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Maturational and Social Factors Contributing to Relative Age Effects in School Sports: Data from The London Youth Games.

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Running Head: Relative age effects in school sports.

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Abstract

Background Few studies have investigated whether Relative Age Effects (RAE) exist in school sport. None have sought to test the competing maturational and social-agent hypotheses proposed to explain the RAE. We aimed to determine the presence of RAEs in multiple school sports and examine the contribution of maturational and social factors in commonplace school sports.

Methods We analysed birth dates of n=10645 competitors (11-18 years) in the 2013 London Youth Games annual inter-school multisport competition and calculated odds ratio (OR) for students competing in based on their yearly birth quarter (Q1-Q4). Multivariate logistic regression was used to determine the relative contribution of constituent year (Grade) and relative age in netball and football which used multi-year age groupings.

Results In girls, RAEs were present in the team sports including hockey, netball, rugby union, cricket and volleyball but not football. In boys RAEs were stronger in common team sports (football, basketball cricket) as well as athletics and rowing. In netball and football teams with players from two constituent years, birth quarter was better-predicted selection than did constituent year. Relatively older players (Q1) from lower constituent years were overrepresented compared with players from Q3 and Q4 of the upper constituent years.

Conclusions RAEs are present in the many sports commonplace in English schools. Selection of relatively older players ahead of chronologically older students born later in the selection year suggests social agents contribute to RAEs in school sports.

Introduction

The Relative Age Effect (RAE) can be observed in the discrepancies that exist in; academic attainment (Diamond 1983), lifelong earnings (Du et al. 2012), self-esteem (Thompson et al. 2004) and wellbeing (Patalay et al. 2015; Thompson et al. 1999) according to individuals' birth date. In sport, the RAE describes: '*The relationship observed between an individual's month of birth relative to their peers and their achievement in sports*.' (Cobley et al. 2009)

Youth athletes born in the first and second yearly quarters (Q1, Q2) after the age-group cut off are significantly overrepresented in youth sport teams and sporting academies (Cobley et al. 2009). Delorme et al. (2011) suggested that the inherent selection bias in favor of older, bigger players: '*blinds selectors to age-related differences in potential'*. Those players born later in the year (Q3 or Q4) who are selected are still more likely to drop out of academies or development pathways than relatively older players (Delorme et al. 2010; Delorme, Chalabaev 2011; Vandendriessche et al. 2012).

In non-selective education, RAEs tend to manifest in the higher academic attainment achieved by relatively older students compared with those born later in school year. (Diamond 1983; Roberts & Fairclough 2012; Vincent & Glamser 2006). Poor attainment is associated with lower lifetime earnings (Du, Gao 2012), self-esteem (Thompson, Barnsley 2004) and poorer mental health (Patalay, Belsky 2015; Thompson, Barnsley 1999). The disparities in academic attainment associated with birth date so large and persistent that they cannot be explained solely by differences in chronological age or maturity (Diamond 1983). There is evidence that relatively older students receive higher grades in physical education (Roberts & Fairclough 2012; Vincent & Glamser 2006). In England, school sports generally use a one year age-grouping with the same cut-off date as the academic year (September 1st). Two studies of Englsih schools sports have reported that students born in 3-6 months following the September 1st cut-off date are overrepresented in school sports teams (Cobley et al. 2008; Wilson 1999) as reported in many other youth sport settings (Cobley, Baker 2009).

The overrepresentation of relatively older players in youth sport has been attributed to the physical advantages associated with advanced maturation (Brewer 1992). Studies of youth academy athletes have produced inconsistent results with regard to whether there are significant differences in body dimensions (Hirose 2009; Malina et al. 2007; Musch & Grondin 2001) and physical fitness (Carling et al. 2009; Deprez et al. 2012; Gil et al. 2014) of athletes according to birth date. This may be due to the selection processes used by academies which tend to create a artificially homogeneous study population (Deprez, Vaeyens 2012). Non-selective (state) schools naturally provide more heterogeneous study population in which a number of researchers have identified significant differences in children's cardiorespiratory fitness (Roberts et al. 2012; Sandercock et al. 2013), strength (Sandercock, Taylor 2013) and motor-skill (Birch et al. 2014) according to birth date. Disparities in are attenuated, but not eliminated, when adjusted for age (Veldhuizen et al. 2015) demonstrating chronological age accounts for some of the reported differences in fitness. While fitter, stronger students are more likely to be selected for certain sports teams, the realtively modest differences in fiteness reported do not appear to be of sufficient magnitude to fully explain the extent of RAEs in school sports.

Hancock et al. (2013) proposed an integrated theoretical model to explain the RAE in sport in which relatively older children's success in sport is a combination of the initial advantages of being older (Matthew Effect) combined with the higher expectation of others (Pygmalion Effect) and of themselves (Galatea Effect). There is strong evidence that all three effects play a role in educational RAEs but the roles these social-agents play in schools sports has not been investigated.

The potential physical and psychological benefits of physical education and school sports are manifold (Bailey 2006) but less than 20% of English schoolchildren participate in competitive, interschool sport competition (DCMS 2010). These concerns, raised prior to the London 2012 Olympic Games, prompted the UK government to pledge a commitment to: 'delivering a sporting legacy for young people, and to bringing back a culture of competitive sport in school' as part of their plans for an Olympic legacy (DCMS 2010). If competitive sport is to be able to increase physical activity it must be accessible to as many children as possible. While data are limited (Wilson, 1999, Cobley et al. 2008), they show large RAEs in English school sport. If confirmed, these may present an significant barrier to participation; particularly for students born late in the school year.

We sought, therefore, to determine the extent of RAEs in competitive school sports we analysed data from the London Youth Games (LYG); an annual multisport event for which students are selected to represent their school. Based on relative age differences in body dimensions and physical fitness we hypothesized that RAEs would be present in sports for which height is advantageous, physically demanding events and contact sports. We hypothesized that RAEs would be less obvious in less physically demanding events and absent in events that were weight categorized and those in which shorter stature is advantageous. As depth of competition for team places is necessary for an RAE to be present in any sport (Schorer et al. 2015), wee hypothesized that RAEs would be larger in the most physical sports most commonly practiced in schools.

Where sports have multiyear age-groupings, there may be further bias according to constituent (whole-year) age (Steingrover et al. 2016) as well as relative (within-year) age. Investigating interactions between constituent and relative age may provide insight into the relative contributions of maturational and social agents to the sporting RAE. We hypothesized that constituent and relative age would be independently associated with team selection. Finally we hypothesized that social agents would promote the selection of more players born in the first quarter (Q1) of lower constituent years than from the relatively youngest birth quarter (Q4) of the adjacent constituent year above.

Methods

Data were provided by the LYG organisers. Students representing their schools in the 2013 LYG, provided their date of birth and consent for analysis and reporting of anonymous data by third parties for the purposes of education and research. The initial analysis included data from events open to either sex that had at least 100 participants. Events at the LYG vary annually and not all events are offered to boys and girls, so analyses are presented according to sex. Selection-year cut-offs were calculated for each event; for most, this was 1st September. The majority of participants were, therefore, grouped according to birth date in the following yearly quarters; Q1: September-November, Q2: December-February, Q3: March-May, Q4: June-August. In sports with alternative cut-offs the birth quarters were shifted according.

Statistical Analysis

To describe the RAE, we tabulated the frequencies of competitors in each event according to birth quarter and compared the observed frequencies with expected values and calculated the likelihood (Odds Ratio, [OR] and 95% Confidence Intervals [95%CI]) of a student from that birth-quarter competing at the LYG compared with the reference population (students from all four birth quarters competing in that event).

As those competing represent a potentially biased, pre-selected reference population, we also used logistic regression to calculate the relative likelihood of students competing in each event y calculating the OR (95% CI) of selection (=1) in Q1, Q2 and Q3 compared with the referent category: Q4 (OR=1.00). To calculate the ratio selected versus non-selected students in each quarter we calculated the expected population from which competing students had been selected. Authors commonly assume an even birth-date distribution across quarters (Lames et al. 2008; Steingrover, Wattie 2016). However, as yearly quarters are of unequal durations (Q1 and 2 are shorter) and due to seasonal fluctuations in birth rate, data to support the null hypothesis (no RAE) should not show an even distribution of competitors from Q1-Q4 (Delorme, Boiche 2010). We therefore, calculated expected frequencies based on the number of days in each quarter and UK birth-rate data (Office_For_National_Statistics 2015). Some bias still remains using this approach (Delorme & Champely 2015) when interpreting the results of χ^2 tests and due to differences in sample size between events, by sex and the use of multiple comparisons we did not use statistical significance (*P*-values) when interpreting our findings. Instead we reported magnitude of RAEs determined from the mean estimate (OR) and lower 95%CI recommended (Batterham & Hopkins 2006; Hackshaw & Kirkwood 2011). A mean estimate at our threshold value of 20% (OR=1.20) with a lower 95%CI <1.0 will not be statistically significant yet may still indicate a meaningful effect (Batterham & Hopkins 2006).

Contribution of maturational and social agents

To assess the relative contribution of social and maturational mechanisms underlying RAE we first identified sports with a significant RAE, in which teams were selected from more than one grade. To facilitate meaningful analyses, we required sports to potentially have n>100 participants per school grade. Netball (girls) and football (boys) met these criteria; teams were selected from Grade 8 and Grade 9 students.

We used multivariate logistic regression to predict the likelihood (OR, 95%CI) of students presence in each team (selection) according to their school grade (Grade 8, Grade 9) and birth quarter (Q1-Q4). The lower constituent year (Grade 8) and the youngest relative age group (Q4) were used as referent categories. To test the null hypothesis that neither factor was associated with selection the reference population comprised the expected number of students by grade and birth quarter according to annual birth statistics.

The supplementary materials provide hypothetical examples of birth date distributions that we assumed to support the maturational and social agent hypothesis. Identification of grade as the only significant predictor of selection was assumed to support the hypothesis that maturational factors. If birth quarter alone predicted selection, this was interpreted as support for the social-agents hypothesis. If both factors were associated with selection when mutually adjusted for one another we compared ORs to determine the relative contribution of maturational factors and social-agents. We also assumed that a higher frequency of competitors from chronologically younger (versus older) birth quarters as evidence supporting the role of social agents. All data were analyzed using SPSS 20.0. (SPSS Inc. An IBM Company).

Results

Twenty events open to girls and eighteen open to boys met our inclusion criteria of >100 participants and were, therefore included in the initial analysis. These events provided a total sample size of n=10645 (49.08% girls, 50.02% boys).

Girls born in Q1 (September-November) were overrepresented in: athletics, cricket, netball, rugby union and outdoor rowing (Table 1). There was evidence of meaningful (OR>1.20) overrepresentation of Q1-born girls in: hockey, volleyball, table tennis, indoor rowing and both Q1 and Q2 girls in cross-country running. In the two rowing (indoor and outdoor) events, 31.5% (*n*=120/382) competitors were born in Q1. Overrepresentation of girls born in Q1 was even greater in netball (38%) and rugby union (36%).

There was no evidence of RAE evident in swimming, football, triathlon, handball, cycling or tennis. A non-significant but potentially meaningful RAE was evident in Q1-3 in Judo. A 'reversed RAE was evident in two events; girls born in Q3 and Q4 were overrepresented in canoeing and trampolining.

Q1, 2 and 3 boys were overrepresented in the two most popular events (cross-country and football). RAEs were evident in basketball (Q1, Q2) cricket (Q1, Q2), athletics (Q1, Q2), volleyball (Q1), and handball (Q1). In football and cricket, boys born Q1 Q3 were all overrepresented compared with those born in Q4. Boys born in Q1 accounted for 34% of all competitors in football and 36% of basketball competitors. In comparison, Q4 boys comprised 19.3% and 20% of football and basketball competitors respectively.

Table 2 shows the likelihood of students being present in teams according to birth quarter. The largest RAE was observed in athletics in which Q1 boys were more than three times as likely to compete (Q1 OR=3.2) and over 40% (40.5%) of male competitors were born in Q1. Despite smaller participant numbers, Q1 boys were overrepresented both in whether indoor (39.8%) and outdoor (35.6%) rowing.

Weaker RAEs were evident in tennis, fencing and hockey but there was no evidence for RAE in: Judo, Swimming, Cycling or Triathlon. Q4 boys were 20% more likely to be competing in Canoeing than those born in Q1. Q4 boys comprised 30% (*n*=50/168) of all table tennis competitors and were more likely to be competing in this event than boys born in any other quarter.

Contribution of maturational and social agents

Table 3 shows that girls from Grade 9 were only 7% more likely to represent their school at netball than those from Grade 8. Girls born in Q1 were 1.87 (95%CI: 1.27-2.75) times more likely to compete at netball than girls born in Q4. Teams comprised a greater number of Q1 and Q2-born girls from the younger constituent year (Grade 8) than (chronologically older) Girls from Grade 9 born in Q3 and Q4.

In football, Grade 9 boys were 14% more likely (OR=1.14, 95%CI: 0.83-1.57) to represent their school those in year 8 boys (p>0.05). Compared with Q4-born boys, those born in Q1 were more than three times (OR=3.25, 95% CI: 2.12-4.98). Football teams contained more boys born in Q1 and Q2 of the younger constituent year (Grade 8) than boys born in Q3 or Q4 of Grade 9..

Discussion

This is the first study to describe the presence of relative age effects in English schoolchidlren across such a wide range of both individual and team sports. In common with previous research we found evidence of RAEs in boys' football and rugby teams (Cobley, Abraham 2008; Wilson 1999), girls' netball (Cobley, Abraham 2008) and hockey (Wilson 1999) teams are commonplace for both sexes in English schools and the only study aiming to determine the presence RAEs autumn-born girls. We also found overrepresentation of autumn-born (Q1) players in girls' (OR=1.34, 95%CI: 0.86-2.07) and boys' (OR=1.27, 95%CI:0.82-1.96) school hockey teams.

The present data share a number of commonalities with the findings of studies concerning birth quarter distributions in youth sport. Sports in which physical presence or height are clearly advantageous all tended to show some evidence of RAE. This was true for individual events such as rowing (Cobley, Baker 2009) and for team events like basketball (Delorme & Raspaud 2009; Steingrover, Wattie 2016) and handball (Delorme et al. 2009). The distribution of birth dates skewed in favor of players' born just after the age-group cut-off demonstrates an RAE is present, but not its possible causes.

The large RAEs evident in (outdoor and indoor) rowing are novel yet unsurprising as performance relies on strength, power and endurance, which all increase during maturation (Mikulic & Markovic 2011). Rowing is, however, one of few sports with a national talent identification programme including stature in its entry criteria. Purposeful selection of taller individual illustrates of how initial age-related advantages (stature) can promote the RAE via Matthew Effect. Early selection into rowing provides taller individuals with access to training and support all of which increase their likelihood of future success. (Hancock, Adler 2013)

Canoeing also requires strength and power but stature is not a prerequisite for selection (Alves et al. 2012) yet the birth date distribution of canoeists was the reverse that for rowing. It may be, that students not selected for rowing, shift from rowing and focus instead on canoeing. The uptake alternative sports by relatively younger athletes termed 'strategic adaptation' (Delorme 2014) might also explain the why the distribution of birth dates in male table tennis competitors was also a mirror image of that observed in tennis. Further evidence for strategic adaptation from competition to officiating can be seen in the birth-date distributions junior football referees, which mirror those within squads of successfully selected players (Delorme et al. 2013).

Relative Age Effects in Sports Commonplace in English Schools

Rowing and canoeing are offered by a minority (12%) of English schools compared with football (98%), athletics (93%), cricket (89%) and netball (79%) (Department_for_Education 2013). Table 3 shows the large RAEs in most sports commonly offered in English schools. These commonly offered sports are also those with most competitors at the LYGs and the Large RAEs observed support the hypothesis (Schorer, Cobley 2015) that depth in competition is a pre-cursor to RAE. If a sport is played by throughout a school, theoretically, every student is available for selection and competition for places increased. By considering sports that are commonplace in English schools it is possible to estimate the magnitude of RAE within school sport. If football, athletics (including cross-country) and cricket are offered to boys, those born in Q1 are twice as likely to represent their school as those born in Q4. Girls born in Q1 are 27% more likely to represent the school than those born in Q4. Relatively younger girls may find some respite from RAE in gymnastics (91% of schools) and dance (96% of schools) which do tend to show RAEs (van Rossum 2006). A summer birth date is likely a greater barrier to sports participation in boys due to the presence and magnitude of RAEs in so many sports commonly offered to them.

Contribution of maturational and social agents

Few data are available on how constituent year interacts with relative age in multiyear age-grouped sports (Lames, Augste 2008; Steingrover, Wattie 2016) Our data support the hypothesis for an interaction between constituent year and birth quarter (Steingrover, Wattie 2016). The overrepresentation of players from Q1 of Grade 8 in netball and football teams compared with individuals up to 6 months older (Q3 and Q4 of Grade 9) may also indicate a role of social, rather than purely maturational factors, are responsible for the RAE observed in. The lack of anthropometric data means we cannot discount the possibility that players born in Q1 of the lower year were actually more mature than the chronologically older students who were not selected.

We believe this is the first study to compare the birth date distribution of players from birth quarters within adjacent constituent years. Our findings are not, however, novel as this trend can also be seen in the birth date distribution of licensed French basketball players (Delorme & Raspaud 2009). In the 13-14 year old age group (Minimies) twice as many girls (14%) were born in Q1 of the lower constituent year than in Q4 of the year above (7.4%). This trend is repeated in 13-14 year old boys and 11-12 year olds of both sexes. While the authors made no mention of these findings they did find that relatively older players were taller than those born later in the selection year, but only compared mean values by birth quarter within constituent year. Visual analysis of means shows height increases with players' chronological age. Q4 players from higher constituent years are uniformly taller than those born in Q1 of the lower constituent year. As height is advantageous in basketball, the overrepresentation of younger, shorter players born in Q1 (versus older players born in Q4) suggests maturational factors alone cannot explain the RAE in basketball.

An investigation of RAEs in the assessment of physical education students (Roberts & Fairclough 2012) also reported higher test scores (6.5 ±1.5) in students born in Q1 of Grade 8 compared with their chronologically older peers born in Q4 of Grade 9 (5.6 ±2.6). Again the authors did not mention this potentially novel finding in the discussion. Nevertheless, such data suggest that maturational differences alone cannot explain the RAE observed in youth sport. Potential social agents contributing to the RAE may include the Matthew Effect – whereby older, larger girls show an initial preference for a sport or the product of initial selection bias into school sports teams (Delorme, Chalabaev 2011). Initial selection provides access to coaching and support which facilitate continued improvement and continued selection. Initial advantages may further drive the RAE through the continued participation of more Q1 and Q2 born individuals. Higher expectations placed upon relatively older players by coaches and team mates may motivate continued improvement or drive further (re)selection bias in their favour (the Pygmalion Effect). Through continued training and playing time, players may receive feedback from coaches family and peers that increase their self-expectations – the so called Galatea Effect (Hancock, Adler 2013).

Strengths and Limitations

These data represent the first attempt to disentangle maturational and social factors underlying observed RAE in school sports. An important limitation of this study is that we did not assess maturational status of students; instead, we restricted our multivariate analysis to sports with >100 expected cases per birth quarter. Within these relatively large samples, we assumed each ascending yearly quarter of students were more mature as well as being three months older than the preceding group as shown previously (Delorme & Raspaud 2009). Using a sample drawn from London children may reduce the generalizability of our findings for several reasons. First, London's population is much more ethnically diverse than the rest of the UK, but no data regarding participant ethnicity were available. Currently, 27.1% of all young people living in London are foreign-born residents. This may challenge the validity of using UK national birth statistics as reference data.

Despite the limitations of the data presented, we found strong evidence for a RAE in many of the sports offered by schools. There is evidence for life-affecting consequences of the RAE across multiple domains and disciplines but awareness of the phenomenon remains low; even in teachers and coaches who routinely observe and likely potentiate the effect. Only one in five schoolchildren engage in competitive sport, and even fewer adults do so. Despite such low participation rates, current governmental strategies to increase physical activity in children retain a strong focus on competitive sport (DCMS 2010; Department_for_Education 2013). For example, the School Games, introduced as part of the Olympic legacy strategy, are a national multi-sport interschool competition with some similarities to the LYG. It seems likely, therefore that comparable RAEs may be observed in the School Games – although no data are available. The impact of relative age on participation in English school sports is not known. Neither is the potential impact relative age may have on adults' participation in sport as, unfortunately, The Active People Survey used to monitor sports participation in English adults does not record respondents' birth date.

Perspectives

This is the first large-scale study to describe the distribution of birth dates in favour of students born soon after the cut-off date in team games and events that are commonplace in English schools. The significant underrepresentation of relatively younger students in school sports teams likely represents a significant barrier to participation for children born in the months March through August.

The bias in selection of students for sports teams by birth date was so strong that students from lower grades appear to have been selected ahead of students 3-6 months chronologically their senior. It seems unlikely that such findings can be explained by maturational differences and so suggest that positive social agents associated with their favorable birth dates have aided the development of younger players facilitating their selection. Alternatively, the

underrepresentation of relatively younger students may be due to their non-availability for selection due to actions of negative social agents curtailing their participation in that sport.
Our data cannot determine the exact nature of these social agents but the Matthew, Pygmalion and Galatea effects are likely candidates. Despite an abundance of evidence educators and policy-makers appear unfamiliar with the relative age effect. Interventions to promote awareness and, ultimately, eliminate relative age effects in sport and education are warranted.

References.

Alves CRR, Pasqua L, Artioli GG, Roschel H, Solis M, Tobias G, Klansener C, Bertuzzi R, Franchini E, Lancha AH, Gualano B. Anthropometric, physiological, performance, and nutritional profile of the Brazil National Canoe Polo Team. *J Sports Sci*. 2012: **30**: 305-311.

Bailey R. Physical education and sport in schools: a review of benefits and outcomes. *J Sch Health*. 2006: **76**: 397-401.

Batterham AM, Hopkins WG. Making meaningful inferences about magnitudes. *Int J Sports Physiol Perform*. 2006: **1**: 50-57.

Birch S, Cummings L, Oxford S, Duncan MJ. Examining relative age effects in fundamental skill proficiency in British children aged 6-11 years. *J Strength Cond Res*. 2014.

Brewer J. The influence of birth date and physical development on the selection of a male junior international soccer squad. *J Sports Sci*. 1992: **10**: 561-562.

Carling C, le Gall F, Reilly T, Williams AM. Do anthropometric and fitness characteristics vary according to birth date distribution in elite youth academy soccer players? *Scand J Med Sci Sports*. 2009: **19**: 3-9.

Cobley S, Abraham C, Baker J. Relative age effects on PE attainment and school sport representation. . *Phys Educ Sport Ped*. 2008: **13**: 267–276.

Cobley S, Baker J, Wattie N, McKenna J. Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports Med*. 2009: **39**: 235-256.

DCMS. PLANS FOR THE LEGACY FROM THE 2012 OLYMPIC AND PARALYMPIC GAMES London, UK.: Department for Culture Media & Sport., 2010.

Delorme N. Do weight categories prevent athletes from relative age effect? *J Sports Sci*. 2014: **32**: 16-21.

Delorme N, Boiche J, Raspaud M. The Relative Age Effect in Elite Sport: The French Case. *Res Q Exerc Sport*. 2009: **80**: 336-344.

Delorme N, Boiche J, Raspaud M. Relative age effect in elite sports: Methodological bias or real discrimination? *Eur J Sport Sci*. 2010: **10**: 91-96.

Delorme N, Chalabaev A, Raspaud M. Relative age is associated with sport dropout: evidence from youth categories of French basketball. *Scand J Med Sci Sports*. 2011: **21**: 120-128.

Delorme N, Champely S. Relative Age Effect and chi-squared statistics. *International Review for the Sociology of Sport*. 2015: **50**: 740-746.

Delorme N, Radel R, Raspaud M. Relative age effect and soccer refereeing: A "Strategic Adaptation' of relatively younger children? *European Journal of Sport Science*. 2013: **13**: 400-406.
Delorme N, Raspaud M. The relative age effect in young French basketball players: a study on the whole population. *Scand J Med Sci Sports*. 2009: **19**: 235-242.
Department_for_Education. Evidence on physical education and sport in schools: DFE-00092-2013. London, UK., 2013.
Deprez D, Vaeyens R, Coutts AJ, Lenoir M, Philippaerts R. Relative age effect and Yo-Yo IR1 in youth soccer. *Int J Sports Med*. 2012: **33**: 987-993.
Diamond GH. The birthdate effect--a maturational effect? *J Learn Disabil*. 1983: **16**: 161-164.
Du QQ, Gao HS, Levi MD. The relative-age effect and career success: Evidence from corporate CEOs. *Economics Letters*. 2012: **117**: 660-662.
Gil SM, Badiola A, Bidaurrazaga-Letona I, Zabala-Lili J, Gravina L, Santos-Concejero J, Lekue JA, Granados C. Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *J Sports Sci*. 2014: **32**: 479-486.
Hackshaw A, Kirkwood A. Interpreting and reporting clinical trials with results of borderline significance. *BMJ*. 2011: **343**: d3340.
Hancock DJ, Adler AL, Cote J. A proposed theoretical model to explain relative age effects in sport. *Eur J Sport Sci*. 2013: **13**: 630-637.
Hirose N. Relationships among birth-month distribution, skeletal age and anthropometric characteristics in adolescent elite soccer players. *J Sports Sci*. 2009: **27**: 1159-1166.
Lames M, Augste C, Dreckmann C, Georsdorf K, Schimanski M. Der,
“Relative Age Effect”: neue
Hausaufgaben f€ur den Sport.
. *Leistungssport*. 2008: **6**: 4–9.
Malina RM, Ribeiro B, Aroso J, Cumming SP. Characteristics of youth soccer players aged 13-15 years classified by skill level. *Br J Sports Med*. 2007: **41**: 290-295; discussion 295.
Mikulic P, Markovic G. Age- and gender-associated variation in maximal-intensity exercise performance in adolescent rowers. *Int J Sports Med*. 2011: **32**: 373-378.
Musch J, Grondin S. Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Developmental Review*. 2001: **21**: 147-167.
Office_For_National_Statistics. Birth Summary Tables - England and Wales. London, UK., 2015.
Patalay P, Belsky J, Fonagy P, Vostanis P, Humphrey N, Deighton J, Wolpert M. The Extent and Specificity of Relative Age Effects on Mental Health and Functioning in Early Adolescence. *J Adolescent Health*. 2015: **57**: 475-481.
Roberts SJ, Boddy LM, Fairclough SJ, Stratton G. The Influence of Relative Age Effects on the Cardiorespiratory Fitness Levels of Children Age 9 to 10 and 11 to 12 Years of Age. *Pediatric Exercise Science*. 2012: **24**: 72-83.
Roberts SJ, Fairclough SJ. The Influence of Relative Age Effect in the Assessment of High School Students in Physical Education in the United Kingdom. *J Teaching Physical Ed*. 2012: **31**: 56-70.

Sandercock GRH, Taylor MJ, Voss C, Ogunleye AA, Cohen DD, Parry DA. Quantification of the Relative Age Effect in Three Indices of Physical Performance. *J Strength Cond Res*. 2013: **27**: 3293-3299.

Schorer J, Cobley S, Bräutigam H, Loffing F, Hütter S, Büsch D, Wattie N, Helsen WF, Baker J. Developmental Contexts, Depth of Competition and Relative Age Effects in Sport: A Database Analysis and a Quasi-Experiment. *Psychological Test and Assessment Modeling*. 2015: **51**: 126-143

Steingrover C, Wattie N, Baker J, Helsen WF, Schorer J. The interaction between constituent year and within-1-year effects in elite German youth basketball. *Scand J Med Sci Sports*. 2016.

Thompson AH, Barnsley RH, Battle J. The relative age effect and the development of self-esteem. *Educational Res*. 2004: **46**: 313-320.

Thompson AH, Barnsley RH, Dyck RJ. A new factor in youth suicide: the relative age effect. *Can J Psychiatry*. 1999: **44**: 82-85.

van Rossum JHA. Relative age effect revisited: Findings from the dance domain. *Percept Motor Skills*. 2006: **102**: 302-308.

Vandendriessche JB, Vaeyens R, Vandorpe B, Lenoir M, Lefevre J, Philippaerts RM. Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players (age 15-16 years). *J Sports Sci*. 2012.

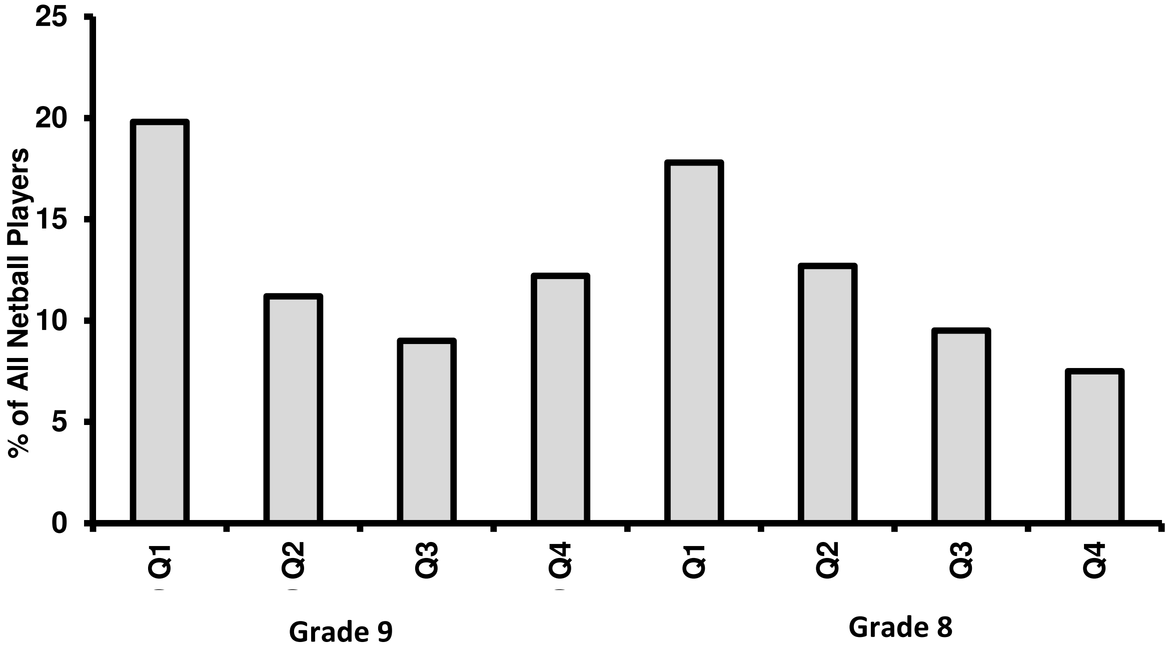
Veldhuizen S, Cairney J, Hay J, Faught B. Relative age effects in fitness testing in a general school sample: how relative are they? *J Sports Sci*. 2015: **33**: 109-115.

Vincent J, Glamser FD. Gender differences in the relative age effect among US olympic development program youth soccer players. *Journal of sports sciences*. 2006: **24**: 405-413.

Wilson G. The Birthdate Effect in School Sports Teams. *European Journal of Physical Education*. 1999: **4**: 139-145.

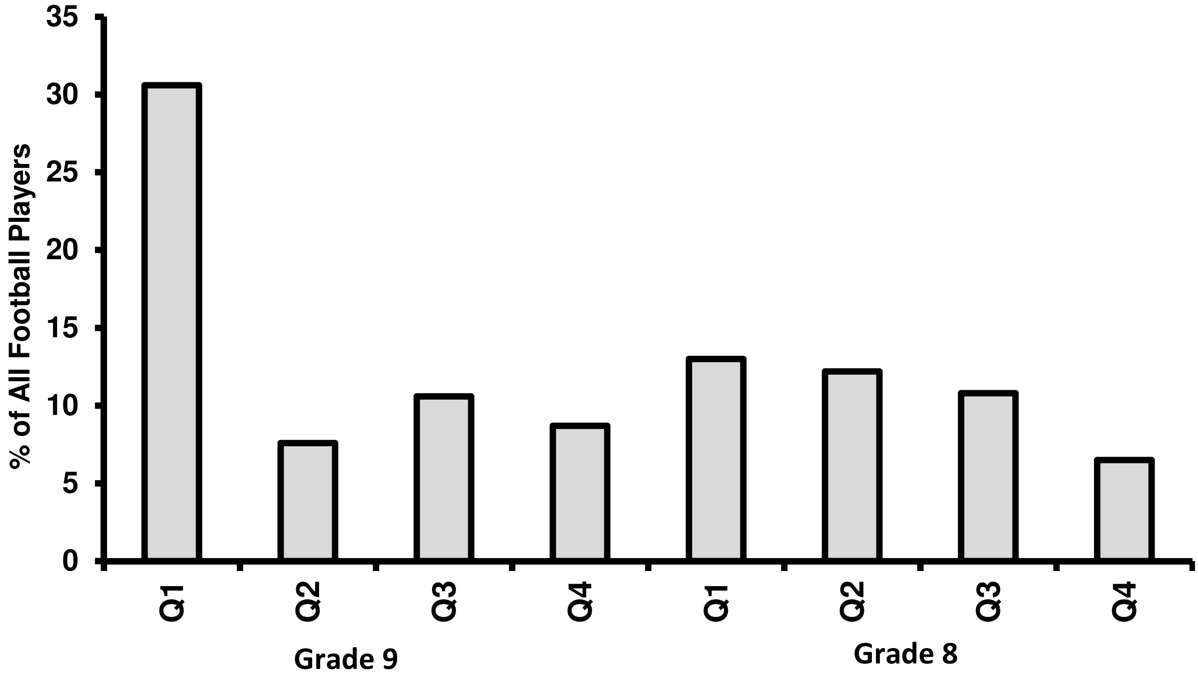
Wilson G. The birthdate effect in school sports teams. *Phys Ed Sport Pedagogy*. 1999: **4**.

Figure 1. Distribution of birth dates (%) across the two-year age grouping for in girls' netball at the 2013 London Youth Games.



Legend: Girls (*n*=409) all competitors at the 2013 London Youth Games. Cut-off date for netball was 1st September; Q1 – September-November, Q2-December- February, Q3-March-May, Q4 June-August 31st.. Mean age of competitors 14.4 ±0.5 years. Age (years) by Group: Grade9 Q1, 14.9±0.04; Grade9 Q2, 14.6±0.06; Grade9 Q3, 14.3±0.06; Grade9 Q4, 14.0±0.04; Grade8 Q1, 13.8±0.10; Grade8 Q2, 13.6±0.06 ; Grade8 Q3, 13.3±0.06 Grade8 Q4, 13.1±0.04

Figure 2. Distribution of birth dates (%)across the two-year age grouping for boys' football at the 2013 London Youth Games.



Legend: Boys (n=676) all participants at the 2013 London Youth Games. Cut-off date for netball was 1st September; Q1 – September-November, Q2-December- February, Q3-March-May, Q4 June-August 31st . Mean age of competitors 14.6 ±0.5 years. Age (years) by Group: Grade9 Q1, 14.9±0.04; Grade9 Q2, 14.6±0.06; Grade9 Q3, 14.3±0.06; Grade9 Q4, 14.0±0.05; Grade8 Q1, 13.9±0.11; Grade8 Q2, 13.6±0.04; Grade8 Q3, 13.3±0.03 Grade8 Q4, 13.1±0.06

Table 1. Frequency of girls' participation in events at the 2013 London Youth Games according to annual birth quarter

					Birth Quarter				
Girls		**Q1**		**Q2**		**Q3**		**Q4**	
	Total	***n*=**	**%**	***n*=**	**%**	***n*=**	**%**	***n*=**	**%**
	***n*=**	**OR**	**(95%CI)**	**OR**	**(95%CI)**	**OR**	**(95%CI)**	**OR**	**(95%CI)**
Cross-country	798	222	27.8%	223	27.9	168	21.1	185	23.2
		1.10	(1.07-1.13)	1.16	(1.15-1.17)	0.84	(0.83-0.85)	0.90	(0.89-0.91)
Swimming	585	166	28.4	146	25.0	133	22.7	140	23.9
		1.12	(1.09-1.16)	1.03	(1.02-1.04)	0.91	(0.90-0.92)	0.93	(0.82-0.94)
Football	584	152	26.0	142	24.3	129	22.1	161	27.6
		1.03	(1.00-1.106)	1.01	0.98-1.04	0.89	(0.86-0.92)	1.08	(1.04-1.11)
Cricket	410	108	26.3	116	28.3	91	22.2	95	23.2
		1.04	(1.00-1.08)	1.17	(1.13-1.21)	0.89	(0.86-0.92)	0.90	(0.87-0.97)
Netball	409	154	37.7	98	24.0	76	18.6	81	19.8
		1.49	(1.41-1.55)	0.99	(0.95-1.03)	0.75	(0.71-0.80)	0.77	(0.74-0.83)
Rugby Union	379	138	36.4	83	21.9	83	21.9	75	19.8
		1.44	(1.39-1.49)	0.91	(0.87-0.95)	0.88	(0.83-0.93)	0.77	(0.80-0.87)
Athletics	372	114	30.6	91	24.5	88	23.7	79	21.2
		1.21	(1.17-1.25)	1.01	(0.99-1.03)	0.95	(0.94-0.97)	0.83	(0.79-0.86)
Hockey	337	102	30.3	83	24.6	82	24.3	70	20.8
		1.20	(1.17-1.23)	1.02	(1.00-1.04)	0.98	(0.94-1.01)	0.81	(0.79-0.84)
Basketball	323	94	29.1	90	27.9	64	19.8	75	23.2
		1.15	(1.13-1.18)	1.15	(1.13-1.17)	0.79	(0.73-0.84)	0.91	(0.88-0.94)
Volleyball	316	90	28.5	77	24.4	80	25.3	69	21.8
		1.13	(1.11-1.15	1.01	(0.99-1.03)	1.02	(0.99-1.06)	0.85	(0.84-0.85)
Triathlon	248	60	24.2	65	26.2	59	23.8	64	25.8
		0.96	(0.94-0.98)	1.08	(1.06-1.12)	0.95	(0.93-0.97)	1.01	(0.99-1.03)
Rowing Indoor	218	68	31.2	47	21.6	53	24.3	50	22.9
		1.24	(1.22-1.26)	0.89	(0.88-0.90)	0.97	(0.92-1.00)	0.89	(0.86-0.93)
Rowing Outdoor	164	52	31.7	37	22.6	35	21.3	40	24.4
		1.26	(1.23-1.29)	0.93	(0.91-0.95)	0.86	(0.80-0.93)	0.95	(0.90-0.98)
Handball	146	38	26.0	42	28.8	32	21.9	34	23.3
		1.03	(0.95-1.11)	1.19	(1.13-1.25)	0.88	(0.82-0.93)	0.91	(0.83-0.94)
Canoeing	144	26	18.1	26	18.1	42	29.2	50	34.7
		0.71	(0.70-0.72)	0.75	(0.73-0.77)	1.17	(1.15-1.19)	1.35	(1.32-1.38)
Judo*	126	30	23.8	34	27.0	39	31.0	23	18.3
		0.94	(0.94-0.95)	1.12	(1.11-1.13)	1.24	(1.23-1.25)	0.71	(0.69-0.73)
Cycling	125	36	28.8	24	19.2	29	23.2	36	28.8
		1.14	(1.11-1.17)	0.79	(0.72-0.74)	0.93	(0.88-0.97)	1.12	(1.10-1.14)
Trampolining	115	26	22.6	27	23.5	25	21.7	37	32.2
		0.90	(0.88-0.93)	0.97	(0.93-1.01)	0.87	(0.81-0.95)	1.25	(1.23-1.27)
Tennis	114	25	21.9	30	26.3	26	22.8	33	28.9
		0.87	(0.83-0.92)	1.09	(1.03-1.14)	0.91	(0.87-0.95)	1.13	(1.09-1.17)
Table Tennis	102	34	32.7	20	19.8	26	25.7	22	21.8
		1.32	(1.29-1.35)	0.81	(0.76-0.85)	1.02	(0.95-1.06)	0.84	(0.82-0.86)

Legend: OR – Odds Ratio; CI – Confidence Intervals. ORs calculated separately for each birth quarter as the likelihood of students born in each quarter (Q1-Q4) competing in each event compared with students born in any quarter. *-Weight categorized event.

Table2.Boys' frequency of participation in the London Youth Games according to annual birth quarter.

		Birth Quarter							
Girls		**Q1**		**Q2**		**Q3**		**Q4**	
	Total *n*=	***n*=** OR	**%** (95%CI)	***n*=** OR	**%** (95%CI)	***n*=** OR	**%** (95%CI)	***n*=** OR	**%** (95%CI)
Cross-country running	863	304 1.39	35.2 (1.38-1.4)	215 1.03	24.9 (1.02-1.04)	193 0.90	22.4 (0.89-0.91)	151 0.68	17.5 (0.67-0.69)
Football	676	229 1.34	33.9 (1.27-1.41)	144 0.88	21.3 (0.84-0.92)	168 1.00	24.9 (0.95-1.05)	135 0.78	20.0 (0.75-0.81)
Swimming	572	131 0.91	22.9 (0.90-0.92)	154 1.11	26.9 (1.1-1.12)	130 0.91	22.7 (0.90-0.92)	157 1.07	27.4 (1.06-1.08)
Basketball	429	153 1.41	35.7 (1.38-1.44)	96 0.93	22.4 (0.91-0.95)	97 0.91	22.6 (0.89-0.93)	83 0.75	19.3 (0.73-0.77)
Cricket	403	132 1.30	32.8 (1.25-1.35)	103 1.06	25.6 (0.99-1.13)	89 0.89	22.1 (0.83-0.95)	79 0.76	19.6 (0.71-0.81)
Judo*	395	90 0.90	22.8 (0.89-0.91)	99 1.04	25.1 (1.03-1.05)	106 1.08	26.8 (1.07-1.09)	100 0.99	25.3 (0.98-1.00)
Athletics	390	158 1.60	40.5 (1.54-1.66)	102 1.08	26.2 (1.01-1.15)	77 0.79	19.7 (0.74-0.84)	53 0.53	13.6 (0.49-0.57)
Cycling	344	84 0.97	24.4 (0.96-0.98)	87 1.05	25.3 (1.04-1.06)	98 1.14	28.5 (1.13-1.15)	75 0.85	21.8 (0.84-0.86)
Volleyball	324	114 1.39	35.2 (1.37-1.41)	72 0.92	22.2 (0.90-0.94)	63 0.78	19.4 (0.76-0.80)	75 0.90	23.1 (0.89-0.91)
Hockey	317	96 1.20	30.3 (1.16-1.24)	72 0.94	22.7 (0.91-0.97)	78 0.99	24.6 (0.95-1.03)	71 0.87	22.4 (0.85-0.89)
Indoor Rowing	241	96 1.58	39.8 (1.56-1.60)	60 1.03	24.9 (1.01-1.05)	48 0.80	19.9 (0.79-0.81)	37 0.60	15.4 (0.59-0.61)
Triathlon	232	62 1.06	26.7 (1.04-1.08)	51 0.91	22.0 (0.89-0.93)	57 0.99	24.6 (0.98-1.00)	62 1.04	26.7 (1.02-1.06)
Handball	176	60 1.35	34.1 (1.24-1.46)	48 1.13	27.3 (1.05-1.21)	40 0.91	22.7 (0.84-0.98)	28 0.62	15.9 (0.59-0.65)
Outdoor Rowing	174	62 1.41	35.6 (1.39-1.43)	38 0.90	21.8 (0.88-0.92)	48 1.11	27.6 (1.09-1.13)	26 0.58	14.9 (0.56-0.60)
Canoeing	169	39 0.91	23.1 (0.89-0.93)	49 1.20	29.0 (1.18-1.22)	36 0.85	21.3 (0.84-0.86)	45 1.04	26.6 (1.00-1.08)
Table Tennis	168	47 1.11	28.0 (1.09-1.13)	43 1.06	25.6 (1.04-1.08)	28 0.67	16.7 (0.65-0.69)	50 1.16	29.8 (1.14-1.18)
Tennis	119	35 1.16	29.4 (1.10-1.20)	28 0.97	23.5 (0.94-0.96)	33 1.11	27.7 (1.10-1.14)	23 0.75	19.3 (0.72-0.79)
Fencing	119	33 1.10	27.7 (1.09-1.11)	30 1.04	25.2 (1.02-1.06)	30 1.01	25.2 (1.00-1.02)	26 0.85	21.8 (0.84-0.86)

Legend: OR – Odds Ratio; CI – Confidence Intervals. ORs calculated separately for each birth quarter as the likelihood of students born in each quarter (Q1-Q4) competing in each event compared with students born in any quarter. *-Weight categorized event.

3. Likelihood of students born in Q1, Q2 or Q3 competing at the 2013 London Youth Games according to annual birth quarter: Q1, Q2 and ative to Q4 (referent category).

	Girls					Boys			
Event	**Q1 OR (95%CI)**	**Q2 OR (95%CI)**	**Q3 OR (95%CI)**	**Q4 1.00**	**Event**	**Q1 OR (95%CI)**	**Q2 OR (95%CI)**	**Q3 OR (95%CI)**	**Q4 1.00**
Cross Country	1.20 (0.91-1.58)	1.21 (0.92-1.59)	0.91 (0.68-1.21)	1.00	**Cross country**	2.01 (1.53-2.63)	1.42 (1.07-2.13)	1.27 (0.96-1.69)	1.00
Swimming	0.83 (0.60-1.58)	0.98 (0.71-1.35)	0.83 (0.60-1.16)	1.00	**Football**	1.69 (1.23-2.27)	1.36 (1.11-1.81)	1.59 (1.18-2.14)	1.00
Football	0.94 (0.68- 1.29)	0.88 (0.64 1.22)	0.80 (0.58-1.11)	1.00	**Swimming**	0.82 (0.52-1.16)	0.97 (0.69-1.36)	0.83 (0.59-1.17)	1.00
Cricket	1.64 (1.11-2.43)	1.40 (0.87-1.95)	1.13 (0.75-1.70)	1.00	**Basketball**	1.88 (1.29-2.37)	1.19 (0.80-1.76)	1.28 (0.86-1.90)	1.00
Netball	1.91 (1.30-2.80)	1.19 (0.79-1.98)	0.92 (0.64-1.53)	1.00	**Cricket**	1.67 (0.89-1.91)	1.50 (1.02-2.20)	1.31 (2.11-4.92)	1.00
Rugby Union	1.82 (1.22-2.72)	1.09 (0.72-1.67)	1.09 (0.72-1.67)	1.00	**Judo**	0.86 (0.58-1.28)	0.98 (0.66 1.15)	1.05 (0.71-1.46)	1.00
Athletics	1.46 (1.00-2.19)	1.15 (0.76-1.75)	1.12 (0.73-1.69)	1.00	**Athletics**	3.23 (2.11-4.92)	1.94 (1.25-2.97)	1.48 (0.95-2.31)	1.00
Hockey	1.34 (0.86-2.07)	1.00 (0.64 1.57)	1.08 (0.69 1.69)	1.00	**Cycling**	1.02 (0.50-2.11)	1.50 (0.74-3.04)	0.97 (-0.10-1.98)	1.00
Basketball	1.19 (0.77-1.83)	1.13 (0.73-1.73)	0.76 (0.48-1.20)	1.00	**Volleyball**	1.54 (1.24-1.86)	1.01 (0.71-1.26)	0.86 (0.55-1.20)	1.00
Volleyball	1.30 (0.84-2.03)	1.12 (0.71-1.25)	1.16 (0.74-1.82)	1.00	**Hockey**	1.27 (0.82-1.96)	0.98 (0.63- 1.55)	1.07 (0.68-1.67)	1.00
Triathlon	0.93 (0.57-1.54)	1.02 (0.66-1.26)	0.96 (0.54-1.52)	1.00	**Indoor Rowing**	2.44 (1.45-4.10)	1.45 (0.90-2.77)	1.24 (0.71-2.16)	1.00
Indoor rowing	1.35 (0.79-2.24)	0.92 (0.53-1.59)	1.06 (0.62-1.82)	1.00	**Triathlon**	0.92 (0.55-1.53)	0.82 (0.49-1.48)	1.00 (0.60-1.66)	1.00
Outdoor rowing	1.86 (1.03-3.00)	0.55 (0.28-1.08)	0.87 (0.47-1.64)	1.00	**Handball**	2.22 (1.20-4.21)	1.47 (0.82-2.62)	1.25 (0.71-2.17)	1.00
Handball	0.96 (0.49-1.87)	1.06 (0.55-2.05)	0.68 (0.35-1.32)	1.00	**Outdoor Rowing**	2.38 (1.28-4.44)	1.50 (0.78-2.87)	1.89 (1.00-3.56)	1.00
Canoeing	0.44 (0.23-0.85)	0.51 (0.21-0.97)	0.72 (0.40-1.33)	1.00	**Canoeing**	0.83 (0.45-1.15)	1.08 (0.69-1.96)	0.80 (0.43-1.96)	1.00
Judo*	1.26 (0.61-2.63)	1.43 (0.69-2.95)	1.69 (0.83-3.47)	1.00	**Table Tennis**	0.71 (0.37-1.28)	0.69 (0.37-1.28)	0.63 (0.32-1.27)	1.00
Cycling	1.03 (0.53-2.03)	0.69 (0.34-1.41)	0.82 (0.42-1.67)	1.00	**Tennis**	1.52 (0.76-3.25)	1.30 (0.62-2.75)	1.53 (0.74-3.20)	1.00
Trampoline	0.56 (0.27-1.27)	0.80 (0.37-1.36)	1.05 (0.47-2.37)	1.00	**Fencing**	1.27 (0.59-2.53)	1.12 (0.53-2.32)	1.12 (0.53-2.32)	1.00
Tennis	0.77 (0.38-1.56)	0.94 (0.50-1.99)	0.64 (0.31-1.34)	1.00					
Table Tennis	1.54 (0.72-3.32)	0.94 (0.42 1.24)	1.23 (0.56-2.70)	1.00					

d: OR – Odds Ratios; CI – Confidence Intervals. ORs based on binary logistic regression analysis expressing the relative likelihood of students 1 Q1-Q3 representing schools in events with n>100 competitors at 2013 London Youth Games compared with those born in Q4 (referent). nt category for representation is non-selected students - calculated as expected number of students born in each quarter according to al birth statistics.

Table 4. Students' likelihood of representing school according to constituent year (grade) and relative age within year (birth quarter) in common team sports with two-year age grouping,

Girls		Netball	
	OR	95%CI	p-value
Grade 8	1.00 (Referent)	-	
Grade 9	1.07	0.71 - 1.23	0.633
Q4 (youngest)	1.00 (Referent)	-	
Q3	0.93	0.61 - 1.41	0.743
Q2	1.19	0.80 - 1.78	0.393
Q1	1.87	1.27 - 2.75	<0.001
Boys		**Football**	
	OR	95%CI	p-value
Grade 8	1.00 (Referent)	-	
Grade 9	1.14	0.83 - 1.57	0.331
Q4 (youngest)	1.00 (Referent)	-	
Q3	1.36	0.87 - 2.12	0.179
Q2	1.25	0.79 - 1.96	0.393
Q1	3.25	2.12 - 4.98	<0.001

Girls *n*=409, Boys *n*=676 participants at the 2013 London Youth Games. Mean age girls 14.4±0.5 Mean age boys 14.6 ±0.5 years. Both sports employed a two-year age grouping in which the lower constituent year was Grade 8, and Grade 9 was the upper constituent year.