The impact of physical growth and relative age effect on assessment in physical education.

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Abstract

Introduction: Physical Education (PE) is perhaps the school subject most likely to produce relative age effects (RAE). Like in sports, physical maturity gives students an advantage in PE, which might well be mistaken for superior ability. The aim of the present study is to investigate the extent to which physical growth, measured as height, and RAE reflect the assessment in Norwegian PE. Furthermore, we wanted to examine whether there is any gender differences in the assessment in PE as a function of physical growth and RAE. **Method**: The participants (n=2978) were pupils in the last three years of secondary school (13–16 years old). A custom-made questionnaire was designed to collect the necessary data. **Results**: The correlations between height and mark in PE for boys in 8th, 9th and 10th grades are respectively $r = 0.14$, $r = 0.32$, and $r = 0.29$. For girls, the correlations are $r = 0.11$, $r = 0.33$, and $r = 0.21$. All correlations are significant ($p < 0.05$). The number of pupils achieving top marks was 114 in the first half of the year, whereas it was 65 in the second half of the year. **Discussion**: The present study showed that physical growth has an impact on the pupils' PE attainment. The physical growth is of course also mediated by the pupils' age. RAEs were found in PE attainments also in the Norwegian school system for both genders, despite all the intentions expressed in the PE curriculum.

INTRODUCTION

Scientists have investigated the association between individuals' birth dates and variability in development since the beginning of the last century. They found that young people with eminent achievements were often born early in their year of birth (Huntington, 1938; Kassel, 1929; Pintner & Forlano, 1934). This early research has been the inspiration to an extensive research of the link between birth date and achievements in, for example, sports and education (Bell, Massey, & Dexter, 1997; Cobley, Abraham, & Baker, 2008).

In Norway, as in many other countries, children and adolescents in both school and sports are grouped based on year of birth. By definition, there will be a range of one year between people who compete in the same age group in sports or attend the same educational stage in school. The difference in age within the same age group is called the relative age difference (Musch & Grondin, 2001; Wattie, Cobley, & Baker, 2008). Within the same age group, this factor will contribute to individual differences in the rate of development and maturation, on top of and in interaction with genetic factors, experience, gender, and so forth. Therefore, the relative age difference can contribute to advantages and disadvantages for individual achievement in both a sport and a school (Baker, Schorer, Cobley, Schimmer, & Wattie, 2009; Cobley, Baker, Wattie, & McKenna, 2009; Martin, Foels, Clanton, & Moon, 2004; McPhillips & Jordan-Black, 2009). This effect is defined as the 'relative age effect' (RAE) (Musch & Grondin, 2001; Wattie et al., 2008). RAE is at its maximum when a child born in late December is compared with another child born in early January the same year. However, as the children grow, it is reasonable to expect that the RAE as such will disappear when they reach maturity. This does not mean that secondary effects might not still be present, which is discussed later as the Pygmalion effect (Rosenthal & Jacobsen, 1968).

Therefore, it is reasonable to hypothesise that the RAE would be more prominent for younger children (i.e., early grades in school), because of the age differences being relatively larger. This has been shown for cognitive abilities and performance (see Musch & Grondin, 2001). This picture will, however, be complicated by individual differences for the onset of puberty (Malina, 1994). Especially within a subject such as physical education (PE), this might be an important performance factor. In most sports, those reaching puberty early have an advantage over their later-developing peers, because the biological-maturity status is a major factor for performance capacity (Baxter-Jones, 1995; Müller, Müller, Hildebrandt, & Raschner, 2016).

In sports where height, body mass, strength, and power are an advantage, the early maturing boy or girl at any given age is likely to have a biological advantage over those who mature later (Baxter-Jones, 1995). This applies of course especially to sports that favour those who are tall (Khosla, 1983). The individual's maturation together with the selection procedures in sports are suggested to influence the individual's ability to invest time into the practice and to accumulate sport-specific skills and experience, factors which are critical for long-term performance (Baker & Horton, 2004).

Theoretical support for the RAE can be found in the concept of developmental-advantage socialisation and the Pygmalion effect or self-fulfilling prophecy (Harter, 1978; Rosenthal & Jacobson, 1968). Given the relative age difference in the same cohort, a 6 to 12-month developmental advantage can be decisive. Children born early in the year are more often defined as talents and are selected for talent camps or teams. The selected children are provided with the best coaches and facilities; they are thus given the best opportunities for development. The initial selection appears, as such, justified because these children develop more than the non-selected ones. The prophecy, thus, becomes self-fulfilling (Rosenthal & Babad, 1985). Therefore, RAEs in sports seem to be enhanced by the so-called Pygmalion effect (Rosenthal & Jacobson, 1968), that is, the fact that an individual will perform better when more is expected of him/her. Moreover, Harter's (1978) competence motivation theory suggests that athletes who perceive that they are able to perform at a high level and think that they are talented are more likely to continue perfecting their abilities and to invest more time and effort into their sport with predictable results.

PE is perhaps the school subject most likely to produce RAEs because of the physical component in the scale of marks. Although PE is less competitive and selective than sports, students' attainments depend on their physical performance rather than academic or cognitive variables like in most other subjects in school. Like in sports (see, for example, Brewer, Balsom, Davis, & Ekblom, 1992), physical maturity gives students an advantage in PE, which might well be mistaken for superior ability. True enough, previous studies have reported RAEs in PE attainment for different age groups (Aune, Pedersen, Ingvaldsen, & Dalen, 2015; Bell et al., 1997; Cale & Harris, 2009; Cobley et al., 2008). Also relevant is the interaction effect from students' participation in sports outside of the school environment, which most likely will carry over into PE lessons.

In Norway, children enter school when they are six years old. The school year starts in August, meaning that those who are born early in that year are over six and a half years old, whereas those born late in the year are five and a half years old. This difference of one year is, of course, the same whichever the chosen cut-off point (entry month). The Norwegian PE curriculum contains several competence goals directed towards participation based upon abilities. An example of this is participation in various activities, and exploring their own physical potentials (Norwegian Ministry of Education and Research, 2012). Thus, pupils should have equal opportunities for high attainment in PE. Due to difficulties in objective evaluating of all mark-, factors, such as motivation and attitude, general ratings of performance are commonly used (Cale & Harris, 2009). Therefore, the aims of the present study is to investigate the extent to which physical growth, measured as height and body mass, and RAE reflect the assessment in Norwegian PE. Furthermore, we wanted to examine whether there is any gender differences in the assessment in PE as a function of physical growth and RAE.

METHODS

Participants

The participants were pupils in the last three years of secondary school, that is, the 8^{th}, 9^{th}, and 10^{th} grades (13–16 years old) and attended a large comprehensive area of schools situated in the middle of Norway. There were 2978 participants in total. The inclusion criteria were year of birth corresponding to normal school progression and past marks in PE. Students who, for some reason, did not fulfil the inclusion criteria were excluded from this study. The study was conducted according to the Helsinki Declaration and approved by the Norwegian Social Science Data Services (NSD).

…Table 1 in about here…

Design and Analyses

The main aim of the survey was to obtain information about the pupils' marks in PE, height, body mass, gender, and date of birth to investigate the relation between these variables. A custom-made questionnaire was designed to collect the necessary data. The questionnaire was distributed to 15 classes at level eight, 14 classes at level nine, and 14 classes at level ten. The survey took place within three weeks after the pupils received their half-year marks in PE. Only students present in the classroom at the time of the data collection were included in the survey. All of the students present took part in the survey, and under 0.1 % were excluded because of a birth month that did not correspond to normal progression. The month of birth and marks were classified in quartiles (Q1, January–Mars; Q2, April–June; Q3, July–September; Q4, October–December). The students were allocated to one of the four subgroups depending on the quartile in which they were born. In order to analyse the data for height and body mass across the school levels 8–10 relative to quartiles, z-scores were calculated for each level and sex.

In Norway, PE is graded with numbers from 1 to 6, were 6 is the best and 1 is a fail. Students failing PE are usually those who, for some reason, do not participate sufficiently for the teachers to give a mark. The lowest real mark for a student is therefore 2, which is the lowest grade included in this study. To indicate if the mark is strong or weak, the teacher can add a plus or minus. For example, 5+ indicates a strong 5. To consider this, 0.33 was added to the basic mark for a plus, and 0.33 was deducted for a minus, that is, (5+ = 5.33) and (5- = 4.67). Two groups were thus defined: a high-attainment group for students with marks 5+ or 6 and a low-attainment group for students with marks 3 or 2.

Statistics

In the data analysis, the students were also divided on the basis of their sex. The group differences were evaluated by using non-parametric methods, Mann-Whitney U-test, and Kruskas Wallis test for independent samples. In order to eliminate the differences in height and body mass due to class level (age), the scores for each level were standardised. A factor analysis and varimax rotation for grades, month of birth, height, body mass, and sex where used and the criteria for identifying a factor was set to an eigenvalue of 1.00.

The statistical analyses were performed in SPSS (Version 19.0, SPSS, IBM Armonk, NY, USA), and a criterion alpha level of $p \leq 0.05$ was used to indicate statistical significance.

RESULTS

As expected, the pupils are still growing from one class level to the next (table 1).

The correlations between height and mark in PE for boys in 8th, 9th and 10th grades are respectively $r = 0.14$, $r = 0.32$, and $r = 0.29$. For girls, the correlations are $r = 0.11$, $r = 0.33$, and $r = 0.21$. All correlations are significant ($p < 0.05$).

To further explore this effect, the high and low achievers in each subgroup were compared (table 2) by using a Mann-Whitney U-test. All differences in height between the groups are significant, that is, the high achievers students are higher than their low achievers classmates are.

-----Table 2 in about here ------

An independent-sample Kruskal-Wallis test detected no differences between the distribution of marks across the different quartiles ($p = 0.46$) for girls. The same test showed that boys had a decline in marks from the first to the fourth quartile ($p = 0.001$). The number of high marks for each quartile for boys and girls are presented in figure 1. The number of pupils achieving top marks was 114 in the first half of the year, whereas it was 65 in the second half of the year, which emphasises the declining trend in the results across quartiles.

…Figure 1 in about here…

Because height and age (RAE) are highly correlated, a factor analysis was also performed for the variables collected. In order to eliminate the differences in height and body mass due to class level (age), the scores for each level were standardised. A factor analysis using an eigenvalue of 1.0 and a varimax rotation for grades, month of birth, height, body mass, and sex, show two distinct factors. Sex, body mass, and height were grouped together (eigenvalue = 1.30) as a distinct factor explaining 36.6% of the variability before rotation and 38.1% after rotation. In addition, grade and month of birth formed a factor (eigenvalue = 1.010), relatively independent of the first factor, which explains 22.5% and 23.1% of the variability in the data before and after rotation.

DISCUSSION

The present study showed that physical growth has an impact on the pupils' PE attainment. The physical growth is of course also mediated by the pupils' age. Therefore, the PE grades in the factor analysis are more closely linked to RAE than body size as such.

RAE are commonly associated with several advantages, such as physical capabilities, experience, and psychological factors. Physical development is undoubtedly a significant determinant of success in sports (Malina, 1994). The explained variance from correlations between height and mark show minor importance of height for the 8th graders (1 % variance explained), but increasingly (~10 % variance explained) important for the 9th and 10th graders (14-16 years), an age that is normally associated with growth spurt. Even though early maturation is not always associated with better performance (le Gall, Carling, Williams, & Reilly, 2010; Musch & Grondin, 2001), it is related to greater body size, better agility, and superior performance in sprinting and endurance (Musch & Grondin, 2001).Therefore, our first explanation is that those who are tall seem to have better physical capabilities in PE. Although differences in age of less than 12 months have little or no effect in adults' physical development, they may have a significant effect on adolescents who go through rapid changes in growth and development. The assessment-based Norwegian PE curriculum is adjusted to a small degree to assess performance. The competence aims in secondary school are largely for the pupils to be able to participate in various activities and to explore and conquer their physical potentials. In sports, the tendency to be taller than average from an early age suggests that body size is likely to have influenced the selection of specific sports (Baxter-Jones, 1995). The difference in height between those who have high and low attainments in this study shows that the same mechanisms are present in the assessment in Norwegian PE. Pupils born early in the year often have the advantage of being taller, stronger, and faster (Meylan, Cronin, Oliver, & Hughes, 2010). In contrast to this is the gymnastics, one of the few sports where early maturation is a disadvantage (Baxter-Jones, 1995). Late maturation has repeatedly been observed among successful gymnasts (Malina, 1994). The increasing difference with age in attainment between boys and girls and the difference in the number of top marks could also indicate this effect in PE. The onset of puberty for females contains several physiological factors that constrain their athletic performance compared with male peers (Vincent & Glamser, 2006). These maturational factors suggest that the athletic performance of females plateaus shortly after menarche, negating some of the physiological benefits of being born early in the year (ibid.). The relationship between dates of birth and success in sports, particularly in sports where advanced physical development is advantageous, implies that the youngest age group is at a disadvantage (Baxter-Jones, 1995). In PE, this might be mistaken for superior ability in favour of those who are mature early and therefore are more readily positively evaluated in class. However, the three main subjects in the Norwegian PE curriculum are Sports Activities, Outdoor Life, and Exercise and Lifestyle (Norwegian Ministry of Education and Research, 2012). In Sports Activities, the emphasis is placed on movement, play, and creative activities that are adapted to the skill level and aptitude of each pupil. Outdoor Life covers competence and skills needed to do things safely in nature and to see the value of visiting natural environments. Exercise and Lifestyle focuses on various activities and how training and exercise can influence one's health. Therefore, the Norwegian PE curriculum emphasises participation over performance (Norwegian Ministry of Education and Research, 2012). According to the curriculum, children's physical capacity and maturation should not directly contribute to their end-of-year attainments and should not be monitored. However, because attitude and motivation are not easily measured, more-traditional ratings of sport performance might be used, including physical-fitness testing (Cale & Harris, 2009). The results from this study would indicate that Norwegian PE appears to be using traditional ratings of sport performance in assessment in PE. Several studies show that this assessment is biased and affected by the children's relative age and physical maturity (Aune et al., 2015; Bell et al., 1997; Cobley et al., 2008; Wattie et al., 2008).

The second issue that our results bring attention to is the element of experience. It is suggested that the quantity and quality of practice are primary mechanisms explaining skill or performance attainment (Baker & Horton, 2004). An 11-month difference in age represents almost a year of opportunities to practice, which means an opportunity for more training for the oldest pupils. The likelihood of the relatively younger pupils to be selected for school competition or benefit from coaching might be reduced across the school years. This may not be related to the school environment only, because older and more-mature children have been found to have a higher likelihood of being chosen to be part of a team and high-ability groups in their leisure time (Cobley et al., 2008). This will give the more-mature pupils better coaching, the opportunity to face better opponents, more training, and higher competition levels. Furthermore, more-mature children will have the possibility of more active participation in the games, both in schools and in different teams during their leisure time. If the teachers use ratings of sport performance to assess attainment in PE, as the results of this study indicate, children born in January have an advantage over others. This seems to apply to boys only in this study. We speculate that this difference is because girls are compared to and compete with boys; therefore, they will not have the same advantage when born early compared to boys.

The third explanation is the psychological factors that will contribute to motivation, self-esteem, and willingness and ability to participate in PE (Cobley et al., 2008; Musch & Grondin, 2001). Perceived competence is a powerful determinant of participation in sports (ibid.). A relatively younger child is more likely to be frustrated by his or her limited ability to compete, and a relatively older child is likely to be erroneously perceived as the most talented in a given age group (Cobley, et al., 2009; Musch & Grondin, 2001). The psychological consequences of this advantage may also create greater confidence and self-esteem derived from a comparison of ability to younger physically and cognitively less mature members of an age group (Cobley et al., 2008). According to Harter's (1978) competence motivation theory, the pupils who perceive that they are able to perform at a high level and perceive that they are talented are more likely to continue perfecting their abilities and invest more time and effort in the subject.

Conclusion

RAEs were found in PE attainments also in the Norwegian school system for both sexes, despite all the intentions expressed in the PE curriculum. There is a risk of adopting some of the negative consequences of RAE shown within sport to PE, despite the teaching program essentially being noncompetitive. Practical implications of such findings is that researchers, teachers and education policymakers have to understand that associations of birth date and evaluation of performance is not minor for the respective child. On the contrary, repeated and enduring RAEs in several areas affect individuals more than at a single point in life, and it is important to be aware that it might have considerable developmental consequences across the lifespan. Some of the described consequences of the RAE are dramatic for the respective individual. It would be beneficial for researchers, teachers and education policymakers to have increased awareness of the RAEs, and then try to find strategies to reduce the variability in attainment due to relative age differences.

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Table list:

Figure list

Table 1: Subjects included in the study; class, gender (n), height (mean / SD), weight (mean / SD), and physical education mark (mean / SD)

Class	Gender	Height	Body mass	Mark PE
8th	Male (n = 528)	165.2 / 8.2	53.7 / 9.1	4.42 / 0.74
	Female (n = 496)	162.2 / 6.4	51.0 / 8.2	4.35 / 0.72
9th	Male (n = 485)	171.1 / 8.0	60.9 / 10.1	4.45 / 0.75
	Female (n = 489)	164.8 / 6.0	55.4 / 10.0	4.35 / 0.74
10th	Male (n = 499)	175.8 / 7.2	65.9 / 9.3	4.55 / 0.71
	Female (n = 481)	166.7 / 5.3	58.4 / 7.5	4.34 / 0.75

Table 2: Mean rank scores (Mann-Whitney) in height for pupils in levels 8, 9, and 10 in secondary school. The pupils are divided into groups according to gender and high or low attainment in PE.

Class / Gender	**Low attainment** Mean rank (n, mean height, SD)	**High attainment** Mean rank (n, mean height, SD)	**Z**	**P <** (2-tailed)
8th / Male	28.0 (53, 162.0, 8.3)	54.3 (36, 171.6, 6.1)	-5.0	0.001
9th / Male	30.8 (42, 164.7, 9.8)	65.9 (38, 178.9, 5.7)	-6.3	0.001
10th / Male	21.8 (29, 170.4, 6.7)	48.8 (47, 179.5, 5.1)	-5.2	0.001
8th / Female	24.7 (51, 159.2, 7.2)	41.1 (15, 166.0, 4.8)	-3.4	0.001
9th /Female	27.6 (40, 159.7, 7.1)	53.5 (19, 170.9, 6.9)	-4.6	0.001
10th / Female	32.8 (55, 164.1, 5.4)	56.6 (24, 169.7, 4.0)	-4.2	0.001

Figure 1