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Influences of competition level, gender, player nationality, career stage and playing position on relative age effects

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Relative age, referring to the chronological age differences between individuals within annually age-grouped cohorts, is regarded as influential to an athlete's development, constraining athletic skill acquisition. While many studies have suggested different mechanisms for this effect, they have typically examined varying sports, precluding an examination of the possible inter-play between factors. Our three studies try to bridge this gap by investigating several moderators for relative age effects (RAEs) in one sport. Handball is a sport with position-specific demands, high cultural relevance and a performance context with established developmental structures and levels of representation for males and females. In Study 1, we investigated the influence of competition level and gender on RAEs before adulthood. In Study 2, elite participation, player nationality and stage of career are considered during adulthood. In Study 3, playing position and laterality (i.e., right vs left handedness) are investigated as moderators. Collectively, the results emphasize the complex inter-play of direct and indirect influences on RAEs in sports, providing evidence toward explaining how RAEs influence the development and maintenance of expertise.

Relative age, referring to the chronological age differences between individuals within annually age-grouped cohorts (Barnsley et al., 1985), is regarded as influential to an athlete's development, constraining athletic skill acquisition. Sport governing bodies, similar to education systems, employ annual-age groupings during childhood and youth in an attempt to "age-match" participants, reducing potential physical and cognitive differences in participation and competition. Nonetheless, such a strategy does not seem sensitive enough to prevent relative age effects (RAEs), specific selection, participation and attainment (dis)advantages according to one's relative age (see Musch & Grondin, 2001).

RAEs were first noticed in the examination of birth-date distributions of players in Canadian ice hockey and volleyball. Controlling for general population distributions, Grondin et al. (1984) found unequal birth-date distributions for male and females at recreational, competitive and senior professional levels for both sports during the 1981/1982 season. Specifically, players born shortly after "cut-off" dates used for annual age groupings were consistently over-represented when compared with their relatively younger peers. Similar findings were reported among male Canadians within elite developmental and junior ice hockey leagues (Barnsley & Thompson, 1988; Barnsley et al., 1985). Subsequently, and with few exceptions (e.g., golf, Côté et al., 2006), greater proportions of relatively older male athletes have been confirmed across age groups and levels of competition for culturally popular sports (e.g., baseball, Thompson et al., 1991, 1992; soccer, Verhulst, 1992; Musch & Hay, 1999; Helsen et al., 2005). In many studies, RAEs have been considered only in high-performing samples (e.g., Australian Rules football and both codes of rugby; Abernethy & Farrow, 2005), while examinations of RAEs in female sports have been largely inconclusive (e.g., Hoare, 2000; Vincent & Glamser, 2006), leaving minimal cohesive understanding of RAEs across an athlete's development.

Several mechanisms have been hypothesized as causes of RAEs, with maturational differences being cited most often (e.g., Barnsley & Thompson, 1988). For example, greater height and mass (to a degree) are believed to underpin successful performance in sports requiring power, speed and endurance (Malina, 1994; Malina et al., 2004). Thus, relatively older players are (on average) consistently and repeatedly advantaged (assuming similar cut-off dates are applied each and every year of competition) due to their extended chronological age, allowing for greater maturation, particularly during the childhood and adolescent years (Norikazu et al., 2007). This notion is also supported by data from elite junior soccer players, who were above the 95th percentile for height and weight when compared with age-matched normative data (Brewer et al., 1992). RAEs also appear to be inflated when positions or roles are physically intensive. In elite ice hockey, Grondin and Trudeau (1991) reported that 68% of National Hockey League (NHL) goalkeepers, between the periods of 1985 and 1999, were born in the first half of the year, with proportional birth-date discrepancies less distinguished for other positions. Such data reinforce maturation as a key mechanism for RAEs, but without consideration of other factors it is difficult to explain precisely how early maturity advantages lead directly to long-term athletic attainment.

Evidence suggests that maturational differences lead to an increased likelihood of being identified as talented and selected by coaches for higher tiers of competition (Sherar et al., 2007). Generally, only when selected can athletes compete at levels of sport beyond recreation. Along with selection comes access to greater resources such as coaching expertise and opportunities to practice that will help develop team/positional/event-specific skills (Helsen et al., 1998). At the same time, those not selected, perhaps on the basis of physical and cognitive delay, are less able to access practice facilities, coaching and competition. Together, maturation and selection processes are suggested to influence an individual's ability to invest in practice and accumulate sport-specific skill and experience, factors deemed critical for long-term attainment (see Baker & Horton, 2004). The importance of selection and experience is emphasized when considering that some of the most robust RAEs have been found in Canadian ice hockey and European soccer (see Boucher & Mutimer, 1994; Helsen et al., 1998), sports whose developmental structures contain several tiers of selection and representation at the junior/adolescent ages (i.e., 11–16 years old).

RAEs are not solely the consequence of maturation and selection processes; additional factors have been implicated. For instance, RAEs appear to be dependent on the amount of competition (i.e., the number of individuals wanting to access events or teams in a given sport, emphasizing the importance of sport popularity; Musch & Grondin, 2001) and the amount of opportunity (i.e., teams and clubs) available for participation (see Helsen et al., 1998). The necessity of competition suggests that RAEs are unlikely in culturally less popular sports. Daniel and Janssen (1987) proposed that the emergence of RAEs in Canadian ice hockey coincided with the integration of earlier competition, talent streaming and structured tiers of proficiency, responses to performance concerns on the international stage. Similarly, Wattie et al. (2007) associated population expansion and participation increases in ice hockey as additional possible mechanisms for RAE emergence. Together, these studies suggest that social-cultural variables cannot be discounted when examining the patterns and prevalence of RAEs within sports contexts.

Despite the consistency of RAEs across sports contexts, the possible inter-play between factors that may account for the variability in RAEs across and within sporting contexts is not completely understood. In this paper, we consider several moderators of RAEs (i.e., competition level, gender, skill, career stage & playing position) in handball – a sport with position-specific demands, high cultural relevance and a performance context with established developmental structures and levels of representation for males and females. Below we present the results from three studies. Our goal is to provide an in-depth examination of variables that may moderate RAEs. By examining a single sport in detail, we hope to provide a more comprehensive examination of these relationships than would be possible with multiple examinations of different sports.

Study 1 – competition level and gender

The purpose of Study 1 was to test the hypothesis that processes of ongoing selection to access higher levels of competition during youth handball are associated with greater RAEs (Barnsley et al., 1985). Considering the present developmental structure of handball, which starts with a regional selection and ends with the selection of the national senior team, we hypothesized that RAEs would be evident at the first level of selection and would continue to higher competition levels (i.e., youth national team) with increasing effect sizes. Such increases would occur across youth developmental structures of handball and persist into adulthood, reflected by RAEs in senior elite teams. At the adult level of elite participation (18–40 years), we hypothesized that RAEs would decrease, because maturational differences will be minimal at this age. At this level of elite handball, different constraints occur because there are two senior elite teams – an A-squad and a B-squad. Both are selected from the same age groups by the national coaches. Although the A-squad players are always the best national players in the country, the selection criteria for the B-squad may change over time (e.g., sometimes the B-squad is truly made up of the "second-best" players and other times this squad is used to develop younger players who are believed to possess skills and abilities that will be useful for the A-squad at a later date).

On the basis that few studies have examined female athletes, we also examined RAE prevalence across competition levels for female handball, although little is known about RAEs in this sample and whether ongoing stages of selection would be influential. To this end, a descriptive examination of female handball was conducted to generate hypotheses for further study.

Study 1 – methods

Athlete data were provided by the Handball Federation (for national and regional squads). Varying selection levels according to age are differentiated for male and female players within the Handball Federation. For the seasons 1993–2007, we obtained data for 1513 male and 1734 female athletes. Five levels of selection from D-squad (lowest) to A-squad (highest) are differentiated within the German system. For the first level of selection, players from over 20 regional federations were observed and tested, representing the regional development system (D-squad; $n_{\mathrm{male}} = 401$, 13–16 years; $n_{\mathrm{female}} = 333$, 12–15 years). The second and third selection (higher) levels represented the German youth national (D/C-squad; $n_{\mathrm{male}} = 517$, 16–18 years; $n_{\mathrm{female}} = 502$, 15–17 years), followed by the German junior national team (C-squad; $n_{\mathrm{male}} = 184$, 19–21 years; $n_{\mathrm{female}} = 327$, 18–20 years), respectively. These selections are carried out within 2-year categories and this multi-annual age-grouping remained constant for national selections until the senior level. In adulthood, starting around the age of 19 years, players are either selected for the National team (A-squad; $n_{\mathrm{male}} = 236$; $n_{\mathrm{female}} = 434$), which participates in international events like the Olympic Games or the World Championship, or they are chosen for another National team (B-squad; $n_{\mathrm{male}} = 175$; $n_{\mathrm{female}} = 138$), which is thought to support younger players as well as players who might have a chance for the A-squad if they continue to develop their skills. B-squad athletes also participate in tournaments and matches on an international level. All national selections during the senior years are grouped by performance (i.e., A vs B) and not by age as in the younger years.

To test RAEs in all studies, birth-dates for all selected players between 1993 and 2007 were collected and each player's birth month was re-coded to reflect his or her birth quartile (Q). The calendar year for handball is from January 1 to December 31 and accordingly, Q1 = January, February, March; Q2 = April, May, June; Q3 = July, August, September; and Q4 = October, November, December. As with much of the previous research in this area, comparisons for the D-squads were based on the assumption of equal distribution of births across months of the year (c.f. Cobley et al., in press). Afterwards, comparisons were drawn on the percentages of players per quarter and gender for the next older or higher squads to examine whether they are any changes between selection levels. For example, the distribution of birth dates at a given level was considered relative to the normal population (assumed to be equally distributed across quartiles) as well as to the distribution of the level immediately lower (e.g., D/C squad distribution was compared relative to the D-squad).

Study 1 – results

The results are presented in two parts: the first section relates to the male athletes and the second to the female athletes. For both groups, the changes in distribution with selection levels as well as in comparison with the general population are reported.

Male players

As can be seen in Fig. 1(a), there was a significant over-representation of athletes with birth dates in the first quarter in the D-squad, $\chi^2(3) = 60.95$; $P < 0.001$, $w = 0.39$. Almost 40% of regionally selected athletes were born in the first quartile, while $<15\%$ were from the last quartile. The same trend was observed for the D/C-squad, $\chi^2(3) = 78.19$; $P < 0.001$, $w = 0.39$. Again the difference between the first and the fourth quartile was above 25% and exceeded 10% between the second, third and fourth quartile. The comparison between distributions of D- and D/C-squads failed to reach significance, $\chi^2(3) = 3.43$; $P = 0.33$. The comparison between D/C-squads and C-squads indicated that the RAE effect sizes became smaller as the level of competition increased ($\chi^2(3) = 19.02$; $P < 0.001$, $w = 0.32$). While there were 5% less athletes within the first and second quartiles, the fourth quarter gained around 10% on average. Still, comparing this distribution with the general population, a significant RAE for C-squads was found, $\chi^2(3) = 8.04$; $P = 0.046$, $w = 0.21$. For B-squads, the number of athletes from the fourth quartile continued to grow on a descriptive level, but this altered distribution missed significance, $\chi^2(3) = 7.27$; $P = 0.06$, $w = 0.22$). As with all other previously presented squads, their distribution differed significantly from the general population, $\chi^2(3) = 10.39$; $P = 0.02$, $w = 0.26$. For the A-squad, an almost equal distribution between quartiles was observed with a small over-representation of the outer two quartiles, $\chi^2(3) = 2.51$; $P = 0.47$. This distribution was significantly different from the B-squad, $\chi^2(3) = 9.49$; $P = 0.02$, $w = 0.20$.

Female players

As can be seen in Fig. 1(b), a significant over-representation of players was found in the first two quartiles for the D-squad, $\chi^2(3) = 18.99$; $P < 0.001$,

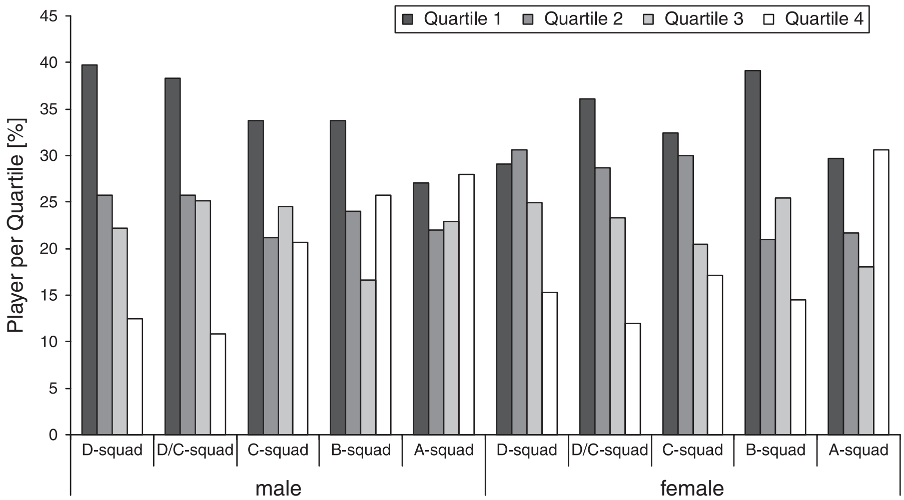

Fig. 1. Distributions of male (a) and female (b) national players per squad in percent.

$w = 0.24$. In the D/C-squad, the percentage of athletes born in the first quartile increased by approximately 7%, while the percentage in the fourth quartile decreased. This change in distribution reached significance, $\chi^2(3) = 13.12$; $P < 0.001$, $w = 0.16$, as did the comparison with the general population, $\chi^2(3) = 62.03$; $P < 0.001$, $w = 0.42$. The same descriptive pattern was seen for the C-squad, but the RAE became significantly smaller with this selection step, $\chi^2(3) = 9.69$; $P = 0.02$, $w = 0.17$. The comparison with the general population values remained significant, $\chi^2(3) = 21.20$; $P < 0.001$, $w = 0.25$. The results for the B-squad showed an increase in the first quartile and again a decrease in the fourth quartile. This change from the C-squad just failed significance, $\chi^2(3) = 7.78$; $P = 0.051$, $w = 0.25$; however, the comparison with population values remained significant, $\chi^2(3) = 18.00$; $P < 0.001$, $w = 0.37$. A reverse trend was observed within the last selection step to the A-squad. Here, as in the male athletes, the percentage of players from the fourth quartile was as high as that from the first quartile, resulting in a significant difference between B- and A-squad distributions, $\chi^2(3) = 97.29$; $P < 0.001$, $w = 0.47$, as well as in comparison with the general population, $\chi^2(3) = 19.92$; $P < 0.001$, $w = 0.21$.

Study 1 – discussion

The results from this first study provided some support for the hypothesis that RAE are strongest early in development and that the "strength" of RAEs decreases over time. As predicted, the size of RAEs was consistently different across the selection steps for females (i.e., each successive level was significantly different from the one before); however, the difference in distributions for males was less consistent, suggesting variability in RAEs with sex.

An interesting finding is the difference in the strength of RAEs in the first regional selection step between female and male athletes. Over 40% of male athletes were born within the first quartile, while the numbers for the female athletes were below 30%. This difference might be explained by the competition for positions at the regional level, which may be higher for male athletes. Nonetheless, these findings indicate a major selection bias in local junior representative handball at early stages of participation. Data for the year 2006 from the Handball Federation showed that for players aged 7–14 years, 121,901 male and 95,531 female children played club handball in Germany. This difference was relatively smaller for the 15–18 year age group with 61,671 male and 51,193 female athletes. These data suggest that the depth of competition may be different between female and male athletes. As competition for selection intensifies in female athletes (i.e., particularly at the national level), an over-representation of the first quartile can be observed. These results provide some unique information regarding the possible mechanisms underpinning RAEs in sport. First, findings indicating the strength of the effect decreases over time implicate early development processes as more salient in "creating" RAEs. Moreover, they suggest that interventions designed to reduce RAEs should target early participation phases. Second, findings suggest that although relatively younger athletes are significantly under-represented in early stages of the selection process, many of them still manage to navigate the sport development system and find their way into more senior levels of competition. Coaches and athletes are advised to place increased emphasis on recruiting relatively younger athletes back into sports as they may have withdrawn due to relative age biases.

Study 2 – elite league participation, nationality and career stage

Within the last 10 years, male handball has witnessed an increase in commercialization and professionalization. The German first league is one of the strongest in the world, with all three European titles going to a club from this league in the 2006–2007 season. Currently, handball has two professional elite leagues arranged hierarchically as well as several leagues below the professional level. Players participating in the professional leagues are contracted full-time without the need for additional financial income to support their living. Further, with these leagues being a stronghold for handball, they attract the most skilled international players. At present, around 20% of league players come from other countries. With cut-off dates for annual age-grouping (i.e., January 1st) determined cross-nationally by the International Handball Federation, the handball context provided a unique opportunity to assess whether RAEs differed within the professional skill level band (notably between the two German professional leagues) and allowed an exploratory comparison as to whether imported international players also reported RAEs.

The examination of elite samples also provided an opportunity to assess whether RAEs were related to career stages within elite professional handball. Evidence from Study 1 (and other sources, e.g., Cobley et al., under review) suggests that the strength of RAEs in adult sport is less than those observed in youth sport; however, accounting for such an observation is difficult. No studies have directly examined whether RAEs continue to decrease across career stages of adult professionals. Bäumler (1998) provided some insight when examining German first league soccer players, demonstrating that in a given year relatively older players were more likely to withdraw from elite league participation than relatively younger players, with such a trend increasing with age (i.e., from 18 years up to 35 years). However, the mechanisms leading to earlier withdrawal from elite sport have yet to be fully determined.

The purpose of Study 2 was to test the influence of adult male player characteristics on the prevalence of RAEs in elite handball. Based on previous work, we hypothesized a higher RAE in the first professional league compared with the second, and that international players participating in the elite German leagues would show RAEs; however, we hypothesized that the strength of RAEs would decrease across career stages at the elite professional level, with older-aged elite professionals less likely to show RAEs.

Study 2 – methods

Athlete data were provided by the Handball League for 2291 male players from the first league and 4824 from the two second leagues identified from the 1998/1999–2005/2006 seasons. Of these 7115 elite athletes, 5326 players were German and 1789 were from outside Germany (i.e., international). As in Study 1, each player's birth month was re-coded to reflect his birth quartile (Q) based on the cut-off date of January 1st. Once again, comparisons were based on the assumption of an equal distribution of births across months of the year. Additionally, age in years was used to divide all players into 4 year groups: (1) developmental years (age 21 and below), (2) early adult years (22–25), (3) middle adult years (25–29) and (4) later adult years (above 30). These age categories represent four stages in the career of a player.

Study 2 – results

An analysis of all players revealed a significant over-representation in the first two quartiles, $\chi^2(3) = 99.31$; $P<0.01$, $w = 0.12$. An examination of maintenance over all seasons (Fig. 2) revealed that an over-representation in the first two quartiles remained stable at a descriptive level, only failing to reach significance in one (season 2001/2002) out of eight seasons, 1998/1999: $\chi^2(3) = 18.75$; $P<0.01$, $w = 0.16$, 1999/2000: $\chi^2(3) = 23.64$; $P<0.01$, $w = 0.17$, 2000/2001: $\chi^2(3) = 7.89$; $P = 0.048$, $w = 0.10$, 2001/2002: $\chi^2(3) = 7.64$; $P = 0.056$, $w = 0.09$, 2002/2003: $\chi^2(3) = 12.34$; $P<0.01$, $w = 0.11$, 2003/2004: $\chi^2(3) = 11.34$; $P = 0.01$, $w = 0.11$, 2004/2005: $\chi^2(3) = 11.81$; $P<0.01$, $w = 0.11$, 2005/2006: $\chi^2(3) = 12.59$; $P<0.01$, $w = 0.11$.

For both international and German players, significant differences in distributions were found compared with a normal distribution (German: $\chi^2(3) = 58.33$; $P<0.001$, $w = 0.10$; international: $\chi^2(3) = 52.78$; $P<0.001$, $w = 0.18$). Additionally, there were significant differences between the two groups, $\chi^2(3) = 15.83$; $P<0.01$, $w = 0.10$. As can be seen in Fig. 3, over-representation in the first quartile was approximately 4% higher in international than in German players.

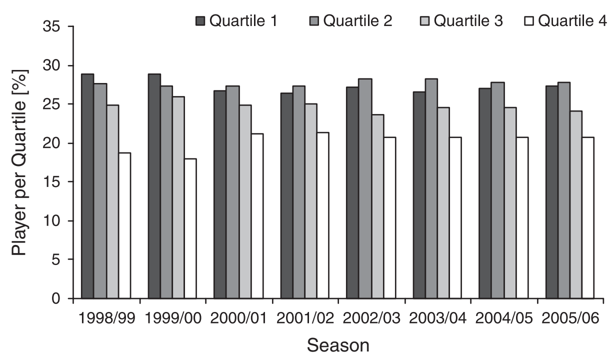

Fig. 2. Distributions of first league players per season in percent.

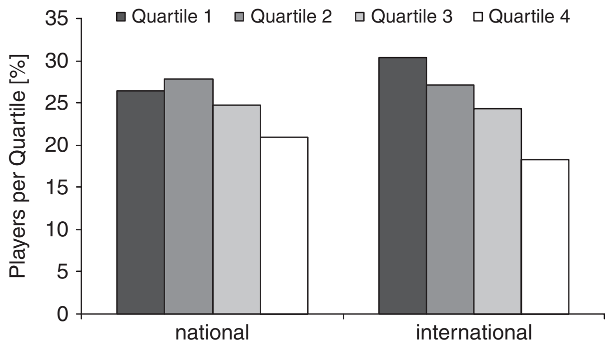

Fig. 3. Distribution of first league players per nationality in percent.

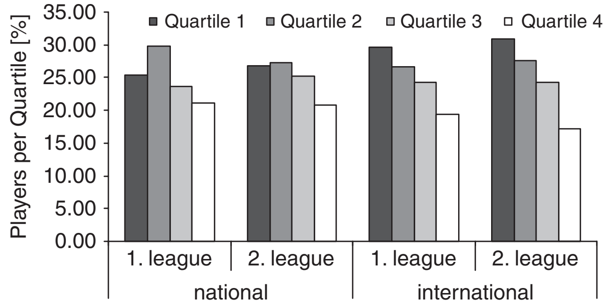

Fig. 4. Comparison of distributions for varying leagues and nationalities in percent.

Differences in the RAEs between the first and second leagues were considered and results indicated a significant over-representation of players born in the first two quartiles of the year in both leagues, $\chi^2(3) = 35.66$; $P<0.001$, w = 0.12 (1st league), and $\chi^2(3) = 65.63$; $P<0.001$, w = 0.12 (2nd league), with no significant differences between the two leagues, $\chi^2(3) = 5.85$; $P = 0.11$. Separating national and international athletes, the results still showed similar distributions for first and second leagues (Fig. 4). For international players, a significant over-representation of relatively older players was found in the first, $\chi^2(3) = 19.70$; $P<0.01$, $w = 0.15$, and the second leagues, $\chi^2(3) = 34.34$, $P<0.01$, $w = 0.20$. Similarly, for the German players significant asymmetries were observed for the first, $\chi^2(3) = 22.85$, $P<0.01$, $w =$ 0.13, as well as for the second league, $\chi^2(3) = 40.04$, $P<0.01$, $w = 0.10$. Comparing the distributions in both leagues differentiated between international and national athletes, significant differences with a small effect size in the distributions could be seen but only for international players (German, $\chi^2(3) = 5.88$; $P = 0.11$, $w = 0.06$; international, $\chi^2(3) = 9.20$; $P = 0.02$, $w = 0.06$).

The results for the comparisons of RAEs across the stages of career for international athletes are presented in Fig. 5(a). The results suggest that a growing number of international players join the national leagues in later stages of their career; however, a significant RAE was observed throughout all stages, junior years: $\chi^2(3) = 8.23$; $P = 0.04$, $w = 0.32$; early adult years: $\chi^2(3) = 31.68$; $P<0.01$, $w = 0.28$; middle adult years: $\chi^2(3) = 14.21$; $P<0.01$, $w = 0.15$; late adult years: $\chi^2(3) = 11.33$; $P<0.01$, $w = 0.13$. A different profile of results can be seen in Fig. 5(b) for the German players. First, the numbers of German players who remained in both elite leagues decreased toward the later stages of their career. Additionally, the strength of the RAE decreased in later stages of German players' careers, junior years: $\chi^2(3) = 66.46$; $P<0.01$, $w = 0.19$; early adult years: $\chi^2(3) = 18.86$; $P<0.01$, $w = 0.11$; middle adult years: $\chi^2(3) = 6.95$; $P = 0.07$, $w = 0.08$; late adult years: $\chi^2(3) = 16.28$; $P<0.01$, $w = 0.12$.

Study 2 – discussion

The results indicate a relatively stable small effect (around 0.10) for seven seasons. For the eighth season, the effect size was similar but the distributions were not significantly different, and so the RAE can only be seen on a descriptive level. RAEs seem to be stable and constant over the years but rather small in comparison with other studies (e.g., Cobley et al., in press). As possible moderators of effect size, nationality, skill level and stage of career were investigated in greater detail.

The comparison between national and international players revealed differences between the distributions, with RAEs more prominent in international players. One possible explanation for this is that international players who make it into a foreign professional league go through more specialized selection processes than national players who are already within the system. Additionally, international players who make it into a foreign league are often considered leading players for their original team; therefore, they might play in key positions on the team, for example, in the backcourt, where height is an advantage. Because physical maturation (e.g., height) is often proposed as a critical factor underpinning the RAE, a stronger effect among international players seems reasonable, considering that within younger years the most mature athletes likely play the key positions in their teams.

We also considered whether small skill differences, such as between elite and near-elite players from two different leagues, would affect the strength of RAEs. It should be kept in mind that even second league international players represent their countries at international events (e.g., World Championships). The results showed small effect sizes and, interestingly, the distributions for the international players showed the classic RAE pattern across both leagues. Related to German players alone, RAEs are still

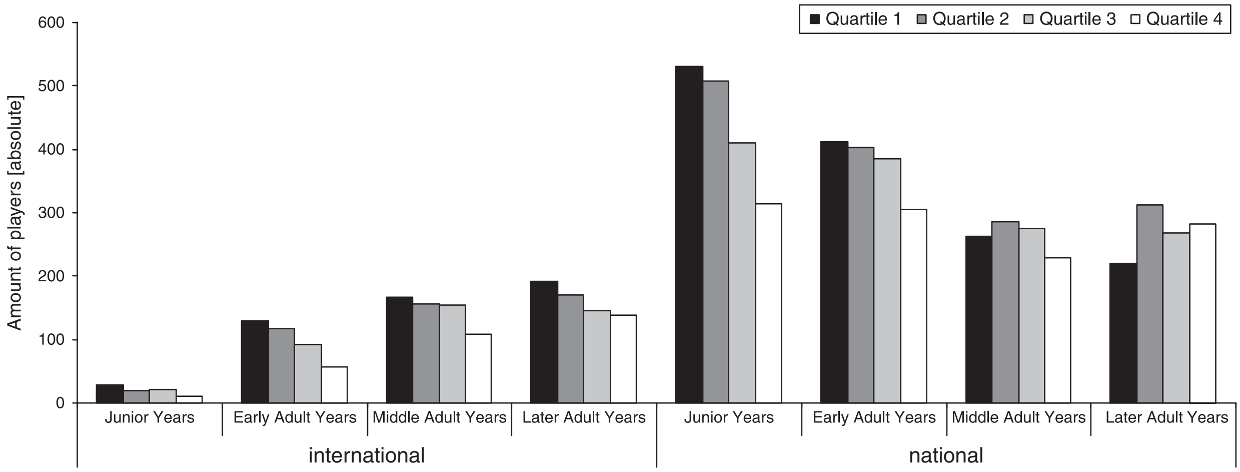

Fig. 5. Comparison of distributions for varying stages of the career for German (a) and international players (b).

evident but considerably less prominent compared with international players.

An interesting pattern of results was found for the relative age distributions across the different career stages for the national and international players. First, an increase in the number of international players was seen across the career stages. However, this result may not be surprising because international handball players often have to gain international recognition through participation in international tournaments to become visible and attractive to foreign leagues. As expected, RAEs were almost constant across the career stages for international players. However, different patterns were observed for the German players. Here the number of players in the league decreased with later stages of their career. One explanation might be that young German players are chosen for the league as players in junior years. If these players do not fulfill their potential, their contracts are not extended (the above results suggest they are replaced by an international player). This might also explain the diminishing RAE in the latter stages of the German players' careers. As can be seen in Fig. 5(b), RAEs were only observable in the younger stages of a player's professional career. In the later stages, there was almost a normal distribution for the middle adult years, while an overrepresentation for the second and fourth quartiles was apparent for the later adult years. This latter finding is especially intriguing, considering the consistent disadvantages for the relatively younger across youth and early professional stages of handball. The formerly successful relatively older player is less likely to play in elite handball during the later years (i.e., above 30 years of age), perhaps due to injury, aging, physical and mental fatigue or a combination of factors, providing opportunities for other (relatively younger) professionals. Their presence in later career years, above and beyond the relatively older, perhaps illustrates the value of game experience and knowledge at the professional elite level, as well as a delayed benefit for maintaining involvement. Within handball, skilled, experienced international and German players appear to be important commodities that override the maturation advantages – although inexperienced – associated with the initial stages of an elite professional career. Preservation and maintenance of the athletes appear to be important factors to consider related to performance in later career stages. Overall, "the results" from Study 2 identify significant moderators of the RAE; moreover, each of the results may be influenced by the varying demands and skills associated with different playing positions in handball. In Study 3, we explore this possibility.

Study 3 – playing position and laterality

Previous research has suggested that the magnitude of RAEs may relate to physically demanding contexts and playing positions (e.g., Grondin & Trudeau, 1991). In handball, performance in some positions may benefit from both physical attributes and the preferred hand used in throwing. During a game, players are typically designated to a position on court such that demands differ between left and right wing players, left and right backcourt players circle players, center backcourt players, and goalkeepers (see Fig. 6). Because of this tactical positioning, there are varying demands on the players on these positions. For players on the leftside (wing and backcourt), it is an advantage to be righthanded and for athletes on the rightside (wing and backcourt) it is better to be lefthanded. In contrast, circle center backcourt players and goalkeepers are perceived to gain no real advantage from being left or

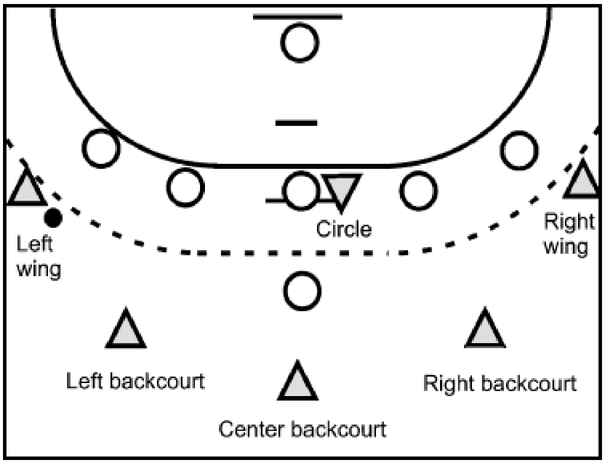

Fig. 6. Playing positions in handball.

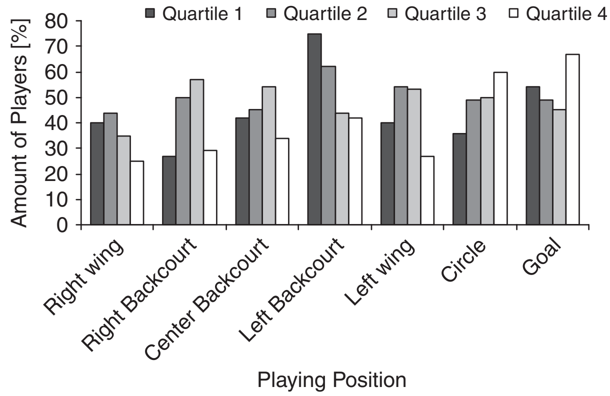

Fig. 7. Distributions of first league players by playing position in percent.

right handed. The advantage and value of being lefthanded is reflected in the fact that there are usually three to four left-handed players on a typical 14- player Handball team (~ 21–28%). However, in a normal population only 10–13% are left-hand dominant (cf. Raymond et al., 1996). Such over-representation of left-handed players required for specific positions is not unique (see Holtzen, 2000; Brooks et al., 2004). Nonetheless, the demands for left-handers for particular playing positions in handball may be one mechanism that buffers against RAE prevalence.

The purpose of this final study was to examine the influence of player position (and associated physical and skill demands) on RAEs in elite handball players. Like Grondin and Trudeau (1991), we hypothesized that backcourt players – advantaged by greater height and weight to a degree – would show larger RAEs. In addition, we expected that the size of RAEs would interact with player positions affected by laterality (i.e., being right vs left-handed), with positions advantaged by being left-handed demonstrating weaker RAEs.

Study 3 – methods

Athlete data were provided by the Handball League. Additionally, playing position and handedness was acquired from different internet sources. In total, birth-date and playing position of 1289 players from the handball first league were identified for the seasons 2004/2005 to 2007/2008. Before 2004/2005 information could not be identified reliably. Birth months were re-coded into birth quartiles as in Studies 1 and 2.

Study 3 – results

For this study, differences between playing positions were considered and no obvious trend was observed (see Fig. 7). Nevertheless, left backcourt players had a significant over-representation in Q1, $\chi^2(3) = 13.21$; $P < 0.01$, $w = 0.24$. Also significant were the differences for the right backcourt, $\chi^2(3) = 16.61$; $P < 0.01$, $w = 0.32$, and left wing, $\chi^2(3) = 11.15$; $P = 0.01$, $w = 0.25$, but not for the center backcourt, $\chi^2(3) = 4.68$; $P = 0.20$ or right wing, $\chi^2(3) = 5.61$; $P = 0.14$. For most field positions, except for the circle players, the lowest number of players were born in the last quartile. This result was reversed for circle players, $\chi^2(3) = 5.96$; $P = 0.11$, and goalkeepers, $\chi^2(3) = 5.11$; $P = 0.16$, but for both groups no significant differences were observable.

To test whether the observed results were universal, we tested German players and international players separately. As can be seen in Table 1, some differences between the two sub-groups must be stated. For the German players, significant differences were revealed for center backcourt, left wing and circle player. For left wing and center backcourt, there was an over-representation in the middle two quarters. For circle players a clear right shift was observed. The same descriptive trend can be seen for goalkeepers. Noteworthy is the leftshift for the left backcourt, which reached significance for the whole group, but not within the German sub-sample. Not surprisingly following this result, the left backcourt showed a significant RAE for international players. For the right backcourt, the middle two quarters demonstrated a significant over-representation, while for goalkeepers the outer two (the first and fourth quartile) were significantly higher.

Study 3 – discussion

The results revealed that playing position affected the distribution of players across the birth quartiles. The backcourt positions, where larger players have an advantage, generally showed an over-representation in the first two quarters; however, other positions like circle players or goalkeepers showed an opposite

Table 1. RAE for playing positions differentiated between German and international players

Nationality	Position	Q1	Q2	Q3	Q4	Statistics
German	RW	24	24	22	16	$\chi^2(3) = 2.00$; $P = 0.58$
	RB	13	16	20	14	$\chi^2(3) = 1.82$; $P = 0.62$
	MB	22	26	27	10	$\chi^2(3) = 8.60$; $P = 0.04$; $w = 0.32$
	LB	32	25	22	15	$\chi^2(3) = 6.34$; $P = 0.10$
	LW	32	41	37	19	$\chi^2(3) = 8.52$; $P = 0.04$; $w = 0.26$
	CI	16	26	31	42	$\chi^2(3) = 12.20$; $P < 0.01$; $w = 0.32$
	GK	20	32	32	41	$\chi^2(3) = 7.13$; $P = 0.07$; $w = 0.24$;
International	RW	16	20	13	9	$\chi^2(3) = 4.48$; $P = 0.22$
	RB	14	34	37	15	$\chi^2(3) = 17.84$; $P < 0.01$; $w = 0.42$
	MB	20	19	27	24	$\chi^2(3) = 1.82$; $P = 0.61$
	LB	43	37	22	27	$\chi^2(3) = 8.39$; $P = 0.04$; $w = 0.25$
	LW	8	13	16	8	$\chi^2(3) = 4.16$; $P = 0.24$
	CI	20	23	19	18	$\chi^2(3) = 0.70$; $P = 0.89$
	GK	34	17	13	26	$\chi^2(3) = 11.78$; $P = 0.01$; $w = 0.36$

trend but only at a descriptive level. Once again, these results – as in Study 2 – need to be differentiated between German and international players. For German players, significant differences were demonstrated for the circle players, who were over-represented in the latest quartiles. Additionally, middle backcourt players were over-represented in the two middle quartiles. For the international players, a clear RAE can be observed – as expected – for the left backcourt. At early levels of competition, larger right-handed players would have an advantage at this position. In handball, height and strength are an advantage especially in the left backcourt because these players are often the shooters, who throw over the opponent's defense, while the middle backcourt is often considered a playmaker. However, by this rationale, a similar distribution would be expected for left-handed players in the right backcourt, but our results showed an over-representation in the middle quartiles. Perhaps most perplexing is the over-representation of the goalkeepers in quartiles 1 and 4. Although these results provide consistent evidence that playing position and laterality affect the strength of RAEs in handball, additional research is necessary to better understand the factors underpinning these relationships.

General discussion

The goal of our studies was to examine different variables that may moderate RAEs in handball. The combination of results within the framework and organizational structure of handball enables us to present suggestions on the interaction of different variables upon RAEs.

One of the major mechanisms hypothesized to cause RAEs relates to selection processes used in elite sport (cf. Sherar et al., 2007). Helsen et al. (1998) suggested that those selected have greater access to resources like high-quality coaching, practices and equipment for event-specific skills. Although this is a plausible explanation, it is not clear what would occur in sports where selection processes are not as strong, such as when the number of available athletes is smaller and the demand for positions is not as great. So far, most robust RAEs have been reported in popular sports like North-American ice hockey (Boucher & Mutimer, 1994) or European football (Helsen et al., 1998), but rarely have smaller sports with fewer competitors been considered. This may be due to two reasons. First, it is possible the RAEs are less likely in less popular sports, and non-significant results are more difficult to publish in peer-reviewed journals. A second hypothesis is that they have not yet been investigated. The data from our studies indicate that the depth of competition (as represented by the number of participants and number of players selected for higher level competition) has an influence on the occurrence of RAEs. While this is implicitly assumed in most hypotheses about the causes of RAEs, our data confirm this assertion. While the rules and demands for male and female youth handball players are similar, there is a reported difference in participation rates in handball as well as clear differences in RAEs between males and females on the D-squad, which then disappears across the stages of selection. The relative difference in the first quarter between male and female D-squads was approximately 10% before equalizing at the elite level. One suggested explanation is the lower number of female athletes within handball compared with males (cf. Study 1 – discussion). It seems plausible to have a smaller RAE when fewer athletes participate in the sport. A similar mechanism was seen in Study 3, where laterality and playing positions were considered as possible moderators of RAEs. For male adults in the two German professional leagues, backcourt players on the left side (i.e., where right-handed throwers have a tactical advantage) showed larger

RAEs than on the right side (i.e., where left-handed throwers normally play). These differences could also be caused by the much smaller number of left-handers in the normal population (~ 10–13%; Raymond et al., 1996). Collectively, these findings suggest that RAEs should become smaller, if not disappear, in sports with smaller pools of athletes. Further research is necessary to determine whether these findings are the result of the same mechanism or different mechanisms with the same consequence.

A second major hypothesis in RAE research is that relatively younger athletes have a disadvantage in sports where height and strength are favored. While this seems to hold in the short and middle period of development of an athlete, it seems debatable in the long run. In the early selection levels and early stages of an athlete's career, a clear over-representation for the relatively older athletes can be seen. This would most likely result in access to better training with highly qualified coaches and better competitors on their teams (cf. Helsen et al., 1998). But this trend seems to change in later career stages. For the male A-squad players from Study 1, the number of relatively younger players increased and represented the highest percentage of athletes. This trend can also be observed – although less prominently – within the German players from the first league at the latest stage of career (Study 2). The question arises, "are RAEs always a disadvantage for younger players?" It might be beneficial for relatively younger players to have the opportunity and necessity to develop the specific technical or tactical skills needed to be able to compete successfully against their older, more mature opponents. In the long run, this may result in a larger repertoire of skills, making them superior performers (for some support for this supposition, see Baker & Logan, 2007). Although this hypothesis requires further scrutiny, it adds another level of complexity to our understanding of RAEs. These findings suggest that RAEs should not only be seen as disadvantaging the relatively younger but also perhaps advantaging the high achieving and more "talented" among them.

Overall, these results suggest an inter-play of variables leading to and moderating RAEs. As a result, traditional methods of reporting overall effects are not sufficient to understand the mechanisms behind this effect. A conceptual model is needed to provide theoretical direction in this area and to present testable hypotheses for future work. The difficulty will be to create a model that takes into account all possible direct and indirect influences on RAEs in sport.

Perspectives

The present studies provide an insight into moderators of RAE in sport as well as the possible inter-play among these variables. The results confirm the disadvantages for young athletes born at different points within structured age groups. Perhaps more importantly, these results suggest that strategies to allow for equal opportunities for all athletes need to be implemented early in an athlete's development. These results also suggest that relatively younger athletes stay longer within high-performance sport and might have a better chance of reaching the adult national team. This would mean that the previous disadvantage for the relatively younger becomes an advantage for the ones still in the system in the later stages of their career.

In the bigger picture, the results provide clear evidence pertaining to how RAE influence the development and the maintenance of expertise (Baker & Horton, 2004). These results shed additional light on the often subtle stimuli constraining or facilitating skill acquisition and athlete development.

Key words: talent, expertise, handball, birth date.

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