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INFLUENCE OF RELATIVE AGE EFFECT ON FITNESS LEVELS OF CHILEAN SCHOOL CHILDREN AGED 14-15 YEARS

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ABSTRACT

Relative Age Effects (RAE) is known as the greater experience and maturity between the older and the younger children and is reflected in better performance in sport and academics. The aim of this study was to assess the existence and size of RAE on a large and nationally representative Chilean population of children aged 14-15 years using a standardised fitness test battery. Cardiorespiratory fitness and musculo-skeletal fitness were measured, including 20m-shuttle-run test, standing broad jump, sit-and-reach, crunches and push-ups tests. Data from 12 817 children (47% girls, age=14.37±0.43; 53% boys, age=14.41±0.46) were analysed. Analysis of covariance, ANCOVA, was conducted for both genders and years separately. Results revealed differences in all tests (p<0.05) for 14-year-old boys and girls, except for the 20m-shuttle-run in girls, although the size of the effect was low. In 15-year-olds, the effect of RAE reached a plateau. These results confirm the existence of RAE among Chilean schoolchildren and support the idea of taking into account the birth date in the evaluation of fitness in order to improve the accuracy of the assessment.

Keywords**:** Birth date; Cardio-respiratory fitness; Musculo-skeletal fitness; RAE.

INTRODUCTION

Within educational, sports- and even health-related contexts, grouping policies are usually based on chronological age. This procedure guarantees that children grouped together show small age differences within a group. Despite that, it is possible that within these groups, age difference of up to one year (between those who were born in the first and last month of the selected cut point, usually January 1st and December 31st, is still prevalent. This age and maturity gaps between the older and the younger children are reflected in better performance in sport and academics (Musch & Grondin, 2001; Wattie *et al*., 2008) which is widely known as *Relative Age Effects* (RAE).

RAE has been previously reported in the context of sports, such as ice hockey (Sherar *et al*., 2007), baseball (Stebelsky & Barnsley, 1991), soccer (Helsen *et al*., 2005) or basketball (Delorme & Raspaud, 2009) and, recently, in the general school population (Veldhuizen *et al*., 2014; Wattie *et al*., 2014). Within an educational context, the relatively older children often achieve better grades in Physical Education classes (Bell *et al*., 1997) and in the sport level the existence of RAE has been shown to exist in talent identification and development in sports (Burgess & Naughton, 2010). These differences remain across different skills levels, but decline in the post-adolescence stage, around the age of 16 years old. Could the talent selection procedures be an effect of RAE? At an early age, children born in the first months of the year will have an initial advantage compared to those born in the last months of the year, which may lead to propagate future advantages due to the access to resources by older children (Musch & Grondin, 2001), as selection by sport teams provide better opportunities and coaches. In this regard, children who were born early in the year, before June, are over represented in elite or national teams (Cobley *et al*., 2009).

Moreover, most data available on RAE are focused in the sport context and in some cases are inconclusive (Cobley *et al*., 2009). In fact, studies in general population samples are scarce (Roberts *et al*., 2012; Sandercock *et al*., 2013). Roberts and colleagues examined the relationship between RAE and cardiorespiratory fitness using a large cross-sectional cohort of children aged 9-12 years from a general population in England (Roberts *et al*., 2012). They found RAE ($p<0.01$) among all age group categories analysed, even when physical maturity was controlled.

Recently, Wattie *et al*. (2014) analysed RAE regarding performance using some coordination and fitness tests. They found only significant differences for height, weight and 20m-sprint time (only for boys) and these differences were very low statistically. Given that few studies analysing RAE in a general population and, to our knowledge, only the Wattie *et al*. (2014) study using a battery of different fitness tests, more studies are needed in order to analyse RAE using a large sample of a general population. The assessment of physical fitness in a general population could have implications for public health as epidemiological study. Additionally, analysing RAE in other socio-cultural contexts will provide valuable information, for example, how sports infrastructures are perpetuating RAE in South America or Asia compared to North America or Europe? (Cobley *et al*., 2009).

PURPOSE OF STUDY

The purpose of this study was to assess the existence of RAE on a large and nationally representative Chilean population of 14 and 15 years of age using a battery of fitness tests. To date, most studies that aim to analyse RAE on fitness performance have been undertaken using sports or selective populations, while only a few studies have analysed this in a general population. Additionally, most of these studies have analysed this phenomenon using only one or two fitness tests, mostly cardio-respiratory tests. To our knowledge, this is the first study analysing the existence and scope of RAE on school children using a complete battery of fitness tests in a large and nationally representative population aged 14 and 15 years. For the analysis, the sample was split according to a gender and age cohort of participants.

METHODOLOGY

For the purpose of this study, five fitness tests (The Course Navette 20m-Shuttle-Run Test, Standing Broad Jump, Short Crunches, Push-ups in 30 seconds and Modified Wells-Dillon) were performed by the participants. Anthropometric characteristics (height, weight and waist circumference) and Socio Economic Status (SES) were used as covariates. These fitness variables, that are usually used by teachers in physical education evaluation, are major measurements in talent identification programmes (Sandercock *et al*., 2013) and recently have been used for health assessment in adulthood (Ortega *et al*., 2008) and childhood (Garber *et al*., 2014; Olivares & Garcia-Rubio, 2016). The independent variable was the birth quarter. Relative age Group 1 (Q1) included children who were born between 1 January to 31 March; Group 2 (Q2) from 1 April to 30 June 3; Group 3 (Q3) from 1 July to 30 September; and Group 4 (Q4) from 1 October to 31 December. The assessment was carried out at the end of the school year, during November 2011.

Subjects

This study used a nationally representative sample from a cross-sectional study done with 8th Grade students who participated in the Chilean System for the Assessment of Educational Quality test (SIMCE) for physical education in 2011 (n=19929). Only students aged 14 and 15 years were included in this study (*n*=12817; girls 47%, mean age=14.33; boys 53%, mean age=14.41). SES were distributed as follows:

- Girls: G1 (11.2%); G2 (32.3%); G3 (33.0%); G4 (14.3%); and G5 (8.8%).
- Boys: G1 (12.2%); G2 (30.6%); G3 (32.6%); G4 (13.0%); and G5 (11.2%).

(The data are available upon request at the following website: http://www.agenciaeducacion.cl/investigadores/bases-de-datosnacionales/).

Battery of tests and procedures

SIMCE certified the validity of the field tests and the collected data (Ministry of Education, 2014). The SIMCE for physical education was carried out in September and this evaluation was approved under the Chilean Law of Sports number 19.712. Written informed consent was required from every school prior to testing by MINEDUC (Ministry of Education) and each school was instructed to inform parents and students with a standardised script about the nature and importance of the tests, the date and time of the assessment, and how to prepare for the tests. Additionally, an ethics committee approved the assessment. The authors of the manuscript complied with the requirements of the Ministry of Education to use the data ethically.

A battery of standardised fitness tests was used in the evaluation of SIMCE for physical education in order to assess basic anthropometric indexes, cardiorespiratory fitness and musculoskeletal fitness (Ministry of Education, 2013; Garber *et al*., 2014; Olivares & García-Rubio, 2016). Anthropometric measures of height (to the nearest 0.1m), weight (to the nearest 0.1kg) and waist circumference (calculated as a horizontal line between iliac crest and last rib) were assessed and were measured according to standardised procedures (Ministry of Education, 2013). The following specific physical tests were used.

Course Navette 20m-Shuttle-Run Test (Leger & Lambert, 1982)

This test is used to evaluate the aerobic capacity based on an indirect-incremental-maximum field test involving a 20m-shuttle-run. The initial speed is 8.5km/h^{-1} and is increased by 0.5 km/h^{-1} each minute, each minute called a stage. Using this test it is possible to estimate the maximal oxygen uptake (VO^2_{max}) using the age and the final speed. In this study, the result of the final stage for each participant was used.

Standing Broad Jump.

This test evaluates the explosive-strength of the lower limbs. It consists of jumping the furthest distance possible (in cm) from a standing start with feet together. The distance between toes at take-off and heels at landing, or whichever body part landed nearest to take-off, was recorded to the nearest 0.1cm. Students had two trials and the better score was recorded.

Short Crunches

This test evaluates the strength of the abdominal muscles. Participants have to perform short crunches in a constant rhythm of 50bpm as indicated by a metronome. The test finishes when the participant cannot complete the action at this rhythm. The result of this test is the last crunch done following the rhythm.

Push-ups in 30 seconds

The push-ups evaluates the strength of upper limb. The procedure was different for the boys and girls. Boys have to lay on their stomach with both legs together. The hands were pointing forward and positioned under the shoulders. They performed push-ups using their toes as a pivotal point. For girls, the knees were bent and served as the pivotal point. All participants performed as many push-ups as possible within 30 seconds.

Sit-and-reach test

This test evaluates the flexibility of the hamstring and lower back. With the subject is seated on the floor and using a standardised support, the participant reaches forward along the measuring line as far as possible. The maximum distance in centimetre to be held for two seconds, is measured.

***Socio Economic Status** (SES)*

This variable was initially calculated to establish a fair comparison between schools in the SIMCE report. Socio-economic groups were formed according to previous cluster analysis (SIMCE, 2010). Variables used in the analysis were educational level of the mother, educational level of the father, economic income (self-reported) and vulnerability index (achieved through National Board of Scholar Help and Grants (Spanish: Junta Nacional de Ayuda Escolar y Becas “JUNAEB”). Five clusters were obtained: (1) Low; (2) Med-low; (3) Middle; (4) Mid-high; and (5) High (SIMCE, 2010). In this study this variable was used as a co-variable.

Statistical analysis

Data was cleaned following the procedure stated by Hoaglin and Iglewicz (1987) in order to eliminate all outliers. Moreover, there were unusual test values in the database. Secondly, participants were assigned to one of four groups based on date of birth (1st, 2nd, 3rd and 4th quarters of the year). Descriptive statistics with means and standard deviations were computed according to age, gender and relative age group. Normality and equality of variance were explored and the analysis was conducted according to the nature of the data.

Analysis of covariance (ANCOVA) was conducted for both genders and year separately. The analysis was carried out while controlling for the anthropometric variables (height, weight and waist circumference) and socio-economic status of the children. Bonferroni post-hoc test was applied for comparisons. Effect sizes were calculated using Cohen´s d for the F-test (effect sizes of 0.20 are small, 0.50 are medium and 0.80 are considered large) (Thalheimer & Cook, 2002). Statistical analyses were performed using SPSS v.21 software (Inc, Chicago, IL, USA). Statistical significance was set at $p<0.05$.

Table 1. **BOYS: ANCOVA OF FITNESS TESTS DIFFERENTIATED BY BIRTH QUARTILES AND CONTROLLED FOR WEIGHT, HEIGHT AND WAIST CIRCUMFERENCE**

Tests	**Q1** (n=475) M±SD	**Q2** (n=964) M±SD	**Q3**(n=2174) M±SD	**Q4** (n=2025) M±SD	F	p	Effect size	Power
	14-year-olds							
20m-shuttle-run (s)	7.0±2.6	6.6±2.7[a]	6.6±2.6[a]	6.3±2.7[a.c]	11.310	0.000	0.17	0.99
Standing Broad Jump	175.9±29.5	173±27	171.7±27.6[a]	167.8±27.9[a.b.c]	9.311	0.000	0.16	0.99
Sit-and-reach (cm)	28.8±8.4	28.2±8.1	28.6±8.0	27.7±8.1[c]	3.256	0.021	0.09	0.75
Crunches (reps.)	22.2±5.4	22.9±4.7	23.0±4.6[a]	22.8±4.9[a]	4.030	0.007	0.10	0.84
Push-ups (reps.)	13±9	11.9±8.2	12.3±8.7	11.9±8.8[a]	3.409	0.017	0.09	0.77
	15-year-olds							
Tests	**Q1** (n=162) M±SD	**Q2** (n=234) M±SD	**Q3** (n=362) M±SD	**Q4** (n=383) M±SD	F	p	Effect size	Power
20m-shuttle-run (s)	7.0±2.8	7.5±2.5	7.0±2.8	6.7±2.9[b]	2.832	0.037	0.16	0.68
Standing Broad Jump	180.8±28.2	182.4±26.1	176.4±28.3	176.6±27.8	3.170	0.024	0.17	0.74
Sit-and-reach (cm)	29.9±8.7	29.4±8.3	28.5±8.3	28.5±8.7	1.452	0.226	0.11	0.39
Crunches (reps.)	21.9±5.7	23.1±4.6	22.2±5.6	22.8±4.5	1.997	0.113	0.13	0.52
Push-ups (reps.)	15.3±9.1	14.5±8.7	13.7±9.2	13.5±9.1	2.569	0.053	0.15	0.63

a=post-hoc $p<0.05$ vs. Q1 b=post-hoc $p<0.05$ vs. Q2 c=post-hoc $p<0.05$ vs. Q3 Standing Broad Jump in cm

Table 2. **GIRLS: ANCOVA OF FITNESS TESTS DIFFERENTIATED BY BIRTH QUARTILES AND CONTROLLED FOR WEIGHT, HEIGHT AND WAIST CIRCUMFERENCE**

Tests	**Q1** (n=321) M±SD	**Q2** (n=756) M±SD	**Q3** (n=2114) M±SD	**Q4** (n=2126) M±SD	F	p	Effect size	Power
	14-year-olds							
20m-shuttle-run (s)	3.4±2.3	3.5±2.3	3.5±2.2	3.5±2.2	0.285	0.594	0.03	0.08
Standing Broad Jump	131.4±24.7	132±23.6	133.9±22.3	131.8±21.8[c]	3.576	0.013	0.11	0.79
Sit-and-reach (cm)	32.5±7.8	32.9±8.2	33.6±7.7	33.2±7.8	3.091	0.026	0.11	0.72
Crunches (reps.)	18.6±7.7	19.4±7.2	20.4±6.9[a.b]	20.3±6.8[a.b]	8.983	0.000	0.18	0.99
Push-ups (reps.)	10.7±7.4	11.1±7.6	12.4±7.6[a.b]	12.2±7.7[a.b]	9.063	0.000	0.18	0.99
	15-year-olds							
Tests	**Q1** (n=91) M±SD	**Q2** (n=120) M±SD	**Q3** (n=222) M±SD	**Q4** (n=269) M±SD	F	p	Effect size	Power
20m-shuttle-run (s)	2.8±1.9	3.3±2.2	3.3±2.3	3.3±2.2	1.058	0.366	0.12	0.29
Standing Broad Jump	125.6±23.3	127.3±21.5	129.1±22.2	129.2±22.5	0.201	0.896	0.17	0.09
Sit-and-reach (cm)	32.1±6.9	32.4±8.8	32.2±7.7	32.2±8.3	0.085	0.968	0.03	0.06
Crunches (reps.)	20±7.7	19.1±7.6	18.7±7.7	18.9±7.8	1.375	0.249	0.14	0.37
Push-ups (reps.)	12.2±7.7	12.1±7.6	11.4±7.1	10.9±7.4	1.804	0.145	0.16	0.47

a=post-hoc $p<0.05$ vs. Q1 b=post-hoc $p<0.05$ vs. Q2 c=post-hoc $p<0.05$ vs. Q3 Standing Broad Jump in cm

RESULTS

Table 1 shows descriptive statistics and ANCOVA for *BOYS* aged 14 and 15 according to birth quartile. Statistically significant RAEs were found ($p<0.05$) in all tests conducted for the 14-year-old cohort, whereas in the 15-year-old range, these differences were only found in the 20m-shuttle-run and standing broad jump. Post-hoc test also revealed different patterns for 14- and 15-year-old participants. For *BOYS* aged 14, there were statistically significant RAEs in Q1vsQ3 comparison for all tests, except sit-and-reach and push-ups.

There were statistically significant differences ($p<0.05$) between Q1 and all the other age groups for 20m.-shuttle-run, and between Q4 and all the other age groups for standing broad jump. For boys aged 15 years, the post-hoc test only showed statistically significant differences in Q2 vs. Q4 comparison. The effect sizes were small for all tests ranging from 0.09 to 0.17.

For *GIRLS* (Table 2), ANCOVA showed statistically significant differences for all tests except 20m-shuttle-run in girls aged 14 years, however, in the group aged 15 years, there were no significant differences in the testing. The Post-hoc test showed differences between Q1 and Q2 vs Q3 and Q4 for crunches and push-ups tests, and standing broad jump also showed differences between Q3 vs Q4 for girls aged 14. For girls, effect sizes also were small for all tests ranging from 0.03 to 0.18.

DISCUSSION

The results are unclear. The existence of RAE in boys aged 14, with the opposite patterns in girls aged 14. This phenomenon tends to disappear in boys aged 15, and not in girls aged 15. These results agree with previous studies, which indicated that RAE decreases as age increases. For example, RAE in females decreases after 12 years of age (Veldhuizen *et al*., 2015). The greatest differences in boys were observed in the 20m-shuttle-run and standing broad jump. However, crunches and push-ups had the greatest differences for girls but in an inverse relationship. Females born Q3 and Q4 performed higher crunches and push-ups scores than those born in Q1 and Q2. Explanations for these differences, in CRF specifically, have been attributed to maturational causes, such as explosive power (Votteler & Höner, 2013; Wattie *et al*., 2014) or body fatness and genetics (Lobelo *et al*., 2009). These possible causes have been recently rejected when Veldhuizen *et al*. (2015) controlled the effects of somatic maturity, gender and body size, and differences still remained. They concluded that RAE is the effect of age (Veldhuizen *et al*., 2014).

In terms of the magnitude of the effects, the extent of all the differences obtained in RAE were low and similar to previous studies (Cobley *et al*., 2009; Wattie *et al*., 2014). This could be due to the heterogeneity of the sample that reduces the RAE. In previous studies that were done using a sample of athletes, the risk of RAE was higher, mainly in very popular sports, such as basketball or soccer (Cobley *et al*., 2009; Baker *et al*., 2010). However, studies like this using large non-selective samples can include a range of subjects selected for sports teams and those that may not participate in any type of leisure activity, thereby increasing the heterogeneity (Wattie *et al*., 2014).

One of the explanations of the relatively small RAE found in this study could be the cut-off date policy to grouping students. In South-America, the school year begins in March due to the austral summer. Usually, age-group cut-offs are from January to December (Raga *et al*., 2013) or from August to July (Carling *et al*., 2009), or September to August (Sandercock *et al*., 2013). Reported research proposed some solutions to RAE, such as Novem systems (Boucher & Halliwell, 1991) or Relative Age Fair (RAF) cycle system (Hurley *et al*., 2001). These systems implement a rotation in the teams and the players to smooth RAE in sport. In Chile, the school bandwidths are 12 months, and goes from 1 April to 31 March. Group age cut-offs of sporting activities, such as team sports, are based on natural years, from 1 January to 31 December. Students of the first quarter of the year are not included in the same school year of their birth year, but they are included in the same year in the sporting context.

Musch and Grondin (2001) have suggested this solution across sports contexts to prevent RAE. That solution is working on Germany (Cobley *et al*., 2009). In fact, some children are relatively older in sporting activities, but relatively younger on school grouping, that reduces the impact of birth date. In our study, some students from the last quartiles score better than those of the earlier quartiles, supporting previous findings. It seems that the intersections between sport and education is an effective solution to smooth RAE.

Despite of these small size effects of RAE, they could have some impact, mainly in the extreme values (Veldhuizen *et al*., 2014). Therefore, it should be considered for the talent selection process in sports, and for the screening of adolescents with health problems related to fitness. At an educational level, specifically in the subject of Physical Education, some studies have concluded that older students achieve better grades, independently of the amount of physical activity, class effort or evolution, among others (Jones *et al*., 2000; Raga *et al*., 2013). Considering that fitness tests have been traditionally used to assess the grades of students in Physical Education, RAE could be responsible for this. Specifically in Chile, schools are assessed by their SIMCE´s scores. Moreover, the evaluation for Physical Education is based on the fitness tests used in this study

CONCLUSION

In summary, although the existence of RAE is unclear in this study due to the differences in grouping policies at school and sport levels, the evaluation of fitness in any context, physical education, health screening process or talent identification, has to be carried out considering the birth date of participants. In addition, RAE affect boys and girls in a different way, suggesting that for girls it is not an issue as important as for boys. The results of this study are easily generalisable due to the sample magnitude and a nationally representative sample.

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