e contexto. Ao alinhar a idade cronológica, a idade da menarca e a prática deliberada acumulada específica do esporte, o contexto esportivo emergiu como um fator importante na formação de mudanças nas fontes de prazer ao longo do desenvolvimento de jovens atletas brasileiras entre 12 e 18 anos. O estudo destaca a importância de incorporar o tempo em abordagens ecológicas para a pesquisa esportiva juvenil por meio de um delineamento de medidas repetidas para operacionalizar adequadamente a abordagem bioecológica. Os resultados não corroboram o argumento de que a especialização precoce pode levar a um baixo prazer e a um comprometimento do comprometimento e da participação sustentada em programas esportivos juvenis.
Palavras-chave: Esporte juvenil; Desenvolvimento de talentos; Adolescência; Teoria bioecológica; Modelagem multinível bayesiana.

1 INTRODUCTION

Organized youth sport programs tend to prioritize performance development, aiming to enhance athletes' competence in their path into adulthood and athletic maturity (Carvalho et al., 2023; Kalén et al., 2021). From a developmental perspective, there is a consensus among stakeholders that sport expertise is positively correlated with extensive exposure to sport-specific deliberate practice (Bruin et al., 2008; Ericsson et al., 1993; Güllich, 2018). Often, early specialization at pre-adolescent ages may be attractive to many national governing bodies, clubs, coaches, parents, and children who aspire to attain sport expertise and reach an elite level.

Recent studies have raised concerns about the potential negative impacts of early specialization on physical, psychological, and social development (Baker et al.,

2009; Bell et al., 2018; Brenner, 2016; DiSanti; Erickson, 2019; Fabricant et al., 2016; Jayanthi et al., 2019; Moseid et al., 2019; Myer et al., 2015; Post et al., 2020; A. D. Smith et al., 2017). Early specialization has been associated with negative psychosocial outcomes, which may result in a decrease in enjoyment, burnout, or even dropping out of sport (Boyd; Yin, 1996; Fraser-Thomas et al., 2008; Larson et al., 2019). However, the available data on the link between psychological characteristics and individual, contextual, and social aspects of sport specialization is inconsistent and limited (DiSanti; Erickson, 2019). In this study, we examine three key issues when interpreting these links.

First, the complexity of factors and interactions involved in youth sport settings requires a stronger theoretical foundation (DiSanti; Erickson, 2021; Moulds et al., 2022). To this end, the bioecological framework (Bronfenbrenner; Ceci, 1994; Bronfenbrenner; Morris, 2007) is particularly appealing as it considers how an individual interacts with their environment in shaping the dynamics of development. It is important to note that this theory emphasizes the consideration of biological aspects in the modeling process. The bioecological theory focuses on four aspects of development: *person*, *process*, *context*, and *time* (also referred to as the PPCT model). In the domain of youth sport research, it is possible to consider that *person* refers to the individual and their characteristics, such as sex, age, biological maturation, social relations and psychological characteristics such as motivation and enjoyment.

Process refers to the dynamic interaction between an individual and the environment through which development occurs (Bronfenbrenner; Ceci, 1994; Bronfenbrenner; Morris, 2007). In young athletes' environment, this can be observed through their interactions with peers, coaches, and team members during training and competition over time. Given the complexity of assessing and measuring such interactions, deliberate practice can serve as a heuristic mediator and a proxy for *process* in young athletes.

In the PPCT model, *context* is described by four types or levels of systems that are considered influential to an individual's development: (i) *microsystem*, which represents the immediate environment surrounding the individual, that can be represented by the age-group team, specifically the teammates and coach; (ii) *mesosystem*, which describes interactions between two or more microsystems, that may be represented by the interaction of age-group teams from different competitive levels; (iii) *exosystem*, which encompasses contexts in which individuals are not

directly involved, but they are still influenced; (iv) *macrosystem*, which considers broad social influences, such as state sport governing bodies like sport federations.

The concept of *time* was a late addition to the bioecological framework (Bronfenbrenner; Morris, 2007), referring to the varying temporal stages of development, including the progression of time over which development occurs, such as the chronological age of an individual. Individuals, institutions, and social relations are not static and follow a non-linear path of development. From this point of view, it is important to consider biological time, as there are considerable differences in the timing and timing of pubertal development among individuals, which can have an impact on physical function, performance and behavior.

Secondly, enjoyment is considered a key psychological outcome in youth sport (Scanlan; Lewthwaite, 1986). This is because it is widely recognized as a primary reason for starting and continuing involvement in sport (MacDonald et al., 2011; McCarthy et al., 2008; Scanlan et al., 1989; Wiersma, 2001). Enjoyment is a significant construct in several sport motivation theories, such as achievement goal theory (Nicholls, 1989), competence motivation theory (Harter, 1978), and the sport commitment model (Scanlan et al., 1993) that encompass the various facets of youth sport participation, including the evaluation of performance and success.

In youth sport research, enjoyment is commonly defined as a positive affective response to the sport experience, reflecting feelings of pleasure, liking, and fun (Scanlan et al., 1993). The sport commitment model, which has consistent empirical support (Scanlan et al., 1993; Scanlan; Lewthwaite, 1986), suggests that sport enjoyment can arise from both intrinsic sources, such as perceptions of competence and control, and extrinsic aspects of competition, such as social recognition.

Enjoyment can result from both achievement, such as goal attainment, and non-achievement, such as social influences from parents or peers (Scanlan; Lewthwaite, 1986). It is important to note that enjoyment is a complex concept that can be perceived differently by athletes, who experience the environment, and coaches, who play a role in shaping it. While there is substantial theoretical consensus on enjoyment, other conceptualizations should also be considered (Kimiecik; Harris, 1996).

Third, when studying the influence of person, process, and context characteristics on young athletes' enjoyment within an ecological framework, it is important to carefully consider the analytical approach. The theoretical approach and observed data present crossed or nested levels, where effects may vary between

subgroups (Judd et al., 2017). Therefore, traditional single-level analyses, such as analysis of variance, are often inappropriate (Diez-Roux, 1998). To address this issue, hierarchical/multilevel modeling approach allows for appropriate analysis of nested or crossed data (Gelman et al., 2012; Gelman; Hill, 2007).

Bayesian hierarchical regression models enable the modeling of constructs of interest as a function of individual, process, or contextual covariates in the context of youth sport. This provides aggregated estimates of a target population and significantly improves estimations of small and sparse group data, and capture dynamic changes overtime (Gelman et al., 2013; Gelman; Hill, 2007).

Given the previous observations, the objectives of the present study were to: (i) examine the influence of person (maturity status), process (deliberate practice accumulated), and contextual factors (including age group, competition level, sport type, and state) on the variation of enjoyment sources among young female athletes; (ii) examine the effect of the dynamic interactions of time with person characteristics (chronological age and biological age), process (years of deliberate practice accumulated in a specific sport), and context on the sources of enjoyment in sport for young female athletes. Specifically, we tested the validity of the assumption that early specialization has a negative association with enjoyment, particularly a decrease in enjoyment in young athletes (Boyd; Yin, 1996; Fraser-Thomas et al., 2008; Larson et al., 2019). Finally, we focused on young female athletes because most of the available information on youth sport is based on male athletes, despite the widespread participation of girls in organized sport (Johnston et al., 2018).

2 MATERIALS AND METHODS

2.1 Study design and participants

Ethical approval was obtained from the author's institutional ethics committee. Participants were informed about the nature of the study, that participation was voluntary, and that they could withdraw from the study at any time. Players and their parents or legal guardians provided written informed consent.

2.2 Cross-sectional data

To gather the data, we started by conducting a cross-sectional survey followed by an analysis of repeated measurements using a mixed-longitudinal design with a sub-sample from the larger survey. Throughout the study, all players involved were engaged in regular training (approximately 300-400 minutes per week) during the competitive season, which typically runs from February/March to November/December in Brazil. The cross-sectional data was based on a survey from 2015 to 2022. We considered a total sample of 243 young female basketball and volleyball players aged, on average, 15.0 (2.1) years, ranging between 10.1 to 19.7 years.

2.3 Repeated measures data

From the total cross-sectional sample, we retained data with repeated measures collected from competitive seasons across the survey period. The sub-sample consisted of 83 young athletes aged, on average, 14.0 years (ranging from 11.5 to 18.1 years) at baseline, with 41 playing basketball and 42 playing volleyball. Observations were made pre-season (February/March), mid-season (July/August), and end-season (November/ December) for each of the competitive seasons, and the players were measured and tested within a week of each observation period. To be included in the analysis of repeated measures, the players had to have at least two measurements across the period of observation. The distribution of measurements per player was as follows: two measurements, n=28; three measurements, n=19; four measurements, n=19; five measurements, n=10; six measurements, n=7).

2.4 Measures

2.4.1 Outcomes Variable

Participants were asked to complete the Portuguese-translated version (Santos; Gonçalves, 2012) of the Sources of Enjoyment in Youth Sport Questionnaire (SEYSQ) (Wiersma, 2001) before practice sessions. The SEYSQ was developed to assess young athletes' perceptions of enjoyment (Wiersma, 2001), based on the on the sport commitment model (Scanlan et al., 1993; Scanlan; Lewthwaite, 1986). The

SEYSQ consists of six dimensions or themes: (i) Self-referenced competency pertains to the athlete's comparison of their current and past performances; (ii) Other-referenced competency and recognition (ORCR) involve being better than other athletes of the same age or in the same sport, and a sense of uniqueness and recognition from others for athletic participation; (iii) Competitive excitement pertains to the challenges and uncertainty of competition and the related emotional reactions; (iv) Effort expenditure involves playing and training hard during practice and competition; (v) Affiliation with peers pertains to forming friendships and connections with teammates in the team and sport; (vi) Positive parental involvement pertains to receiving support from the athlete's parent(s) for participating in sport.

The six dimensions of the SEYSQ have been tested and interpreted in light of the two-dimensional model of sport enjoyment, where sources of enjoyment can be located along an extrinsic/intrinsic and achievement/non-achievement continuum (Scanlan; Lewthwaite, 1986; Wiersma, 2001). The achievement-intrinsic quadrant encompasses self-referenced competency; the achievement-extrinsic quadrant includes ORCR; the non-achievement-intrinsic quadrant encompasses effort expenditure and competitive excitement (Wiersma, 2001).

Social influences, such as affiliations with peers and positive parental involvement in sport, are encompassed in the non-achievement-extrinsic quadrant (Wiersma, 2001). There has been consistent data contributing to the understanding of the construct of enjoyment in youth sport (MacDonald et al., 2011; McCarthy et al., 2008; Scanlan et al., 1989; Wiersma, 2001). However, little attention has been given to testing the dimensional model of sport enjoyment and dimensions in the SEYSQ, taking into account patterns of specialization in youth sport.

The Portuguese version of the SEYSQ has 28 items, which are rated on a 5-point Likert-like scale ranging from 1 (not at all) to 5 (very much). We initially examined the fit of the original factorial structure in the Brazilian youth sport context by conducting a confirmatory factor analysis using a fully Bayesian framework. The results of this analysis and the details of modeling are available in the supplementary material. The analysis confirmed the original factorial structure of the SEYSQ, which consists of six dimensions, although five items from the original scale were removed. For computational convenience, we considered the response $i = 1,\ldots,n$ nested by dimension $j = 1,..,n = 6$.

2.5 Person outcomes

2.5.1 Chronological age

Chronological age was calculated to the nearest 0.1 year by determining the difference between the birth date and the date of observation.

2.5.2 Age at menarche and menarcheal status

Age at menarche was obtained through self-reported via interviews performed by the coaches (female coaches in all cases). Distance to age at menarche was calculated to the nearest 0.1 years by subtracting the menarche date from the date of observation. Players were classified as having early, average, or late maturation based on their age at menarche being minus or plus one year from the mean age at menarche for the Brazilian population.

The reference age at menarche (mean = 12.9 years, 95% CI: 12.7 to 13.1 years) was based on a meta-analysis of data from five studies in the Brazilian population, summarizing data recorded from 1972 to 1992 (Duarte, 1993). Caution with the interpretation of menarche status is warranted and the issue is discussed elsewhere (Soares et al., 2020). Hence, players were grouped into three groups of menarcheal status: early (cross-sectional sample, n=100; repeated measures sample, n=38), average (cross-sectional data, n=109; repeated measures sample, n=41), and late (cross-sectional sample, n=18; repeated measures sample, n=4). For cases where the age of menarche could not be determined or was not attained at the time of observation, the players were classified as unknown (cross-sectional sample, n=16; repeated measures sample, n=1).

2.6 Process outcomes

2.6.1 Sport-specific onset of specialization and accumulated deliberate practice

We considered the accumulated deliberate practice, or training experience, as the difference between the self-reported age when players started formal training and competition in their respective sport, referred to as the age of sport-specific onset of

specialization (Mendes et al., 2018), and their chronological age at each observation. The sport-specific onset of specialization was interpreted considering biological maturation milestones (Lima et al., 2020; Mendes et al., 2021). The biological maturation milestones considered were the age of initiation of the pubertal growth spurt and the age at peak height velocity. Information on how the biological maturation milestones were estimated using data from a meta-analysis of growth studies is available elsewhere (Lima et al., 2020; Mendes et al., 2021).

The reference age of initiation of the pubertal growth spurt was 9.4 (95% CI 9.0 to 9.8) years, and the reference age at peak height velocity was 11.9 (95% CI 11.8 to 12.0) years. Players who had an onset of specialization before the reference age of initiation of the pubertal growth spurt were categorized as pre-puberty specialization, i.e., early specialization (cross-sectional sample, n=59; repeated measures sample, n=9). Players whose onset of specialization was between the reference age of initiation of the pubertal growth spurt and the age at PHV were categorized as mid-puberty specialization (cross-sectional sample, n=122; repeated measures sample, n=48).

Those whose onset of specialization was after the reference age at PHV were classified as late-puberty specialization, i.e., late specialization (cross-sectional sample, n=59; repeated measures sample, n=26). In cases where the onset of specialization could not be determined, the players were classified as unknown (cross-sectional sample, n=3; repeated measures sample, n=1).

2.7 Context outcomes

2.7.1 Microsystem and mesosystem variables

Considering variation by sport in competitive age grouping in Brazil, we assumed a two-year range, the most common competitive age groups in Brazilian youth sport and international South American youth competitions. For the cross-sectional sample, athletes were considered as under 11 (age up to 11.9 years, n=20), under 13 (age between 12.0 to 13.9 years, n=68), under 15 (age between 14.0 to 15.9 years, n=69), under 17 (age between 16.0 to 17.9 years, n=68), and under 19 (age between 18.0 to 19.9 years, n=18).

The athletes selected to represent state-level teams were classified as state-level (cross-sectional sample, n=57; repeated measures sample, n=14), and the

remaining were classified as club-level (cross-sectional sample, n=186; repeated measures sample, n=70).

2.7.2 Exosystem and macrosystem variables

The participants were young female players from basketball (cross-sectional sample, n=171, repeated measures sample,n=41) and volleyball (cross-sectional sample, n=72; repeated measures sample, n=42). All players were engaged in clubs and competitions supervised by the respective sport state federation [Paraná (cross-sectional sample, n=72), Santa Catarina (cross-sectional sample, n=130), and São Paulo (cross-sectional sample, n=41)].

2.8 Data analysis

2.8.1 Models specification

We used Bayesian hierarchical models to model the responses of the players in each item of the SEYSQ. We assume that our outcome of interest y, the probability of response each player p response in dimension j in the SEYSQ, is five ordinal categories ($k \in \{1,2,3,4,5\}$). To model the relative probability of each ordinal category, we stated that the relative probabilities of the ordinal categories are conditional on a set of thresholds τ_k ($k \in \{1,2,3,4\}$). We used a standard cumulative distribution function Φ to allow us to map the cumulative probabilities onto an unbounded parameter space divided up by the thresholds τ_k.

The parameters for Φ were fixed with a mean $\mu = 0$ and a standard deviation $\sigma = 1$ for identification. In our cross-sectional dataset, $\mu_{p[j]}$ is given as function of nesting by each player (captured by $\alpha_{p[j]}^{player}$), and person (i.e. maturity status, $\alpha_m^{menarche}$), process (i.e., specialization, $\alpha_s^{specialization}$) and context (i.e., age group, α_a^{age}; competitive level, β_l^{level}; sport, β_n^{sport}; and state, α_r^{state}) characteristics. We considered competitive level (β_l^{level}) and sport (β_n^{sport}) as a population-level effect (also referred to as fixed effect), given the difficulty of estimating the between-group variation when the number of groups is small (Gelman; Hill, 2007). The predictors included in the models as discrete factors allow us to account for cross-classified nesting in the

outcome of interest. Hence, the Bayesian hierarchical model allows us to incorporate person-, process-, and context-level factors to advance to our understanding of young athletes' enjoyment. The association of these discrete factors and y were captured by a series of varying intercepts:

$$p(y = k|\mu_{p[j]}, \tau_k, \tau_{k-1}) \sim \Phi(\tau_k - \mu_{p[j]}) - \Phi(\tau_{k-1} - \mu_{p[j]})$$

$$\mu_{p[j]} = \alpha_{p[j]}^{player} + \beta_l^{level} + \beta_n^{sport} + \alpha_a^{age} + \alpha_m^{menarche} + \alpha_s^{specialization} + \alpha_r^{state}, \textit{ for } j = 1, \dots J$$

$$\alpha_p^{player} = Normal(0, \sigma_p), \textit{ for } p = 1, \dots P$$

$$\beta_l^{level}, \beta_n^{sport} \sim Normal(0,1), \textit{ for } l, n = 1,2$$

$$\alpha_a^{age} \sim Normal(0, \sigma_{age}), \textit{ for } a = 1,2,3,4$$

$$\alpha_s^{specialization} \sim Normal(0, \sigma_{specialization}), \textit{ for } s = 1,2,3$$

$$\alpha_r^{state} \sim Normal(0, \sigma_{state}), \textit{ for } s = 1,2,3$$

$$\tau_k \sim student - t(3,0,2.5)$$

$$\sigma_p, \sigma_{age}, \sigma_{specialization}, \sigma_{state} \sim Exponential(1)$$

For the repeated-measures data, we assumed that our $t = 1, \dots, n_t$ observations were nested within $j = 1, \dots, n_j$ dimensions, nested within $p = 1, \dots, n_p$ players:

$$p(y = k|\mu_{p[tj]}, \tau_k, \tau_{k-1}) \sim \Phi(\tau_k - \mu_{p[tj]}) - \Phi(\tau_{k-1} - \mu_{p[tj]})$$

We explicitly considered in our model time (Bronfenbrenner; Morris, 2007) as mesotime, considering the joint influence of chronological age, distance to menarche (pubertal growth milestone), and accumulated years of sport-specific deliberate practice. For computational efficiency, the continuous outcomes were standardized by subtracting the mean and dividing by two standard deviations (Gelman; Hill, 2007).

In our model, $\mu_{p[tj]}$ is given by the intercept $\alpha_{p[jt]}^{player}$, the slope terms $\beta_{p[jt]}^{age}$ (for chronological age), $\beta_{p[jt]}^{menarche}$ (for distance to menarche), and $\beta_{p[jt]}^{practice}$ (for

accumulated sport-specific deliberate practice), indicating that each dimension for each player is given a unique intercept and slopes are issued from a normal distribution centered, respectively on α, β^{age}, $\beta^{menarche}$, and $\beta^{practice}$, the grand intercept and slopes, meaning that there might be different mean scores for each player.

The correlation between the varying intercepts and the varying slopes was estimated by modeling $\alpha_{p[jt]}^{player}$, the slope terms $\beta_{p[jt]}^{age}$, $\beta_{p[jt]}^{menarche}$, and $\beta_{p[jt]}^{practice}$, as issued from the same multivariate normal distribution (a multivariate normal distribution is a generalization of the usual normal distribution to more than one dimension), centered on 0 and with some covariance matrix S. Lastly, we included context-level variables in the model by considering the cross-classified nesting of sport and competitive level. Hence, the joint association of time-varying outcomes, discrete context factors, and y were captured by a series of varying intercepts and varying slopes:

$$\mu_{p[tj]} = \alpha_{p[tj]}^{player} + \beta_{p[tj]}^{age} + \beta_{p[tj]}^{menarche} + \beta_{p[tj]}^{practice} + \beta_{l}^{level} + \beta_{n}^{sport}$$

$$\begin{bmatrix} \alpha_{p[tj]}^{player} \\ \beta_{p[tj]}^{age} \\ \beta_{p[tj]}^{menarche} \\ \beta_{p[tj]}^{practice} \end{bmatrix} \sim MVNormal\left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, S\right)$$

$$S = \begin{bmatrix} \sigma_{\alpha}^{2} & \sigma_{\alpha}\sigma_{\beta^{age}}\rho & \sigma_{\alpha}\sigma_{\beta^{menarche}}\rho & \sigma_{\alpha}\sigma_{\beta^{practice}}\rho \\ \sigma_{\alpha}\sigma_{\beta^{age}}\rho & \sigma_{\beta^{age}}^{2} & \sigma_{\beta^{age}}\sigma_{\beta^{menarche}}\rho & \sigma_{\beta^{age}}\sigma_{\beta^{practice}}\rho \\ \sigma_{\alpha}\sigma_{\beta^{menarche}}\rho & \sigma_{\beta^{age}}\sigma_{\beta^{menarche}}\rho & \sigma_{\beta^{menarche}}^{2} & \sigma_{\beta^{menarche}}\sigma_{\beta^{practice}}\rho \\ \sigma_{\alpha}\sigma_{\beta^{practice}}\rho & \sigma_{\beta^{age}}\sigma_{\beta^{practice}}\rho & \sigma_{\beta^{menarche}}\sigma_{\beta^{practice}}\rho & \sigma_{\beta^{practice}}^{2} \end{bmatrix}$$

$$\alpha, \beta^{age}, \beta^{menarche}, \beta^{practice} = Normal(0,5)$$

$$\sigma_{\alpha}, \sigma_{\beta^{age}}, \sigma_{\beta^{menarche}}, \sigma_{\beta^{practice}} = Normal(0,1)$$

$$\beta_{l}^{level}, \beta_{n}^{sport} \sim Normal(0,1), \textit{for} l, n = 1,2$$

$$\tau_{k} \sim student - t(3,0,2.5)$$

$$R = LKJcorr(2)$$

Where R is the correlation matrix $R = \begin{bmatrix} 1 & \rho & \rho & \rho \\ \rho & 1 & \rho & \rho \\ \rho & \rho & 1 & \rho \\ \rho & \rho & \rho & 1 \end{bmatrix}$, ρ is the correlation between intercepts and slopes used for the computation of the covariance matrix S.

Prior distributions. For the priors of τ_k, we regularized the estimates using a student-t(3, 0, 2.5) prior. We used a weakly regularizing prior for the binary population-level parameters, normal(0,1) prior. For continuous variables included as population-level effects we used a normal(0,5) prior.

We used an exponential(1) prior for the varying intercept parameters. In the model with repeated measures, we expect the prior distribution to peak around a zero correlation by using the LKJ(2) prior to the parameter that controls the strength of the correlation matrices.

Posterior predictive checks and computation. We used posterior predictive checks to inspect our models (Gabry et al., 2019; Vehtari et al., 2017). For each model, we run four chains for 3,000 iterations with a warm-up length of 1,000 iterations. The number and length of the chains and warm-up were sufficient to achieve convergence and obtain a reasonable effective sample size, given the computation time.

Bayesian estimations were implemented via R statistical language (R Core Team, 2018) with the “brms” package (Bürkner, 2017), which call Stan (Stan Development Team, 2020). The data and model predictions were visualized using the “ggplot2” package (Wickham, 2016). A repository containing the data and code allowing to recreate the analyses and figures is available at https://osf.io/mj6rh/.

3 RESULTS

The age at menarche in the present sample of young female athletes was, on average, 12.1 (90%CI 11.1 to 13.0) years. The young female basketball and volleyball players in the present analysis were, on average, on time in maturity status. The distribution of onset of specialization in the sample was balanced, with about 50% of the players classified as pre-puberty or late-puberty specialization, and the remaining half sample classified as mid-puberty specialization.

Except for one player, all players categorized as pre-puberty specialization were basketball players, which represents about 34% of the basketball sample. In contrast, about 57% of the volleyball sample (40 out of 70 players) were classified as late-puberty specialization. On average, the young female basketball players had an earlier onset of deliberate practice compared to volleyball.

Our hierarchical ordinal model estimate the probability of young female players´ response in each factor of the SEYSQ, given the athletes' specialization onset, menarcheal status, menarcheal status, sport, competitive level and state, considering the cross-sectional sample. Estimated probabilities of response varied by age group, specialization onset, menarcheal status, sport, competitive level, and state are provided as supplementary material. In Figure 1 is displayed the estimated response probabilities in the factors of the SEYSQ for the cross-sectional sample adjusted for process, person and context characteristics.

The posterior predictions of the probability of responses for the SEYSQ factors in young Brazilian athletes are displayed in Figure 1. The estimated parameters in the Bayesian hierarchical ordinal model for the cross-sectional sample are summarized in Supplementary table 2. In general, the young female athletes mainly agreed (response 5 in the Likert-like scale) with the statements in each factor of the SEYSQ.

Notably, there was no variation in the responses by SEYSQ factors associated with process (onset of specialization), person (menarcheal status), and context (age group, sport, competitive level, and state). Estimated responses plotted by age group, specialization onset, menarcheal status, sport, competitive level, and state are provided as supplementary material.

The posterior predictions of the probability of longitudinal responses aligned by chronological age (upper panels), distance to menarche (middle panels), and accumulated years of deliberate practice (lower panels) in young Brazilian athletes grouped by sport are displayed in Figure 2 for Self-referenced competency, Figure 3 for ORCR, Figure 4 for Effort expenditure, Figure 5 for Competitive excitement, Figure 6 for Affiliation with peers, and Figure 7 for Positive parental involvement.

The estimated parameters in the Bayesian hierarchical ordinal model for the repeated-measures sample are summarized in Supplementary table 3. There was substantial variation between female basketball and volleyball players' longitudinal responses in all SEYSQ factors. There was a consistent trend in all SEYSQ factors showing that the young female volleyball players had higher response values

(response 5 in the Likert-like scale) than basketball players. On the other hand, there was no substantial influence of competitive level on longitudinal responses in all factors of the SEYSQ. There was a trend of an increase in the probability of response 5 on the Likert-like scale for all SEYSQ factors with chronological age, and a corresponding decrease in all other Likert-like scale responses. However, as the young female players were biologically older, there was a substantial decrease in the probability of response 5 on the Likert-like scale for all SEYSQ factors, particularly noticeable for the basketball players. The patterns in the probability of responses for all SEYSQ factors were stable with accumulated years of deliberate practice, although there was substantial variation between players and within factors (Supplementary table 2).

However, the probability of response 5 on the Likert-like scale in the basketball players was substantially lower than in volleyball players. Overall, the responses of biologically mature, older, and more experienced basketball players were more evenly distributed between the 1 to 5 responses in the Likert-like scale of the SEYSQ factors.

4 DISCUSSION

Enjoyment in youth sport plays a key role in understanding commitment and sustained participation (McCarthy et al., 2008; Scanlan et al., 1993; Wiersma, 2001). The current study sought to bring a bioecological approach to investigate changes in sources of enjoyment among young female athletes. This was accomplished through two steps: first, investigating whether sources of enjoyment variations could be explained by person, process, and context factors, and second, examining changes in sources of variation while considering the interactions of time with process (accumulated sport-specific deliberate practice) and person (chronological age and distance to a biological maturation milestone), while also allowing for the influence of context (sport and competitive level).

Youth sport programs that encourage year-round specialization in a single sport with an emphasis on those aspiring for elite status have become the norm (Bell et al., 2016; Buckley et al., 2017; DiSanti; Erickson, 2019; M. M. Smith, 2015). These programs are often assume that maximizing sport-specific, coaching-led deliberate practice would effectively lead to expert performance (Bruin et al., 2008; Ericsson et al., 1993; Güllich, 2018). Despite the interest in early specialization, there is limited available data explicitly studying the consequences of early specialization, in contrast

to the abundance of reviews, commentaries, or editorials (Mosher et al., 2020).The limited data suggested that early specialization may lead to low motivation and enjoyment, which can increase the risk of burnout and dropout (Fraser-Thomas et al., 2008; Larson et al., 2019).

A key finding from the present study points to the lack of influence of the onset of specialization on the enjoyment of young female athletes in sport. On the other hand, we noted a large variation between players in the patterns of responses in the SEYSQ dimensions (both within- and between-dimensions responses) when aligned for accumulated sport-specific deliberate practice (see Supplementary Table 3), and a large variation between contexts (see Figures 2 to 7). The assumption of negative effects due to early specialization on enjoyment of female adolescent athletes was not confirmed in the present observations.

Our data do not support this argument, as evidence-based data on this topic is inconsistent and limited to draw strong causal inferences (DiSanti; Erickson, 2019). The young female athletes of our sample may be able to cope with the sport challenges they are facing, and to construct their own interpretations about the practice climate, pressure from peers, coaches and significant others.

The “rocky road” for sport success (Collins; MacNamara, 2012; Taylor; Collins, 2019) does not seem to affect the young female athletes’ beliefs and expectations. It is worth noting that our study has a narrow focus, as it only explores a limited range of youth sport training and competitive environments, all of which are focused on the development of athletes aspiring for elite status.

While concerns about potential negative impacts of early specialization are likely valid in high-performing environments of youth sport, the data available for such specific contexts are not yet sufficient. As far as we know, our data provide the first insights into enjoyment that need to be replicated in other cultures of youth sport to provide more consistent interpretations about youth sport specialization.

From an achievement goal theory perspective (Ames, 1995), our observations suggest that the development of the young female athletes in the sample appears to be influenced more by intrinsic sources, such as the need to improve oneself through personal effort, than by extrinsic factors such as recognition of competence by others. The high values of response 5 on the Likert-like scale for ORCR across time potentially reflect the direct competition with peers and performance-related feedback that are

ever-present and often serve as the basis for selection decisions made by coaches in youth sport environments.

Overall, the young female athletes consistently responded in the higher ordinal category (i.e., responses of 5 on the Likert-like scales) of the SEYSQ factors. When analyzing the cross-sectional survey data of young female basketball and volleyball players, the study did not find significant relationships between young female athletes' sources of enjoyment and person, process, and contextual factors.

However, when incorporating time into the design and analysis, the study revealed deeper links between the influence of personal, process, and contextual factors on the developmental changes in the sources of enjoyment among the young female athletes. In particular, the longitudinal data displayed a clear pattern of variation in the responses by sport.

Volleyball players consistently responded in the higher ordinal category of the Likert-like scale of the SEYSQ factors, showing a trend of increasing the response for all factors of the SEYSQ with chronological age. On the other hand, the young female basketball players had a lower probability of response 5 on the Likert-like scales of the SEYSQ factors and a more pronounced decrease in these responses when considering the biological maturation age. Overall, these observations were consistent across the sample, even when considering the potential effect of the competitive level of the young athletes.

By aligning the three chronosystems, it is possible to identify that interpretations about the enjoyment of young female athletes across adolescence using only chronological age will be incomplete at best. The present data showed that as the young female players were becoming more mature, their perceptions of enjoyment changed notably, particularly among young Brazilian basketball players.

The present results need to be seen with more detail in order to refine the analysis and elaborate a more nuanced interpretation. The practice environments seem to be key to foster young athletes' positive development, increase their perceived self-competence, autonomy, and desire to improve themselves (MacDonald et al., 2011; Scanlan et al., 1989; Wiersma, 2001).

Our observations identified small variation associated with the sport context, highlighting the sport-specific cultures that potentially influence young athletes' perceptions. It may be reasonable also to consider that the varying structures of a sport-specific career, pedagogical approaches to training, and competition in different

sport may influence players' perceptions. Hence, the results may be a consequence of contextual changes in the training process and competition (e.g., different coaching styles, parental involvement) or different offers and demands of competing activities in sport (e.g., nights out with friends, school results) in the period of the athlete's adolescence (Santos; Gonçalves, 2016).

In addition, these results may be tied to the fact that the observations are from high-performance-oriented environment. Nevertheless, the young athletes' enjoyment across the sport contexts mainly comes from perceptions of self-competence, and physical exertion, which represents for the athlete a sense of commitment and hard work in practice and games (Wiersma, 2001). Experiences in learning and improving skills and abilities, exerting effort, and excitement associated with competitive sport have also been consistently reported in research as being enjoyable to athletes (Bakker et al., 1993; Boyd; Yin, 1996).

Our analytical approach allowed us to map the trends of responses in each dimension of the SEYSQ, specifically considering how person (chronological age and age at menarche), process (represented by the accumulated exposure to sport-specific deliberate practice), and context (represented by different competitive levels across two team sport) mutually influence the young female athletes' enjoyment sources over time. The model fits were examined via posterior predictive checks (i.e., comparing data generated under each model with observed data), which showed that the models fit well (see Supplementary material).

Our observations add to the criticism of interpretations of ecological approaches when failing to accurately operationalize Bronfenbrenner's PPCT research model (Navarro et al., 2022; Tudge et al., 2009, 2016), particularly failing to consider time (Bronfenbrenner, 2005). In sport, it is important to emphasize that the influence of time is measured in years through a continuous commitment to training and competition. The present study assesses a path (or a process) rather than an episodic contact with one or multiple sports (Côté et al., 2020).

We must acknowledge that our research setting is complex, but not too complex to allow for an explanation. Without external influences and personal development, the ecosystem under scrutiny would remain static. The observed changes over time shed light on the constellation of variables that interact to shape individual trajectories regarding enjoyment in sport.

As we are dealing with social relationships, we must be cautious in interpreting the findings as a translation of the real world and not as mere theoretical elaborations. Our aim, when hypothesizing a model with its explanatory mechanisms, is always to discern the common forms and structures that are transversal to the diversity of bioecological settings.

Finally, caution should be exercised in generalizing the results of the present study. Although often overlooked in youth sport research, selection bias based on who was included in the datasets should be considered. In the present study, selection bias is a concern, more so in the basketball context (approximately 25% of the cross-sectional sample was available for repeated measures) than in the volleyball context (approximately 58% of the cross-sectional sample was available for repeated measures).Youth sport contexts present a challenging context for follow-up studies, with many factors contributing to attrition, including sport selection and injury(Kemper, 2007).

In summary, self-referenced competence, other-referenced competence and recognition, effort expenditure, affiliation with peers, and positive parental involvement are key sources of enjoyment for playing sport among young female athletes from basketball and volleyball, adjusting for age-group, the onset of specialization, competitive level, sport, and state. The results of the present study do not support the argument that early specialization may lead to low enjoyment, and consequent compromise in commitment and sustained participation in youth sport programs.

By aligning the three chronosystems (chronological age, menarche age, and accumulated sport-specific deliberate practice), it was possible to identify the importance of the sport context to the changes in the sources of enjoyment across the development of young Brazilian female athletes between 12 and 18 years. Overall, our findings underscore the necessity of incorporating time in ecological approaches to youth sport research through repeated-measures design to properly operationalize Bronfenbrenner’s PPCT research model.

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7 DATA AVAILABILITY STATEMENT

All data presented in this review are available at https://osf.io/mj6rh/.

8 CODE AVAILABILITY

All codes used to extract, model, and plot the data in this review are available at https://osf.io/mj6rh/.

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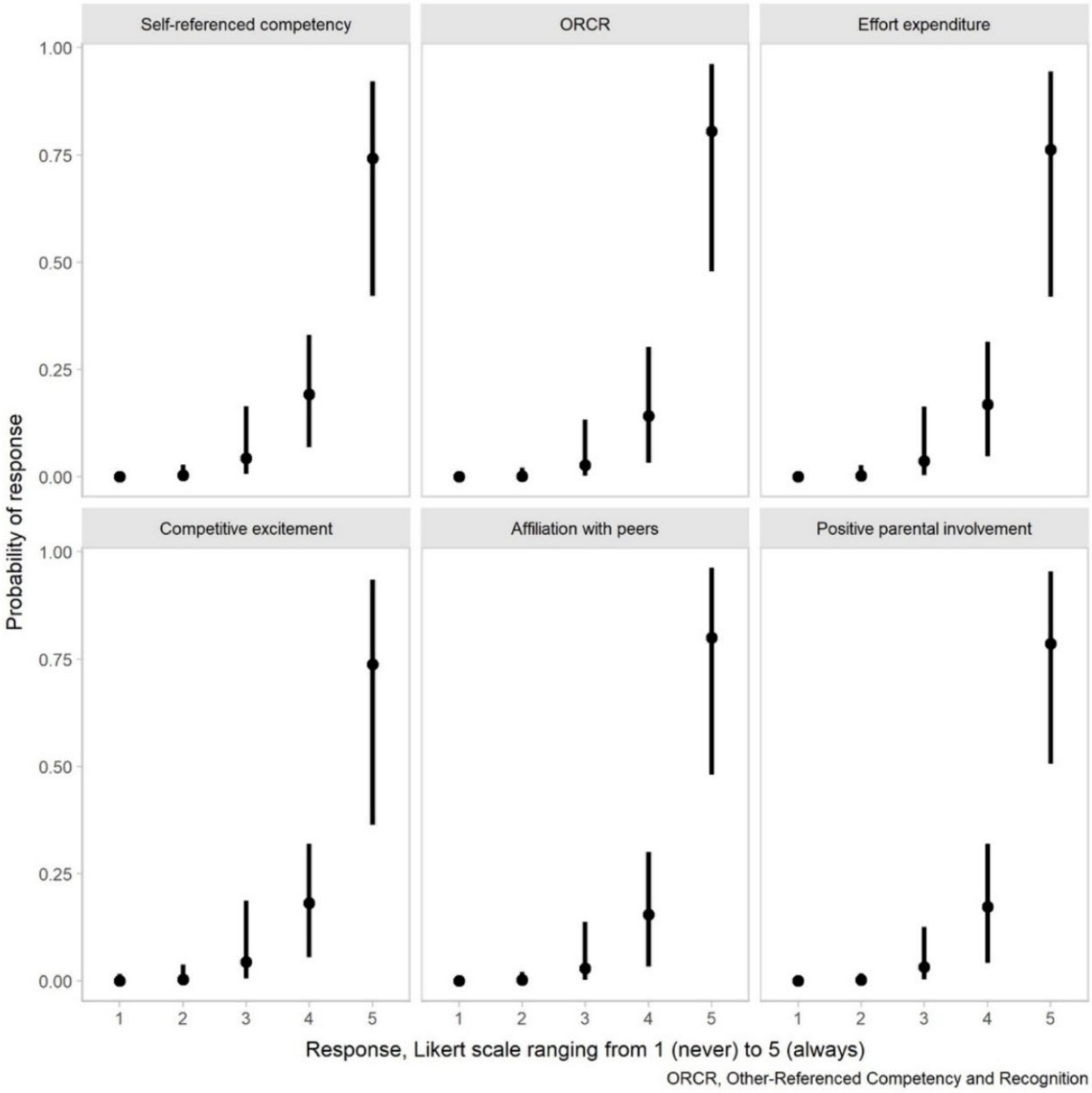
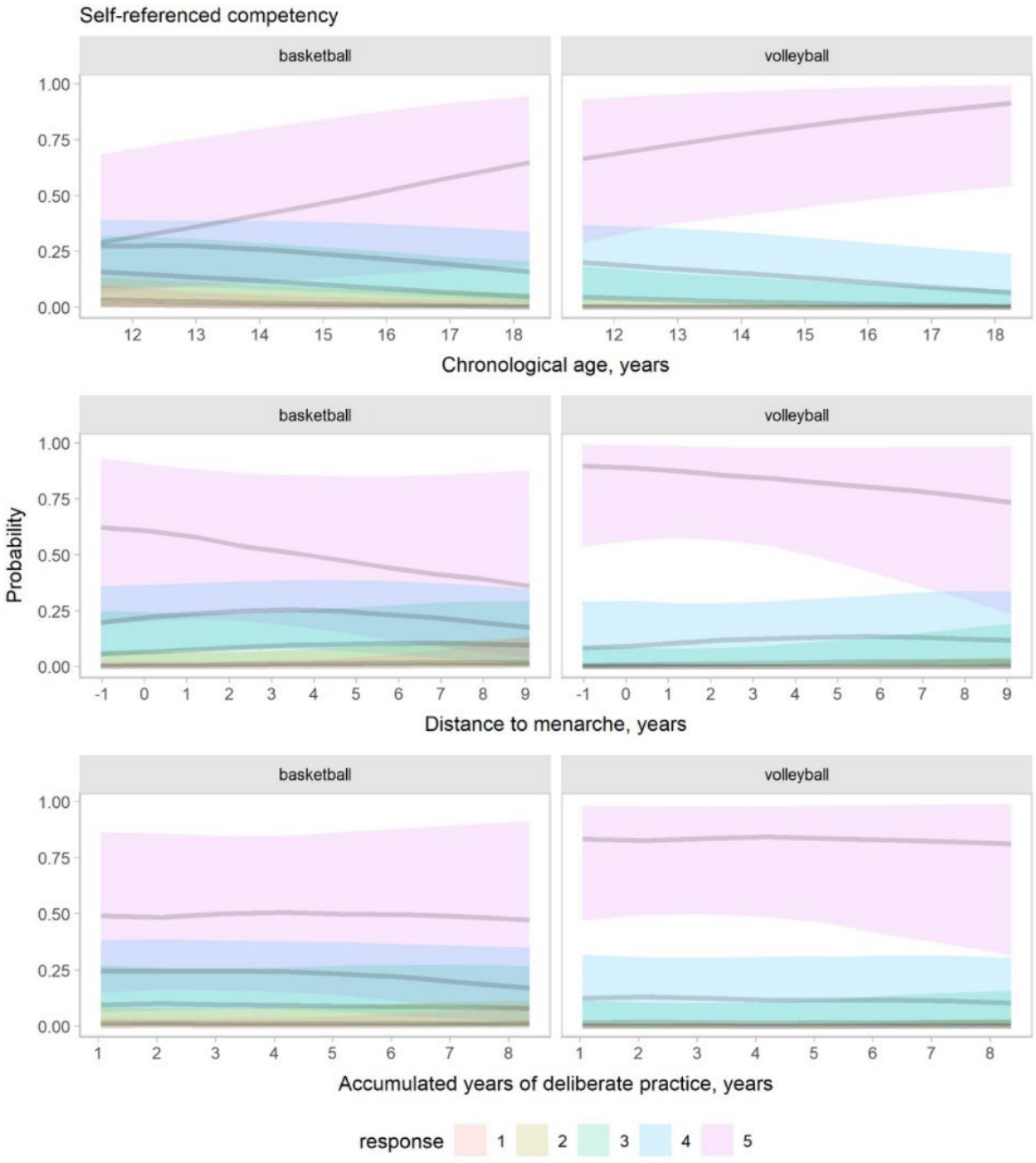
ANNEX I – FIGURES

Figure 1 - Posterior predictions of the probability of responses for the Source of enjoyment in youth sports questionnaire factors in young Brazilian athletes. Uncertainty estimates represent the 50% credible intervals



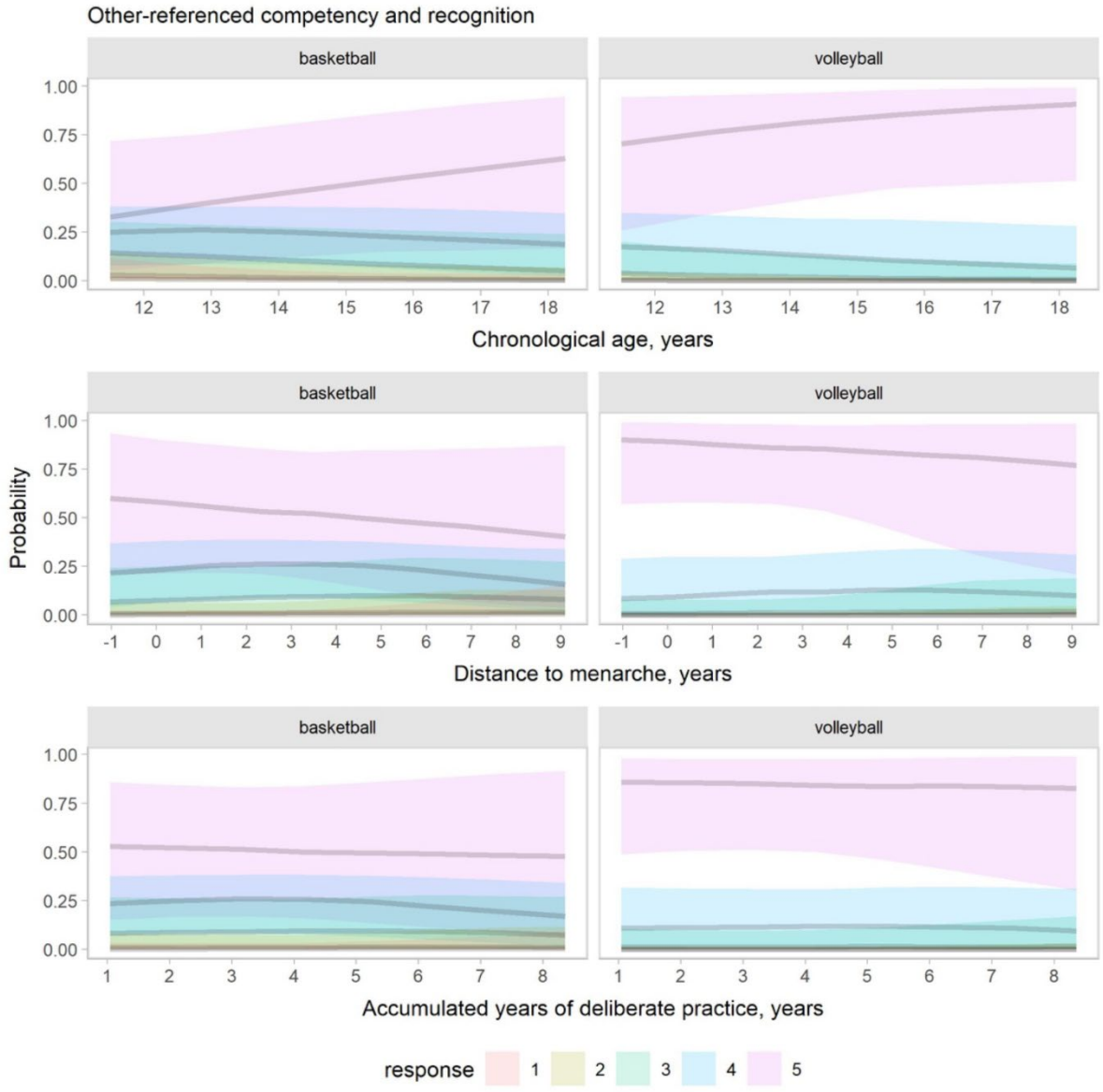
Source: prepared by the authors, 2025

Figure 2 – Posterior predictions of the probability of longitudinal responses for Self-referenced competency aligned by chronological age (upper panel), distance to menarche (middle panel), and accumulated years of deliberate practice (lower panel) in young Brazilian athletes grouped by sport. Uncertainty estimates represent the 50% credible intervals



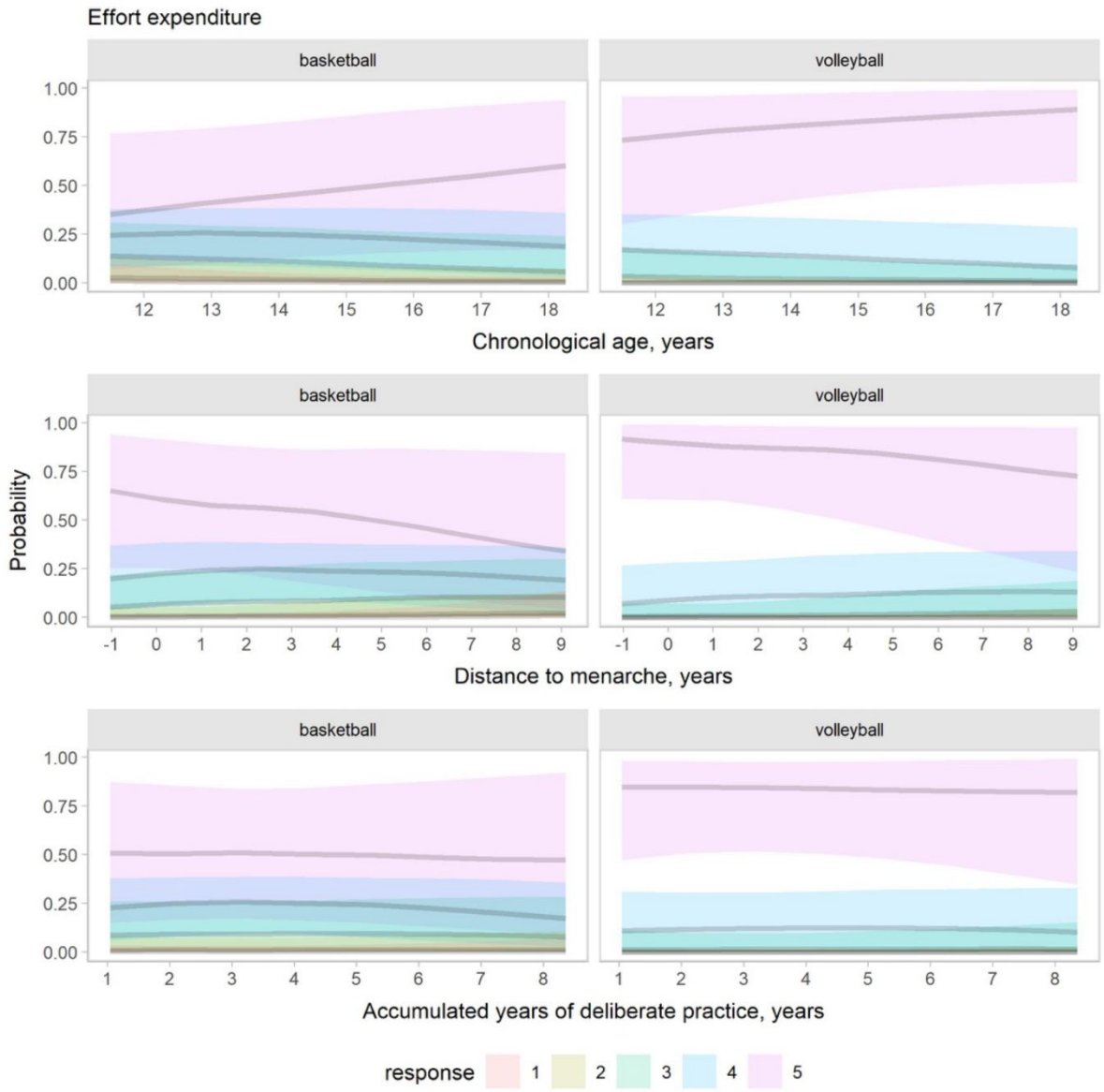
Source: prepared by the authors, 2025

Figure 3 – Posterior predictions of the probability of longitudinal responses for Other-referenced competency and recognition aligned by chronological age (upper panel), distance to menarche (middle panel), and accumulated years of deliberate practice (lower panel) in young Brazilian athletes grouped by sport. Uncertainty estimates represent the 50% credible intervals



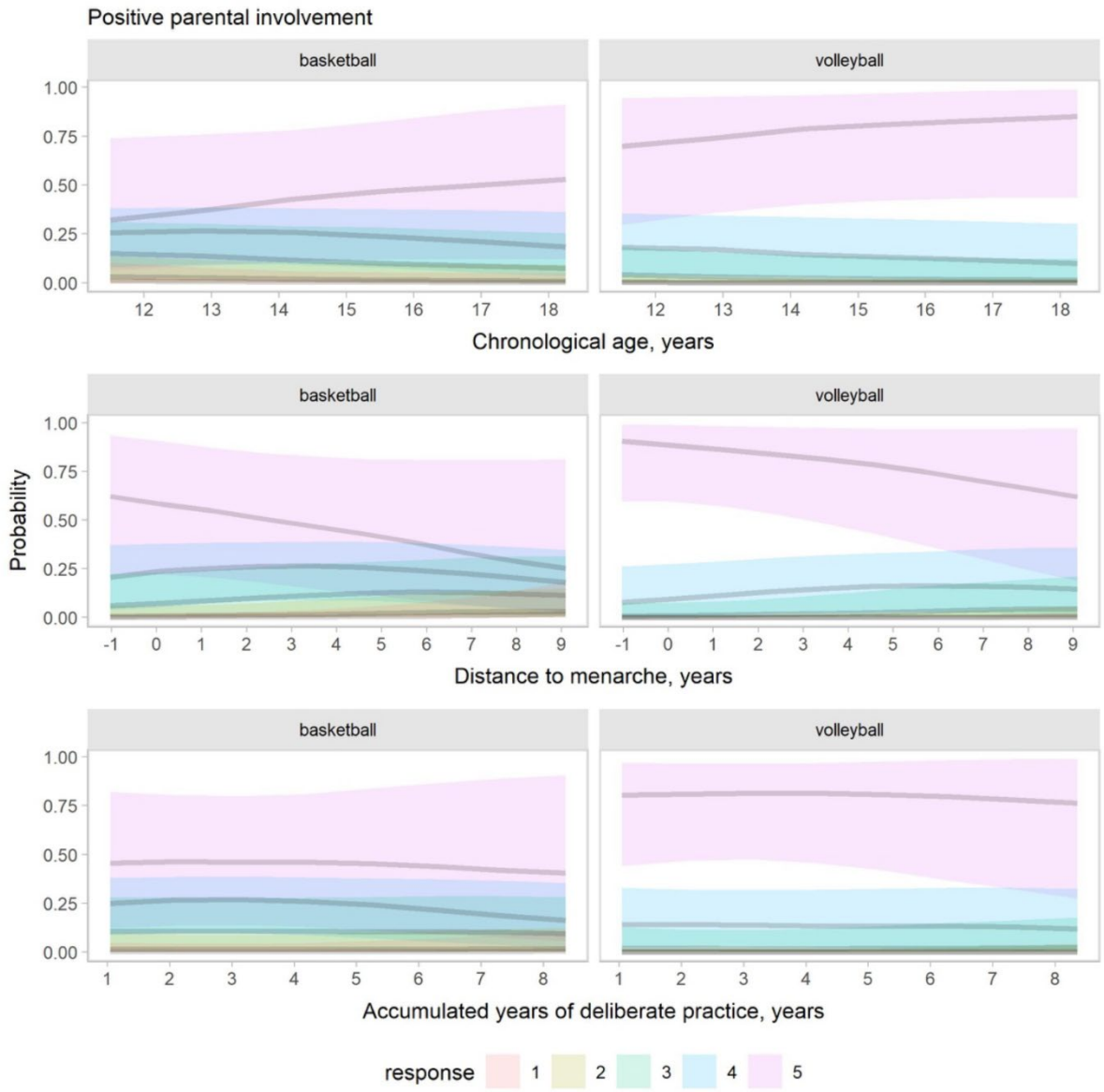
Source: prepared by the authors, 2025

Figure 4 – Posterior predictions of the probability of longitudinal responses for Effort expenditure aligned by chronological age (upper panel), distance to menarche (middle panel), and accumulated years of deliberate practice (lower panel) in young Brazilian athletes grouped by sport. Uncertainty estimates represent the 50% credible intervals



Source: prepared by the authors, 2025

Figure 5 – Posterior predictions of the probability of longitudinal responses for Competitive excitement aligned by chronological age (upper panel), distance to menarche (middle panel), and accumulated years of deliberate practice (lower panel) in young Brazilian athletes grouped by sport. Uncertainty estimates represent the 50% credible intervals



Source: prepared by the authors, 2025