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Original Article

Relative age effects and team performance among elite beach handball athletes

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Abstract
The Relative Age Effect is a well established phenomenon in a wide range of elite team sports. However,the prevalence of this effect was not investigated in beach handball so far. Therefore,this study aimed to investigate whether RAEs are present in elite beach handball athletes and to analyze its relation with team competitive success in World Championships. Data from 777 elite beach handball athletes (391 males and 386 females) from 32 countries who participated in the IHF Beach Handball World Championships (2012 to 2018) were analyzed. Athlete's birth dates were organized according to quarters, based on their month of birth, as follows; Q1 (from January to March), Q2 (from April to June), Q3 (from July to September), and Q4 (from October to December). Athletes' birthdates were compared according to sex and the rankings achieved in Beach Handball World Championships. We performed Chi-squared tests to examine whether sex and final placements modulated RAEs in beach handball sports system. An over representation of athletes born in the first semester was found for both sexes ($p < 0.05$). An over representation of athletes born in Q1 was found, compared to athletes born in Q3 ($p < 0.007$) and Q4 ($p < 0.001$) in male athletes.In females, athletes born in Q1 and in Q2 were more prevalent than athletes born in Q4 ($p < 0.05$). The athletes' birthdates distribution was different from expected ($p < 0.001$) for intermediate classification teams, but not for top-4 ($p = 0.139$) and bottom-4 ($p = 0.103$) ranked teams. In conclusion, RAEs were found in both male and female elite beach handball athletes in senior category. However, RAEs were not associated with competitive success, determined by the final ranking achieved by the national teams in the World Championships.
Keywords: Relative Age Effect, Athletic development, Talent identification, Performance, Beach Handball Championships

Introduction

In most team sports, young athletes are grouped by chronological age as an attempt to provide equal developmental training and competition opportunities (Schorer et al., 2009). However, (dis)advantages within specific age groupings are still present, as individuals born closer to cut-off dates are more likely to be positively evaluated than their relatively younger peers (Cobley et al., 2009). These differences result from the interaction between athlete's birthdates and policies based on age categories to group athletes, and are called Relative Age Effects (RAEs).

In elite sports, RAE may represent a loss of potentially talented players, as coaches have a greater risk to perceive relatively older athletes as more skilled than their young peers during selection, at early stages of sports participation (Nolan & Howell, 2010). At this point, maturation and developmental processes are associated with chronological age, which favors relatively older players. On the other hand, relatively younger athletes tend to be overlook, which can cause higher dropout rates and loss of potential sporting talents (Cobley et al., 2009). Since maturation processes reach a steady state level after adolescent growth spurt (Malina et al., 2015), RAEsare expected to reduce or even disappear at senior age categories (Smith et al., 2018; Wrang et al., 2018). Nevertheless, many studies have reported that RAEs remains up tothe senior category in many elite team sports, such as indoor handball (Figueiredo et al., 2020), soccer (Helsen et al., 2012), rugby (Till et al., 2010) and hockey (Nolan &Howel, 2010). These results indicate that the inequalities produced by age groups policies may

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be associated with long-term sport participation and success, and reinforce the importance of understanding the factors that influence RAE.

Wattie et al. (2015) proposed a constraints-based model of developmental influences aiming to explain the prevalence of the RAE in a sports system based on the interaction of individual, task and environmental constraints. Individual constraints refer to individual's biological factors such as sex, maturational status, and body composition. Task constraints are associated with sports specificity, as there are specific physical and technical-tactical abilities that are more relevant in different sports settings. Finally, environmental constraints refer to the social environment associated to an athlete, as well as the influence that family, coaches, and peers have on this athlete.

One of the individual constraints that play a major role on the magnitude of RAE is sex (Wattie et al., 2015). While several studies often found RAE for male athletes in different elite sports, such as soccer (Yagüe et al., 2018), and ice hockey (Nolan &Howel, 2010), these results are less evident in female athletes (Cobley et al., 2009). In order to address RAEs in female athletes, Smith et al. (2018) performed a review and meta-analysis in this matter. Indeed, it was confirmed that effectswere less frequent and of smaller magnitude in females than in males. Some of the factors that modulate RAE differently across sex are the different popularity of sports, the number of athletes competing on selection processes, the cultural and social contexts, and the level of competitiveness of the sport (Smith et al., 2018; Wattie et al., 2015). In general, the larger the pool of athletes competing for a limited number the spots in a team, the greater the chances of this effect occurring in a given sport system (Cobley et al., 2009; Smith et al., 2018).

RAE is a widely studied phenomenon in team sports (Figueiredo et al., 2020; Nolan & Howell, 2010; Rubia et al., 2020; Yagüe et al., 2018), however little attention has been directed towards the relationship between RAE and competitive success. This relation may have a major practical appeal in sports settings, since the athletes' selection processesemployed by coaches could result in increased teamperformance. Kirkendall (2014) investigated the relationship between RAEs and competitive success in U-16 North-American soccer male and female athletes. Results indicated no association between RAE and competitive success.Similarly, Arrieta et al. (2015) also failed to find an association between RAE and team's final ranking on U-16 and U-18 male and female basketball players that participated in European Basketball Championships. However, this association was reported on U-20 category. In team handball studies, Rubia et al. (2020) found that relatively older athletes were more frequent in teams that achieved better final placements in U-19, U-21 and senior World Handball Championships. On the other hand, Fonseca et al. (2019) did not found RAE in the semi-finalist teams in the U-19 World Handball Championship, which was supported by the lack of association between RAE and final placement in the Championship. Thereby, whether there is an association between RAE and team performance remains unclear, although this relationship seems to be age-sport-dependent. Thus, it is relevant to investigate this phenomenon in emerging sports such as beach handball, in which this issue has not yet been addressed.

Beach handball is a recent sport with an increasing number of participants in all continents. Despite being practiced since the 1990s, the official rules of the sport were only published in 2002 (Achenbach et al., 2018), and the first Beach Handball World Championship was only played in 2004. Although beach handball is currently growing in popularity, there is a lack of scientific data about this sport. The number of studies that investigate beach handball has grown in recent years, in themes such as the injuries pattern (Achenbach et al., 2018) and specific physical demands of the sport (Lemos et al., 2020). One of the topics that has not received attention in beach handball is the investigation of RAE's. Considering the similarities between beach and indoor handball, both in technical/tactical and in physical/anthropometric aspects that influence performance (Lemos et al., 2020) we speculate that the RAE phenomenon may also be observed in beach handball. To the best of our knowledge, no study investigated the prevalence of RAE among elite beach handball athletes and its relationship with successful team performance in official competitions.

The present study aimed to investigate the occurrence of RAE in elite beach handball athletes and to analyze if this occurrence is associated with team competitive success in male and female athletes. Due to physical constraints related to beach handball demands, we hypothesized that RAE would be found in both male and female athletes, with larger magnitude effects for male athletes. This hypothesis is in line with previous RAE literature reviews (Cobley et al., 2009; Smith et al., 2018), which has consistently reported RAE in elite team sports and smaller effects in the female athletes. Regarding the competitive performance analysis, we hypothesized that there would be no association between RAE and success in competitions. This is because RAE is associated with maturation, and the growth process is expected to be finished in senior categories (Gibbs et al., 2012).

Materials and Methods

Participants

Birthdates of 391 male athletes and 386 female athletes that participated in one or more of the 4 editions of the IHF Beach Handball World Championships that were played from 2012 to 2018 in the senior category

were analyzed in this study. Thirty-three countries (Argentina, Australia, Bahrain, Brazil, China, Chinese Taipei, Croatia, Denmark, Egypt, France, Greece, Hungary, Iran, Italy, Kuwait, Mexico, New Zealand, Norway, Oman, Paraguay, Poland, Qatar, Russia, Singapore, Serbia, Spain, Sweden, Thailand, Tunisia, Ukraine, United States, Uruguay and Vietnam) participated in the competitions, held by the International Handball Federation.

Data Collection and Research Design

Data were obtained from the official International Handball Federation webpage (http://www.ihf.info). Information regarding the Beach Handball World Championships played from 2012 to 2018 was obtained from summary rankings (final positions in the competition), and team rosters (athletes' name, birth date, age, and so on). The information was organized according to sex and final championship placement, to investigate the existence of RAE between male and female elite beach handball athletes, and to analyze its relationship with the team's final ranking in the Championships.

The selected athletes' birthdates were organized according to the players' quarter of birth (Q1 – from January to March, Q2 – from April to June, Q3 – from July to September, or Q4 – from October to December), sex (male or female) and the team's final ranking in the championships (top-4 teams, intermediate-4 teams or bottotm-4 teams). In 2012, 2014 and 2016 editions of themale and female Beach Handball World Championships, 12 teams participated in both competitions. Specifically in the 2018 edition, the number of teams competing was 16 in male and female competitions, therefore 4 teams were excluded from the team position analysis. As in the other editions, the top-4 and bottom-4 teams were selected, but only teams positioned 7th to 10th (more intermediate teams) were considered as the intermediate-4 teams. Players that participated in more than one World Championship edition were considered only once in the sex analysis, but were considered as different players for the team performance analysis.

Data Analysis

Data was presented in absolute and relative frequency. Chi-square tests ($\chi 2$) were performed to compare the athlete's birthdate distribution according to sex and teams' final position in the championship. Effect sizes(ω) of the Chi-square tests were calculated according to Cobley et al. (2009). According to the nomenclature of Cohen (1988) 0.1 is considered a small effect, 0.3 a medium effect and 0.5 a large effect. When necessary, Bonferroni adjustment for multi-comparison was conducted to identify specific frequency distribution differences. The number of athletes in each quarter was compared with the expected frequency (Edgar &O'Donoghue, 2005). Additionally, odds ratio (ORs) and 95% confidence intervals were calculated for both quarter and half year's distribution according to the team's final ranking. The analysis was performed using the Statistical Package for the Social Sciences (SPSS) 21.0 version (Chicago, USA). Statistical significance was set to 5%.

Results

Figure 1 presents the relative frequency distribution in quarters of the date of birth of male (Figure 1a) and female (Figure 1b) beach handball athletes. The athletes' distribution was different from expected in both male ($\chi 2 = 15.36$; $p = 0.002$; $\omega = 0.2$; OR Q1:Q4 = 1.92; OR 1st:2st = 2) and female ($\chi 2 = 16.19$; $p = 0.001$; $\omega = 0.2$; OR Q1:Q4 = 1.73; OR 1st:2st = 2.22) athletes. Athletes born in the first semester were more frequent in males and females athletes.The post hoc analysis identified that athletes born in the first quarter were overrepresented compared to athletes born in the third ($p < 0.007$) and fourth ($p < 0.001$) quarters in male athletes. As for the females, athletes born in the first ($p < 0.006$) and in the second ($p < 0.005$) quarters were more frequent than athletes born in the fourth quarter were.

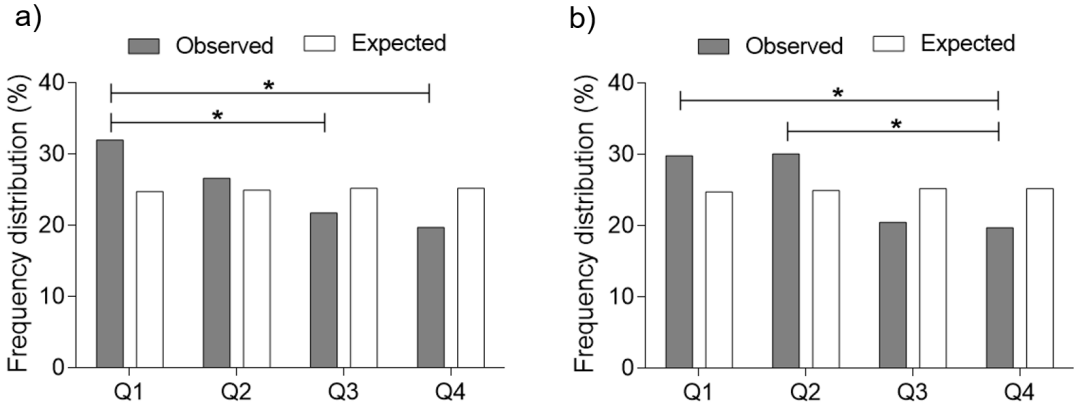

Fig. 1. Distribution of the quarter of birth for (a) male and (b) female beach handball athletes. * represents significant difference; Q1;Q4 represents the birth quarters of the year.

Table 1 shows the frequency distribution in quarters of the date of birth of male athletes according to team final ranking in 2012, 2014, 2016 and 2018 beach handball World Championships. The athletes' distribution was different from expected ($p = 0.039$) for intermediate-4 ranking teams, but not for top-4 ($p = 0.221$) and bottom-4 ($p = 0.924$) ranking teams.

Tab. 1. Absolute distribution of dates of birth as a function of the tournament final position for male handball players.

	TOP-4		**INTERMEDIATE-4**		**BOTTOM-4**	
Quarter of date of birth	Observed	Expected	Observed	Expected	Observed	Expected
Q1	48	39	54 [c,d]	39.3	43	39.5
Q2	43	39.4	40	39.6	40	39.9
Q3	33	39.8	33	40.1	39	40.3
Q4	34	39.8	32	40.1	38	40.3
χ^2	4.40		8.37		0.48	
*p*value	0.221		0.039		0.924	
ω	0.17		0.23		0.05	
OR (Q1:Q4)	1.59		2.04		1.18	
IC95%	(0.95 to 2.64)		(1.23 to 3.39)		(0.71 to 1.95)	
OR (1^{st}:2^{st})	1.84		2.09		1.16	
IC95%	(1.18 to 2.88)		(1.34 to 3.27)		(0.75 to 1.8)	

Note. Q1-Q4 = birth quarter; χ^2 = Chi-square value; ω = effect size; OR = odds ratio; Q1:Q4 = first quarter compared to fourth quarter; 1^{st}:2^{st} = first semester compared to second semester. c and d = pairwise Chi-square comparison different from Q3 and Q4, respectively (adjusted for multiple comparison).

Table 2 shows the frequency distribution in quarters of the date of birth of female athletes according to team final ranking in 2012, 2014, 2016 and 2018 beach handball World Championships. The athletes' distribution was different from expected ($p < 0.001$) for intermediate classification teams, but not for top-4 ($p = 0.139$) and bottom-4 ($p = 0.103$) ranking teams.

Tab. 2. Absolute distribution of dates of birth as a function of the tournament final position for female handball players.

	TOP-4		**INTERMEDIATE-4**		**BOTTOM-4**	
Quarter of date of birth	Observed	Expected	Observed	Expected	Observed	Expected
Q1	45	39.3	43	38.8	36	38.8
Q2	46	39.6	58[c,d]	39.1	46	39.1
Q3	40	40.1	30	39.5	28	39.5
Q4	28	40.1	26	39.5	47	39.5
χ^2	5.49		16.53		6.19	
*p*value	0.139		0.001		0.103	
ω	0.19		0.32		0.20	
OR (Q1:Q4)	1.84		1.9		0.70	
IC95%	(1.08 to 3.14)		(1.1 to 3.28)		(0.42 to 1.15)	
OR (1^{st}:2^{st})	1.79		3.25		1.20	
IC95%	(1.15 to 2.79)		(2.05 to 5.16)		(0.77 to 1.86)	

Note. Q1-Q4 = birth quarter; χ^2 = Chi-square value; ω = effect size; OR = odds ratio; Q1:Q4 = first quarter compared to fourth quarter; 1^{st}:2^{st} = first semester compared to second semester. c and d = pairwise Chi-square comparison different from Q3 and Q4, respectively (adjusted for multiple comparison).

Discussion

The present study analyzed the occurrence of RAE in elite beach handball and its relationship with competitive success in teams that participated in World Championships from 2012 to 2018. As hypothesized, we found that athletes born in the first and second quarters of the year were more frequent than athletes born in the third and fourth quarters of the year. Effects of similar magnitude were found for male and female athletes. This contradicts our hypothesis that RAEs would be more prevalent in male beach handball athletes. Finally, we did not find a relationship between final placement in Championships and RAE, since athletes from teams placed in the top-4 and in the bottom-4 in World Championships were evenly distributed. To the best of our knowledge, this is the first study to demonstrate that RAEs are prevalent in elite beach handball, and that this effect is not associated with the final ranking achieved by teams in World Championships.

The presence of RAE in both male and female beach handball athletes is consistent with other studies that reported RAE in elite-level sports (Figueiredo et al., 2020; Helsen et al., 2012; Yagüe et al., 2018). This may be related to increased pressure to develop/select talented athletes in higher competition tiers. We speculate that our results are also affected by the fact that beach handball is derived from indoor handball. Thus, it is usual that much of the initiation and training processes of beach handball athletes takes place in indoor handball, and the transition to the beach modality occurs later, when these athletes are older. Moreover, as the beach modality is still under development, its low professionalization rates makes it common for several athletes to play both indoor and beach handball. Thereby, it is likely that the detection / selection model of young athletes will be partly the same for both modalities, which partially justifies the prevalence of RAE in both of them.

In several team sports, the physical demands and the likelihood of body contact are increased in elite-level sports (Wattie et al., 2015) in comparison to recreational level. Therefore, it is likely that relatively older athletes may be favored in early selection processes, as these athletes are more likely to be bigger, faster and stronger than their relatively younger peers (Malina et al., 2015). Since relatively older athletes may be perceived as more talented than their relatively younger peers during early selection phases, it is likely that these athletes are given better opportunities to develop in sport (Nolan & Howell, 2010;Krahenbühl& Leonardo, 2020). Although these maturational differences are transient and expected to disappear as age increases (Malina et al., 2015), they may still play a major role on young athletes' opportunities to achieve high-competitive level, as corroborated in data of senior athletes of this study. The rationale that RAE decrease as age categories increase, even disappearing in senior category, has been shown in previous studies that investigated senior elite athletes (Bjørndal et al., 2018; Wrang et al., 2018). However, in some contexts, the RAE is so pronounced during earlier athlete development phases that it remains even in senior categories (Figueiredo et al., 2020; Helsen et al., 2012), which seems to be the case with beach handball. Nevertheless, this remains speculative in beach handball, as we did not analyze data from youth categories in our study. This issue should be investigated in future studies to improve the understanding regarding the presence of RAE on youth beach handball categories.

Despite the fact that RAEs were expected in both male and female elite beach handball athletes, it is surprising that the magnitude of these effects was similar between sexes. Previous meta-analytical reviews have reported that RAE are more evident in male team sports athletes than in female peers (Cobley et al., 2009; Smith et al., 2018), which has been attributed to the various barriers related to girls and women's sports engagement (Smith, 2017). The prevalence of RAE in male athletes was particularly evident when higher competition tiers were evaluated, in sports where more advantageous anthropometric and physical characteristics were determinant for higher performance levels, as is the case of indoor handball (Schorer et al., 2009). Moreover, environmental constraints such as social perception towards beach handball may affect female sports participation, which contributes to the understanding of the results of our study (Wattie et al., 2015). Beach handball is a sport played on the sand, where less physical contact and lower injury rates occur compared to the indoor handball (Achenbach et al., 2018). These aspects may convey an image of a safer and more suitable sport for women, compared to the indoor handball and other team sports. It has already been reported that female athlete's family and friends may act as barriers to sport participation, especially when this sport is considered potentially harmful to girls or if it somehow challenges stereotypes of femininity (Smith, 2018). We speculate that beach handball specificity could positively affect the perception of family, friends and even the athletes themselves towards the safety and adequacy for female practitioners. This, in turn, may increase female participation and consequently generate an increase in competition for places in competitive teams. This hypothesis can contribute to understanding why RAE affect men and women to a similar extent in beach handball.

The top-ranked teams in beach handball World Championships did not present an overrepresentation of relatively older athletes, which corroborates our initial hypothesis. This finding is in line with previous investigations that also failed to identify a link between RAE and higher rankings in competitions (Fonseca et al., 2019; Kirkendall, 2014). This leads to the assumption that this relationship is more noticeable among young athletes, since the biggest differences related to physical performance occur during puberty, due to the influence of the maturation process. As age advances, the differences induced by maturational processes decrease (Cobley et al., 2009; Smith et al., 2018), however, in grassroots sport these processes still cause a series of challenges for younger athletes. In order to overcome their older peers and succeed in selection processes, relatively younger athletes may have had to increase their competitiveness by other means than physical capabilities (i.e. technical and tactical skills improvement), in order to overcome their developmental limitations (Ibañez et al., 2018; Malina et al., 2015). This reduction of RAE bias in elite sports is called the "underdog effect" hypotheses, and indicates that RAE is not a reliable long-term performance predictor (Gibbs et al., 2012). Conversely, our results support that RAE is not a determinant factor for long-term performance in beach handball, as competitive success in team sports depends on multiple aspects such as technical, tactical, physical and psychological.

This study presents some limitations, such as not investigating possible RAE causal factors (i.e. individual performance and individual characteristics) that may affect the phenomenon. Additionally, the time span evaluated may be considered small. This is due to the difficulty in obtaining reliable information about

beach handball prior to 2012. Finally, we speculate that the participation of beach handball athletes in high competitive tiers in indoor handball may have affected our results, as these athletes may have gone through more selective processes than athletes who only played one modality. However, we were also not able to account for beach handball athletes' previous indoor experiences. Therefore, beach handball organizations should aim for better information management allowing future investigations a broader perspective of the RAE phenomenon.

From a practical perspective, our results did not find a relationship between the RAE and team performance in World Championships. These findings reinforce the idea that RAE should be eliminated or reduced in the early stage of athlete development to provide equal opportunities for athletes. Hence, policies must be proposed to increase the chances of relatively younger athletes achieving higher competition tiers. Coaches must be aware of the RAE and educated towards selecting young players that have greater potential of success in the future, instead of selecting players that gives them a higher chance of short-term results (Bjørndal et al., 2018). Professionals involved with long-term athlete's development process could also propose changes in sports participation and competition systems. Reducing the maximum age differences in youth competitions or determining a minimum proportion of players born in the second semester of the year (Lagestad et al., 2018) have already been proposed as alternatives to reduce RAE. These counter-RAE interventions may reduce the likelihood of talent loss of relative younger players in the early age categories, caused by superficial selection processes aiming for immediate results.

Conclusions

In conclusion, we found that RAEs are present in elite beach handball senior athletes, and that sex does not seem to affect the magnitude of this effect. Even though this effect was prevalent among senior athletes, RAE was not determinant for competitive success, as demonstrated by the lack of relationship between RAE and the top-4 ranked teams in World Championships. Such findings add to the literature on RAE indicating that this effect is prevalent on yet another team sport, but is not associated with competitive success in this modality.Moreover, our findings highlight that coaches and sport administrators must work to prevent RAEs in the beach handball context, in order to minimize the inequalities generated by age-grouping system. By doing so, fewer potential sports talents may be lost in the athletic developmental pathway. Future studies are warranted to investigate RAEs in youth age categories, along with more specific performance parameters (i.e., physical and technical) to improve the understanding of the RAE in beach handball sport system.

Conflicts of interest: None.

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