Section III – Sports Training

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Are the Player Selection Process and Performance Influenced by Relative Age Effect in Elite Women's Handball?

by
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The relative age effect (RAE) is a phenomenon present in team sports, but it does not influence each gender to the same extent. This study aimed to examine the RAE and its relation to performance in international women's handball competitions (2017/18 World Championships). The sample was composed of 1,096 female players distributed into three categories: youth or under 18 (n = 369); junior or under 20 (n = 328) and senior (n = 399). The teams were divided into four groups based on their final position (medalist, quarter-finalist, eight-finalist and bottom-eight teams). The birthdate distribution (trimesters and semesters) was analysed according to the competition category and the playing position. Differences between the expected and observed birthdate distribution were checked using the chi-square statistical test followed by the calculation of the odds ratio. The results revealed, by trimester, the presence of the RAE in the youth ($x^2(7)$ = 87.22; p < 0.001) and junior (x^2 (7) = 33.12; p < 0.001) categories, with no impact on senior (p > 0.05). The effect size was relatively strong in the youth category (Vc = 0.48). By semester, the prevalence of the RAE was also found in the senior category (p < 0.05). According to the playing position, the RAE was especially detected in 'goalkeeper' (p < 0.01) and 'centre-back' (p < 0.05) positions, both in U-18 and U-20 categories. Surprisingly, this effect also appeared in the 'back' players in the senior category (p < 0.05). A prevalence of the RAE was identified in teams with a higher final position, but interestingly had a greater impact in the quarter-finalist teams (p < 0.001) than in the medalist teams (p < 0.01). The findings demonstrated that the RAE tends to decrease as the chronological age of players increases, demonstrating a strong presence according to collective performance in international women's handball.

Key words: birthdate, competition performance, team sport, sports success, final team position.

Introduction

In some areas of our society, the clustering of subjects by age or age-groups is common and verified. In sports, and especially in team sports, it is normal to group athletes according to their chronological age in categories of 1 or 2 years (annual or bi-annual cycle). Internationally, January 1 is globally accepted as the beginning of the selection year. This decision, which aims to ensure an appropriate development and maximum equality of opportunities in youth competitive environments, seems a priori fair, but has the disadvantage of obviating the maturational status, that is, the personal, individual and unique way that every person has to grow and evolve over the years (Helsen et al., 2005). Chronological age and the maturational level, which do not have to develop in parallel (Torres-Unda et al., 2013), may have a direct impact on individuals' sports careers, even when two athletes are born in the same year. This is known as relative age and the consequences are named the Relative Age Effect (Musch and Grondin, 2001).

Research based on RAEs has been carried out in different fields, such as education or clinic

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contexts (Dixon et al., 2011; Sprietsma, 2010). In the sport field, the heterogeneity of the studies yielded different results and conclusions based on internal and external factors of the sport transition process. A meta-analysis of the presence of the RAE, composed of 130,108 athletes (Cobley et al., 2009), verified a prevalence in most sports (team sports and individual sport disciplines) and identified the age category, skill level and sport context as influential factors of the RAE. In team sports, the RAE has been the main objective to investigate in different research areas, including talent identification and development (TID) systems (López de Subijana and Lorenzo, 2019), performance evaluation (Lago-Fuentes et al., 2019), player selection processes (Torres-Unda et al., 2013), and specific case studies within clubs or academies (Campos et al., 2017). Most of these investigations, even paying attention to the adulthood or the senior competition category, focused on the analysis of the influence of the RAE throughout the athlete's transition process according to the different moderating factors of the phenomenon (de la Rubia et al., 2020b; Smith et al., 2018).

With regard to the magnitude of the RAE through the athlete's sport transition process, it seems that the impact tends to decrease as the chronological age of the athlete increases. This occurs not only in team sports (Bjørndal et al., 2018b), but also in the context of individual sport disciplines (Mon-López et al., 2020). In the scientific literature, there are several explanations for this phenomenon, but the most plausible is associated with the maturational status of the athlete (Torres-Unda et al., 2016). Physical and anthropometric factors tend to equalise in advanced human development stages (i.e., adulthood); however, this relationship is not always robust. Studies on TID systems have shown that relatively young athletes manage to overcome the initial difficulties caused by a biased selection process and achieve higher performance levels than relatively older counterparts, even reaching more success throughout his/her professional career (Fumarco et al., 2017). This phenomenon is known as the reverse Relative Age Effect (reverse RAE) (Gibbs et al., 2012). Psychological factors such as resilience (McCarthy and Collins, 2014), positive facing of challenges or experiencing a 'trauma' (Collins and MacNamara,

2012), a higher development of technical and tactical specific-skills and a late sport specialisation (Güllich and Emrich, 2014), as well as secondary factors such as family, coaches, and friends (Wattie et al., 2015) seem to be some of the most relevant explanations provided regarding the reverse RAE in sport.

The impact of the RAE differs among genders. While the findings demonstrate a clear presence of the RAE in men's sport, especially in formative categories (de la Rubia et al., 2020b), diversified results were registered in women's sport (Smith et al., 2018). This fact emphasises the greater influence of anthropometric, physical, and physiological factors on the player selection processes that take place in men's sport (Ibañez et al., 2018; Torres-Unda et al., 2016). However, this trend does not seem to be of the same magnitude in women's sport due to factors such as the 'depth of competition', the number of active participants, and the decreased relevance of strength and power abilities and anthropometric variables to sports performance (Baker et al., 2009).

Handball is a team sport that presents a set of physiological demands and technical, tactical, and cognitive requirements to achieve success (Camacho-Cardenosa et al., 2018). However, these conditions depend on, among other factors, the playing position. Thus, the coach, by attributing a specific playing position, could be involuntarily establishing a selection bias in relation to the maturational status of the player. One of the most extensive investigations on this topic was performed by Schorer et al. (2009); those authors showed a prevalence of the RAE in the 'backcourt' positions. Similar findings were reported by Fonseca et al. (2019) in a study with 383 male handball players who participated in the 2017 Youth World Championship. That analysis showed an impact of the RAE on players at 'wing' and 'back' positions. In the same line, de la Rubia et al. (2020a) verified the presence of the RAE in a sample of 3,358 male handball players and 3,273 female handball players, especially for male 'pivots' and 'goalkeepers' and female 'centre-backs'. On the other hand, studies have not found differences with regard to unequal and biased distribution of players by their playing position (Gómez-López et al., 2017; Saavedra and Saavedra, 2020). Despite the lack of homogeneity of results, biological factors (physical,

physiological, anthropometric, and morphological) seem to be the moderating factors of the presence of the RAE by the playing position (Camacho-Cardenosa et al., 2018). Furthermore, the difference perceived by the coach, based on the current characteristics of each player, could influence the final decision when assigning certain playing positions (Krahenbühl and Leonardo, 2020; Matthys et al., 2013).

Within the TID systems employed by national handball federations, the impact of the RAE on female players is less extensive. Bjørndal et al. (2018b) showed that the RAE did not affect the development process of the relatively younger Norwegian female players throughout their sport careers (local, regional, national, and international levels). Wrang et al. (2018) demonstrated, in a sample of Danish female players belonging to U-18, U-20, and senior national teams, that late developers had more opportunities to be re-selected to the senior level than early developers. In that study, a reverse RAE was confirmed, although relatively older players were slightly favoured in the initial stages of the TID system. Even in women's handball, a trend was observed to find more relatively younger players as the competition category/level progressed (Figueiredo et al., 2020). Therefore, this scientific evidence demonstrates great variability in the presence and impact of the RAE on women's handball (Sá et al., 2020).

Given the heterogeneity of the findings in the scientific literature and the non-proliferation of studies associated with high performance women's sports, it is necessary to clarify the real presence of the RAE in international female handball. Therefore, the aims of this study were (i) to analyse and evaluate the prevalence of the RAE in three official female categories (youth, junior, and senior); and (ii) to examine the presence of the RAE according to collective competition performance through qualifying criteria (final team position). Therefore, to the best of our knowledge, this is one of the first studies to examine the RAE in elite performance female contexts in handball.

Methods

Participants

The sample of this study was composed of 1,096 female handball players who participated in World Championships organized by the International Handball Federation (IHF) in 2017 (senior) and 2018 (youth and junior). Players were allocated according to their chronological age and using January 1 as the cut-off date. Therefore, according to biannual competition cycles established by the IHF in formative categories, the sample was classified according to the competition level or category: youth (U-18), junior (U-20), and senior. In the formative categories, players who were not born into the biannual competition cycle competition were excluded from the sample (U-18: n = 21, 5.4%; U-20: n = 45, 12.1%). However, junior players (n = 5) who also participated in the senior competition category were also considered, separately, according to competitive annual cycles (T1-T4). Players included in the sample were further categorised according to handball playing positions: 'goalkeeper' (n = 163, 14.9%), 'wing' (n = 256, 23.4%), 'back' (n = 318, 29.0%), 'centre-back' (n = 186, 17.0%) and 'pivot' (n = 173, 15.7%). The distribution of female handball players by the competition category and the playing position is shown in Table 1.

Design and Procedures

All data linked to players (birthdate and playing position) were extracted and collected from the 'Competitions' – 'World Championships' (WC) – 'Team Roster' section of the IHF official website (https://www.ihf.info/competitions). The information corresponds to each competition analysed: U-18 WC (2018), U-20 WC (2018) and senior WC (2017). Likewise, the final team position was collected from the 'Competitions' – 'World Championships' (WC) – 'Teams Ranking' section of the IHF official website (https://www.ihf.info/competitions).

Birthdates of senior players were distributed in four trimesters (T) and two semesters (S). Consequently, players born between January 1 and March 31 were included in 'Trimester 1' (T1), players born between April 1 and June 30 in 'Trimester 2' (T2); players born between July 1 and September 30 in 'Trimester 3' (T3); and players born between October 1 and December 31 in 'Trimester 4' (T4). However, in the youth (U-18) and junior (U-20) categories, players were categorized according to the competition biannual cycle set by the IHF, grouping the sample into eight trimesters: players

born in even numbered years were included in 'Trimester 1 - T1' (January 1 and March 31); in 'Trimester 2 - T2' (April 1 and June 30); in 'Trimester 3 - T3' (July 1 and September 30); and in 'Trimester 4 - T4' (October 1 and December 31). Players born in odd-numbered years were included in 'Trimester 5 - T5' (January 1 and March 31); in 'Trimester 6 - T6' (April 1 and June 30); in 'Trimester 7 - T7' (July 1 and September 30); and in 'Trimester 8 - T8' (October 1 and December 31). By semester, the sample was distributed in the following groups: in the senior category, players born in the first half of the year (January 1 - 30 June) were categorized in 'Semester 1' (S1) and players born in the second half of the year (July 1 - 31 December) were categorized in 'Semester 2' (S2); in the youth and junior categories, the sample distribution was as follows: for even numbered years, 'Semester 1' (S1) - players born in the first half of the year (January 1 - 30 June); 'Semester 2' (S2) - players born in the second half of the year (July 1 - 31 December). For odd-numbered years, 'Semester 3' (S3) - players born in the first half of the year (January 1 - 30 June); 'Semester 4' (S4) - players born in the second half of the year (July 1 - 31 December).

Teams of each World Handball Championship were classified by previously used qualifying criteria (Vogelbein et al., 2014) in order to be able to perform the analysis of the RAE and collective performance based on the final team position. Teams were grouped into four performance levels: 'very high performance' ('medalists' – from the 1st to the 3rd position); 'high performance' ('quarterfinalists' – from the 4th to the 8th position); 'medium performance' ('eightfinalists' – from the 9th to the 16th position); 'low performance' (bottom-eight teams – from the 17th to the 24th position).

Statistical Analysis

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS 23.0, IBM Corp., Armonk, NY, USA). Differences between the observed and expected birthdate distributions were tested using the chi-square goodness of fit test. In the same line as other studies (Edgar and O'Donoghue, 2005; Saavedra-García et al., 2016), a heterogeneous distribution of the sample was considered according to the number of days contained in each trimester and

semester, assuming a small correction to the uniform probability distribution (Delorme and Champely, 2015). Thus, the expected fraction and relative frequency of any group of players who were born in T1/T5 would be 90¼/365¼ (24.7091034%), compared with 91/365¼ (24.9144422%) in T2/T6 and 92/365¼ (25.1882272%) in T3/T7 and T4/T8. Likewise, by semester, the expected fraction was 181¼/365¼ (49.6235456%) in S1/S3 and 184/365¼ (50.3764544%) in S2/S4. The odd ratio calculation was made in the birthdate distribution according to the competition category with the aim to observe differences between the relatively younger players and the rest of the sample: players born in the reference trimester or semester (T8 and S4 in U-18 and U-20 categories; T4 and S2 in senior category) and other players born in the rest of trimesters or semesters (T1-T7 and S1-S3 in the U-18 and U-20 categories; T1-T3 and S1 in the senior category). In order to determine the strength of association, a 'Cramer's V' statistical test was applied, in which 0.10 to 0.20 indicated a 'weak association'; 0.20 to 0.40, a 'moderate association'; 0.40 to 0.60, a 'relatively strong association'; 0.60 to 0.80, a 'strong association'; and 0.80 to 1, a 'very strong association' (Rea and Parker, 1992). The level of significance was set at $p < 0.05$.

Results

By the competition level - category

With regard to the competition level, an unequal trimester distribution of players' birthdates was observed (Table 2). Statistical analysis revealed a presence of the RAE in the youth ($x^2(7) = 87.22$; $p < 0.001$) and junior categories ($x^2(7) = 33.12$; $p < 0.001$). Post hoc analysis (odds ratio) showed that players born in the first trimester (T1) presented higher values in relation to the reference trimester (T8), in the U-18 ($OR = 6.1$) and U-20 ($OR = 3.1$) categories. The largest effect size was identified in the U-18 category ($Vc = 0.49$ – 'relatively strong association'). No significant differences were found in female senior players ($p > 0.05$).

In relation to the sample distribution by semester, similar results were observed. The number of players born in the first half of the year (S1) was significantly higher in the U-18 ($x^2(3) = 64.88$; $p < 0.001$) and U-20 categories ($x^2(3) = 9.69$;

$p < 0.05$). Interestingly, this also occurred in the senior category ($\chi^2(3) = 4.19$; $p < 0.05$). Post hoc analysis (odds ratio) showed that players born in the first semester (S1) presented higher values in relation to the reference semester (S4/S2) in the U-18 (*OR* = 4.7), U-20 (*OR* = 1.9) and senior categories (*OR* = 1.5). The largest effect size was detected in the U-18 category (*Vc* = 0.42 – 'relatively strong association'). However, the effect size was lower in the U-20 category (*Vc* = 0.17 – 'small effect') than in the analysis by trimester.

By the playing position

Considering the playing position (Table 3), an unequal distribution of players' birthdates by trimester was observed in the whole sample ($\chi^2(7) = 339.20$; $p < 0.001$). According to the competition category, statistical analysis revealed overrepresentation of relatively older players in the following playing positions by the competition category: the U-18 category: 'goalkeeper' ($\chi^2(7) = 24.93$; $p < 0.01$), 'wing' ($\chi^2(7) = 21.30$; $p < 0.01$), 'back' ($\chi^2(7) = 15.16$; $p < 0.05$), 'centre-back' ($\chi^2(6) = 23.26$; $p < 0.01$), and 'pivot' ($\chi^2(7) = 18.01$; $p < 0.05$); the U-20 category: 'goalkeeper' ($\chi^2(7) = 21.02$; $p < 0.01$), and 'centre-back' ($\chi^2(7) = 16.32$; $p < 0.05$). The largest effect sizes were observed in 'goalkeeper' in the U-18 (*Vc* = 0.67 – 'strong association') and U-20 categories (*Vc* = 0.63 – 'strong association'), and 'centre-back' in the U-18 category (*Vc* = 0.62 – 'strong association'). No significant differences were found in female senior players ($p > 0.05$).

Similar findings were found by semester ($\chi^2(3) = 313.14$; $p < 0.001$) (Table 4). Statistical analysis revealed a prevalence of the RAE at all playing positions in the U-18 category ($p < 0.01$), except 'back' ($p > 0.05$). In the U-20 category, significant differences were only found in the goalkeeper position ($p < 0.05$). The largest effect sizes were observed in 'centre-back' (*Vc* = 0.70 – 'strong association') and 'goalkeeper' (*Vc* = 0.58 – 'relatively strong association') positions in the U-18 category. Interestingly, the presence of the RAE at the senior 'back' players was found ($p < 0.05$), with no effect detected on this playing position in the youth and/or junior categories.

RAE and the final team position

Table 5 shows the magnitude of the RAE according to the final team position. Statistical analysis revealed overrepresentation of the relatively older players in the medalist ($\chi^2(7) = 17.47$; $p < 0.05$), quarterfinalist ($\chi^2(7) = 32.20$; $p < 0.001$), and eightfinalist teams ($\chi^2(7) = 46.23$; $p < 0.001$) in the U-18 category. Conversely, the RAE affected the quarterfinalist ($\chi^2(7) = 27.81$; $p < 0.001$) and bottom-eight teams ($\chi^2(7) = 15.54$; $p < 0.05$) in the U-20 category. The largest effect sizes were observed in quarterfinalist teams, both in the youth (*Vc* = 0.63 – 'strong association') and junior (*Vc* = 0.61 – 'strong association') categories, and medalist (*Vc* = 0.61 – 'strong association') and eightfinalist teams (*Vc* = 0.60 – 'strong association') in the U-18 category. Nevertheless, there was a homogeneous distribution of players by trimester in the senior category ($p > 0.05$).

Discussion

The main objectives of this study were to evaluate the presence of the RAE in the female players' selection process throughout their participation in the Handball World Championship and the prevalence of the RAE according to collective competition performance. Moreover, secondary purposes were to analyse the influence of modulating factors of the RAE, such as competition category and playing position. As in other studies focused on female handball (Gómez-López et al., 2017; Schorer et al., 2009), an unequal birthdate distribution by trimester of handball players in the youth and junior categories was observed, detecting no impact of the RAE in the senior category. Nevertheless, this study shows there was overrepresentation of female players born in the first half of the year (S1) in the senior category. Therefore, the RAE widely tends to decrease as the chronological age of the player increases. However, this fact should be interpreted with awareness of specific contextual considerations or methodological concerns corresponding to each study. With regard to the relationship between the RAE and performance, teams that reached a higher final position were mainly composed of players born in T1. Interestingly, teams that ranked between the 4th and the 8th place showed a stronger association between the RAE and collective performance than the medallist teams.

Table 1

Distribution of female handball players (n and [%]) by the competition category and the playing position

POSITION	CATEGORY			Total POS [$n(\%)$]
	U-18[$n(\%)$]	U-20[$n(\%)$]	Senior[$n(\%)$]	
Goalkeeper	55(14.9)	53(16.2)	55(13.8)	163(14.9)
Wing	89(24.1)	78(23.7)	89(22.3)	256(23.4)
Back	110(29.8)	90(27.4)	118(29.6)	318(29.0)
Centre-Back	61(16.5)	54(16.5)	71(17.8)	186(17.0)
Pivot	54(14.7)	53(16.2)	66(16.5)	173(15.7)
Total CAT [$n(\%)$]	369(33.7)	328(29.9)	399(36.4)	1,096(100.0)

Notes: n = absolute frequency; % = relative frequency; U-18 = youth category; U-20 = junior category

Table 2

Birthdate players' distribution (n [%] and odds ratio [OR]) by trimester (T) and semester (S) according to the competition category

TRIMESTERS		T1	T2	T3	T4	T5	T6	T7	T8	x^2	df	p	Vc
		% (OR)	% (OR)	% (OR)	% (OR)	% (OR)	% (OR)	% (OR)	% (OR)				
CAT	U-18	26.0 (6.1)	15.7 (3.3)	13.3 (2.7)	10.3 (2.0)	13.0 (2.6)	8.1 (1.5)	8.1 (1.5)	5.4 (-)	87.22	7	<0.001	0.49
	U-20	22.0 (3.1)	9.1 (1.1)	12.5 (1.6)	12.2 (1.5)	12.2 (1.5)	12.8 (1.6)	11.0 (1.4)	8.2 (-)	33.12	7	<0.001	0.32
	Senior	26.3 (1.5)	28.3 (1.6)	25.8 (1.4)	19.5 (-)	-	-	-	-	7.38	3	0.061	0.14

SEMESTERS		S1		S2		S3		S4		x^2	df	p	Vc
		%	OR	%	OR	%	OR	%	OR				
CAT	U-18	41.7	4.7	23.6	2.0	21.4	1.8	13.3	-	64.88	3	<0.001	0.42
	U-20	31.1	1.9	24.7	1.4	25.0	1.4	19.2	-	9.69	3	0.021	0.17
	Senior	54.9	1.5	45.1	-	-	-	-	-	4.19	1	0.041	0.10

Notes: T1-T4/T8 = birth trimester; S1-S2/S4 = birth semester; % = relative frequency; OR = odds ratio; x^2 = chi square; df = degrees of freedom; p = level of significance; Vc = Cramer's V; CAT = competition category; U-18 = youth category; U-20 = junior category

<div align="right">**Table 3**</div>

Birthdate female players' distribution (n y %) by trimester (T) according to the competition category and the playing position

YOUTH CATEGORY (U-18)

P.P.	T1 n (%)	T2 n (%)	T3 n (%)	T4 n (%)	T5 n (%)	T6 n (%)	T7 n (%)	T8 n (%)	χ^2	df	p	Vc
Gk	17 (30.9)	9 (16.4)	6 (10.9)	9 (16.4)	4 (7.3)	4 (7.3)	5 (9.1)	1 (1.8)	24.93	7	0.001	0.67
W	19 (21.3)	14 (15.7)	12 (13.5)	11 (12.4)	17 (19.1)	9 (10.1)	5 (5.6)	2 (2.2)	21.30	7	0.003	0.49
B	25 (22.7)	13 (11.8)	14 (12.7)	9 (8.2)	16 (14.5)	7 (6.4)	13 (11.8)	13 (11.8)	15.16	7	0.034	0.37
CB	19 (31.1)	13 (21.3)	10 (16.4)	4 (6.6)	7 (11.5)	5 (8.2)	3 (4.9)	0 (0)	23.26	6	0.001	0.62
P	16 (29.6)	9 (16.7)	7 (13.0)	5 (9.3)	4 (7.4)	5 (9.3)	4 (7.4)	4 (7.4)	18.01	7	0.012	0.58

JUNIOR CATEGORY (U-20)

P.P.	T1 n (%)	T2 n (%)	T3 n (%)	T4 n (%)	T5 n (%)	T6 n (%)	T7 n (%)	T8 n (%)	χ^2	df	p	Vc
Gk	16 (30.2)	6 (11.3)	2 (3.8)	4 (7.5)	8 (15.1)	6 (11.3)	3 (5.7)	8 (15.1)	21.02	7	0.004	0.63
W	13 (16.7)	9 (11.5)	14 (17.9)	12 (15.4)	6 (7.7)	7 (9.0)	7 (9.0)	10 (12.8)	6.44	7	0.490	0.29
B	17 (18.9)	7 (7.8)	11 (12.2)	11 (12.2)	13 (14.4)	14 (15.6)	12 (13.3)	5 (5.6)	9.29	7	0.233	0.32
CB	14 (25.9)	2 (3.7)	10 (18.5)	6 (11.1)	8 (14.8)	4 (7.4)	7 (13.0)	3 (5.6)	16.32	7	0.022	0.55
P	12 (22.6)	6 (11.3)	4 (7.5)	7 (13.2)	5 (9.4)	11 (20.8)	7 (13.2)	1 (1.9)	13.95	7	0.052	0.51

SENIOR CATEGORY

P.P.	T1 n (%)	T2 n (%)	T3 n (%)	T4 n (%)	T5 n (%)	T6 n (%)	T7 n (%)	T8 n (%)	χ^2	df	p	Vc
Gk	18 (32.7)	10 (18.2)	16 (29.1)	11 (20.0)	-	-	-	-	3.39	3	0.335	0.25
W	25 (28.1)	27 (30.3)	20 (22.5)	17 (19.1)	-	-	-	-	3.01	3	0.391	0.18
B	30 (25.4)	40 (33.9)	25 (21.2)	23 (19.5)	-	-	-	-	6.10	3	0.107	0.23
CB	17 (23.9)	16 (22.5)	27 (38.0)	11 (15.5)	-	-	-	-	7.46	3	0.059	0.32
P	15 (22.7)	20 (30.3)	15 (22.7)	16 (24.2)	-	-	-	-	1.07	3	0.785	0.13

Notes: T1-T4/T8 = birth trimester; P.P. = playing position; Gk = goalkeeper; W = wing; B = back; CB = centre-back; P = pivot; n = absolute frequency; % = relative frequency; χ^2 = chi square; df = degrees of freedom; p = level of significance; Vc = Cramer's V

Table 4

Birthdate female players' distribution ('n' y '%') by semester (S) according to the competition category and the playing position

YOUTH CATEGORY (U-18)

P.P.	S1 n	S1 %	S2 n	S2 %	S3 n	S3 %	S4 n	S4 %	x^2	df	p	Vc
Gk	26	47.3	15	27.3	8	14.5	6	10.9	18.19	3	<0.001	0.58
W	33	37.1	23	25.8	27	30.3	6	6.7	18.49	3	<0.001	0.46
B	38	34.5	23	20.9	23	20.9	26	23.6	5.77	3	0.123	0.23
CB	32	52.5	14	23.0	12	19.7	3	4.9	29.66	3	<0.001	0.70
P	25	46.3	12	22.2	9	16.7	8	14.8	13.98	3	0.003	0.51

JUNIOR CATEGORY (U-20)

P.P.	S1 n	S1 %	S2 n	S2 %	S3 n	S3 %	S4 n	S4 %	x^2	df	p	Vc
Gk	22	41.5	6	11.3	14	26.4	11	20.8	10.32	3	0.016	0.44
W	22	28.2	26	33.3	13	16.7	17	21.8	4.89	3	0.180	0.25
B	24	26.7	22	24.4	27	30.0	17	18.9	2.57	3	0.462	0.17
CB	16	29.6	16	29.6	12	22.2	10	18.5	2.03	3	0.567	0.19
P	18	34.0	11	20.8	16	30.2	8	15.1	4.85	3	0.183	0.30

SENIOR CATEGORY

P.P.	S1 n	S1 %	S2 n	S2 %	S3 n	S3 %	S4 n	S4 %	x^2	df	p	Vc
Gk	28	50.9	27	49.1	-	-	-	-	0.04	1	0.850	0.03
W	53	59.6	36	40.4	-	-	-	-	3.48	1	0.062	0.20
B	70	59.3	48	40.7	-	-	-	-	4.41	1	0.036	0.19
CB	33	46.5	38	53.5	-	-	-	-	0.27	1	0.602	0.06
P	35	53.0	31	47.0	-	-	-	-	0.29	1	0.588	0.07

Notes: S1-S2/S4 = birth semester; P.P. = playing position; Gk = goalkeeper; W = wing; B = back; CB = centre-back; P = pivot; n = absolute frequency; % = relative frequency; x^2 = chi square; df = degrees of freedom; p = level of significance; Vc = Cramer's V

Relative age effect (RAE) according to collective performance (final team position) by the competition category

YOUTH CATEGORY (U-18)

FINAL TEAM POSITION	T1 n (%)	T2 n (%)	T3 n (%)	T4 n (%)	T5 n (%)	T6 n (%)	T7 n (%)	T8 n (%)	x^2	df	p	Vc
1st - 3rd place	13 (27.7)	10 (21.3)	5 (10.6)	6 (12.8)	5 (10.6)	3 (6.4)	3 (6.4)	2 (4.3)	17.47	7	0.015	0.61
4th - 8th place	25 (30.9)	14 (17.3)	9 (11.1)	6 (7.4)	6 (7.4)	7 (8.6)	10 (12.3)	4 (4.9)	32.20	7	<0.001	0.63
9th - 16th place	37 (28.9)	20 (15.6)	14 (10.9)	11 (8.6)	22 (17.2)	10 (7.8)	7 (5.5)	7 (5.5)	46.23	7	<0.001	0.60
17th - 24th place	21 (18.6)	14 (12.4)	21 (18.6)	15 (13.3)	15 (13.3)	10 (8.8)	10 (8.8)	7 (6.2)	12.96	7	0.073	0.34

JUNIOR CATEGORY (U-20)

FINAL TEAM POSITION	T1 n (%)	T2 n (%)	T3 n (%)	T4 n (%)	T5 n (%)	T6 n (%)	T7 n (%)	T8 n (%)	x^2	df	p	Vc
1st - 3rd place	9 (20.5)	7 (15.9)	3 (6.8)	2 (4.5)	5 (11.4)	11 (25.0)	3 (6.8)	4 (9.1)	13.19	7	0.068	0.55
4th - 8th place	24 (32.0)	8 (10.7)	6 (8.0)	10 (13.3)	8 (10.7)	6 (8.0)	6 (8.0)	7 (9.3)	27.81	7	<0.001	0.61
9th - 16th place	22 (18.6)	11 (9.3)	17 (14.4)	16 (13.6)	17 (14.4)	11 (9.3)	12 (10.2)	12 (10.2)	7.53	7	0.376	0.25
17th - 24th place	17 (18.7)	4 (4.4)	15 (16.5)	12 (13.2)	10 (11.0)	14 (15.4)	15 (16.5)	4 (4.4)	15.54	7	0.030	0.41

SENIOR CATEGORY

FINAL TEAM POSITION	T1 n (%)	T2 n (%)	T3 n (%)	T4 n (%)	T5 n (%)	T6 n (%)	T7 n (%)	T8 n (%)	x^2	df	p	Vc
1st - 3rd place	13 (25.5)	17 (33.3)	12 (23.5)	9 (17.6)	-	-	-	-	2.64	3	0.450	0.23
4th - 8th place	19 (22.9)	21 (25.3)	25 (30.1)	18 (21.7)	-	-	-	-	1.32	3	0.724	0.13
9th - 16th place	34 (25.4)	34 (25.4)	38 (28.4)	28 (20.9)	-	-	-	-	1.55	3	0.670	0.11
17th - 24th place	39 (29.8)	41 (31.3)	28 (21.4)	23 (17.6)	-	-	-	-	7.34	3	0.062	0.24

Notes: T1-T4/T8 = birth trimester; n = absolute frequency; % = relative frequency; x^2 = chi square; df = degrees of freedom; p = level of significance; Vc = Cramer's V

A large prevalence of the RAE was found in other studies based on female team sports (Delorme et al., 2010; Torres-Unda et al., 2016). This fact could imply a lack of opportunities for the relatively younger players in the selection process in relation to those players born at the beginning of the same year. According to Baxter-Jones (1995), the presence of the RAE in youth female sport (e.g., handball) is associated with an early maturational development. Thus, relatively older players tend to be more select and overrepresented due to biological factors (morphological, physical, anthropometric, and physiological), which confirms the 'maturation-selection hypothesis' (Cobley et al., 2009). However, stabilization of this kind of differences occurs earlier in men than in women (Baxter-Jones, 1995). This would cause a slower process in women's sports due to, among other factors, the greater heterogeneity and variability of results (Smith et al., 2018). Therefore, it seems that the selection process in youth categories in women's handball is biased in favour of players with a greater maturation profile in order to achieve a higher and more immediate performance (de la Rubia et al., 2020a; Saavedra and Saavedra, 2020; Schorer et al., 2009).

In the senior category, in which the distribution of players is not biased in biannual competition cycles, a decrease in the RAE was observed. Therefore, an increase in the chronological age of female players seems to involve a lower bias in the player selection process to participate in international competitions. This fact has been explicated by several studies considering different approaches, including sports, sociology, and sport specialization. From a sports perspective, one of the most common and accurate explanations is the 'depth of competition' (Baker et al., 2009; Musch and Grondin, 2001). This theory argues that in female sport, there is an insufficient number of federal licenses in relation to male handball and, therefore, the RAE would not be affected by player selection at high performance levels. From a sociological view, female players tend to bear great pressure to maintain a figure considered 'ideal', which would mean lower competitive performance due to physical development not suitable for sports practice (Vincent and Glamser, 2006). Thus, this could even lead to a high dropout rate among female players (Delorme et al., 2010). From a sport specialization perspective, female senior players could experience a transfer from one sport to another in which performance factors were similar, especially in team sports. Therefore, this would avoid a biased sport context by the RAE (Baker et al., 2009). An alternative explanation, associated with the previous point, would be based on a higher injury rate by relatively older players. This fact would cause competitive interruptions throughout the sport transition process, complicating their career towards high performance levels (Bjørndal et al., 2018b).

With regard to the analysis by the playing position, the RAE seems to be a factor with a great impact on the player selection process, especially at some playing positions (de la Rubia et al., 2020a; Fonseca et al., 2019; Ibañez et al., 2018; Schorer et al., 2009). Findings of the present study showed overrepresentation of relatively older players at all playing positions in the youth category (U-18), while the RAE did not appear in the senior category, highlighting stabilization at the elite level. The largest impact of the RAE was found at the 'goalkeeper' and 'centre-back' positions in the youth and junior categories, according to other studies (Fonseca et al., 2019; Schorer et al., 2009). Those investigations highlighted physical and anthropometric factors as keys in the occupation of back positions, such as the 'centre-back'. Larger and stronger body sizes, higher strength levels and higher shot velocity (Kruger et al., 2014) seem to explain why relatively older players may have some advantages due to greater maturational development than their relatively younger peers (Matthys et al., 2013). In relation to the 'goalkeeper' position, in addition to maturational development, position-specific skill demands may explain the presence of the RAE (Wattie et al., 2015). Early specialization, necessary for this position, through intense training and competition could be influenced by selection processes in which relatively older players would have enjoyed more and better training experience (i.e., more skilled coaches, better facilities and sport programs) than their relatively younger counterparts (Nikolaidis et al., 2015).

Analysis of the influence of the RAE on performance showed, as expected,

overrepresentation of relatively older players in teams with better collective performance, that is, with a better final position. Furthermore, it was shown that this phenomenon did not occur in the same way according to the competition category. Thus, the prevalence of the RAE at higher competition levels was either detected in teams classified at the lower level (junior category) or it disappeared completely (senior category). These findings coincide with previous studies (Campos et al., 2020; Vegara-Ferri et al., 2019; Zimmermann de Oliveira et al., 2017). Most likely, talent identification and development programs, of which priority is to achieve immediate high performance (i.e., national teams), tend to shape rosters with overrepresentation of relatively older players. Thus, athletes with a higher maturational development, especially in female formative categories, would reach better individual performance than their relatively younger peers (Saavedra and Saavedra, 2020), translating into a higher final team position. However, this relationship seems not to be present in male handball competitions (Fonseca et al., 2019) because biological differences among players are not as evident as in women's sport. For these reasons, there was a strong prevalence of the RAE in collective performance in international youth and junior competitions, but it had no influence at the senior level (de la Rubia et al., 2020a).

This study had several limitations. First, we ignored the birthdate distribution among the populations of the countries analysed (Schorer et al., 2009). Second, we did not include, as a study sample, players considered 'minor' because they were born outside the biannual competition cycle. Third, we did not have a performance index rating in handball to individually evaluate the player's specific skills. Fourth, we did not have access to the maturation data of players. Fifth, the analysis focused on a specific competitive period (2017–18), thus it would be necessary to increase the number of seasons or competitions to consider a longitudinal evaluation of the trend of the RAE in women's handball.

Unexpected findings

Surprisingly (by semester), the RAE was detected among female senior players in the 'back' position, whereby relatively older players were favoured over relatively younger ones. This fact is relevant because no prevalence of the RAE

was found for this playing position in lower categories (U-18 and U-20). This result may lead to a paradigm shift in the TID systems in international women's handball (Figueiredo et al., 2020). Considering that the age range of players who compose the sample is wide (16–40 years), it seems that a single talent-selection model has not been applied. Therefore, it seems that in the selection process of talented young players, less relevance is given to physical and conditioning factors to the detriment of more tactical and comprehensive training (Bjørndal et al., 2018a).

An explanation may associate game-specific demands with the biological characteristics of the player. At the elite levels, the 'back' players perform a greater number of actions per match which require a high component of strength or the rate of force development, such as throws, offensive breakthroughs, hard tackles, physical confrontations, etc. (Michalsik et al., 2015). This would mean that relatively older players, whose maturational level is higher, will occupy this playing position to a greater extent due to higher levels of strength (Matthys et al., 2013). Also linked to maturational status, height, and weight, among other anthropometric measures, are relevant factors to this playing position, in which nine meter shots are usually made in offense and blocks in defense (Sarvestan et al., 2019; Schwesig et al., 2017). On the other hand, considering that relatively older players enjoy more and better training experience (skilled coaches, higher competition levels, better facilities, etc.) than their relatively younger counterparts (Hancock et al., 2013), coaches may tend to select relatively older players for positions with a high relative 'weight' in the match, such as the 'back' (Krahenbühl and Leonardo, 2020). Therefore, these results may support the interaction between 'task' (i.e., sport-specific demands) and 'environmental' constraints (i.e., training conditions) to explain the prevalence of the RAE in female senior 'back' players (Wattie et al., 2015).

Practical implications & Future research

Organisations and institutions responsible for the player selection processes (national and international federations, clubs, academies, professional associations) could implement solutions to reduce the consequences of the RAE and, thus, ensure that future talents are not

excluded at early stages of the sport development (formative categories) due to chronological age and maturational status.

Future research should design a global statistical variable which accurately measures individual performance of the handball player and, therefore, be able to analyse how the RAE influences individual competition performance. On the other hand, it is necessary to examine long-term performance of handball players based on the possible selection bias that occurred throughout the sport transition due to the RAE, among other factors. Therefore, a deeper exploration would help mitigate possible negative consequences, such as the dropout of talented handball players. Finally, knowing exactly the most sensitive moment of the player development process, when the mechanisms associated with the RAE could have a greater influence, would help implement strategies in TID systems focused on ensuring suitable sport development conditions. Some of them presented in the existing literature are: rotation of the cut-off date by age, greater attention of coaches to other factors less associated with biological criteria in the player selection process, optimization of the process through a multidisciplinary and long-term approach fleeing immediate and current performance, the design of specific and individualised training programs according to a player profile to improve performance, and even the omission of official competitions at youth and junior levels.

Conclusions

The RAE was especially present in formative categories (youth and junior), reducing or even disappearing at the senior stages in female handball. Thus, relatively older players had greater opportunities to be selected by the national federation in youth and junior categories and, therefore, to compete at the highest level than relatively younger players.

The specific demands of playing positions could cause the player recruitment systems to prioritise the maturational development of the player at the expense of other characteristics (i.e., techniques, tactics, psychological). This could entail the relatively older players to be preferentially considered to occupy certain playing positions. In this way, the RAE would be a determining factor for female player selection, accentuated in the positions in which competitive quality incentives must be experienced to reach high performance (i.e., 'centre-back' and 'goalkeeper'). Unexpectedly, the prevalence of the RAE was found in female senior 'back' players.

The RAE was a factor which affected collective competition performance in women's handball, especially in teams that achieved higher final positions (from 1st to 8th). Nevertheless, the number of relatively older players was reduced as the competitive level (final team position) decreased and the competition category increased.

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