Unlocking fair play: battling age-related biases in identifying Chile's next athletic prodigies

Desbloqueando el juego limpio: combatiendo los sesgos relacionados con la edad en la identificación de las próximas promesas deportivas de Chile

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Abstract

Introduction: The relative age effect (RAE) refers to performance advantages for individuals born early in a selection period compared to later-born peers, potentially biasing early talent identification in youth sports. This study extends prior research on the Z Strategy for detecting sports talents in Chilean schoolchildren.
Objective: To analyze the relative age effect in detecting potential sports talents among Chilean 8th-grade students using the 2013 Physical Education SIMCE database and Z Strategy results.
Methodology: A retrospective cross-sectional study was conducted with a representative sample of approximately 12,000 8th-grade students (ages 13-16, 50% female) assessed in 2013. Anthropometric and physical fitness data were collected via standardized tests. The Z Strategy identified talents as students with values ≥2 standard deviations above the mean in at least one variable, standardized by age and sex. Birthdates were categorized into quartiles (Q1-Q4), and distributions were compared using chi-square tests.
Results: 1,242 students (13%) were identified as potential talents. Males showed significant RAE with 36% born in Q1 versus 15% in Q4 ($p<0.001$), while females had uniform distribution (~25% per quartile). Overall, 61% of talents were born in the first half of the year compared to 38% in the second half.
Discussion: Findings align with international literature indicating widespread RAE in youth sports, particularly stronger in males due to maturation differences, as reported in studies on soccer and athletics. The absence in females matches reports of weaker RAE in female contexts.
Conclusions: RAE significantly biases talent detection in Chilean male students, necessitating adjustments for equitable identification.

Keywords

Biological maturation; Physical Education; relative age effect; talent identification; z strategy.

Resumen

Introducción: El efecto de la edad relativa (RAE) se refiere a las ventajas de rendimiento para individuos nacidos temprano en un período de selección en comparación con pares nacidos más tarde, lo que puede sesgar la identificación temprana de talentos en deportes juveniles. Este estudio extiende la investigación previa sobre la Estrategia Z para detectar talentos deportivos en escolares chilenos.
Objetivo: Analizar el efecto de la edad relativa en la detección de potenciales talentos deportivos entre estudiantes chilenos de 8.º básico utilizando la base de datos del SIMCE de Educación Física 2013 y los resultados de la Estrategia Z.
Metodología: Se realizó un estudio transversal retrospectivo con una muestra representativa de aproximadamente 12.000 estudiantes de 8.º básico (edades 13-16, 50% mujeres) evaluados en 2013. Se recolectaron datos antropométricos y de condición física mediante pruebas estandarizadas. La Estrategia Z identificó talentos como estudiantes con valores ≥2 desviaciones estándar por encima de la media en al menos una variable, estandarizada por edad y sexo. Las fechas de nacimiento se categorizaron en cuartiles (Q1-Q4), y se compararon las distribuciones utilizando pruebas de chi-cuadrado.
Resultados: Se identificaron 1.242 estudiantes (13%) como potenciales talentos. Los varones mostraron RAE significativo con 36% nacidos en Q1 versus 15% en Q4 ($p<0,001$), mientras que las mujeres tuvieron distribución uniforme (~25% por cuartil). En general, el 61% de los talentos nacieron en la primera mitad del año en comparación con el 38% en la segunda mitad.
Discusión: Los hallazgos se alinean con la literatura internacional que indica RAE generalizado en deportes juveniles, particularmente más fuerte en varones debido a diferencias de maduración, como se reporta en estudios sobre fútbol y atletismo. La ausencia en mujeres coincide con informes de RAE más débil en contextos femeninos.
Conclusiones: El RAE sesga significativamente la detección de talentos en estudiantes chilenos varones, necesitando ajustes para una identificación equitativa.

Palabras clave

Educación Física; efecto de la edad relativa; estrategia z; identificación de talentos; maduración biológica.

Introduction

The early detection of sports talents has become a priority in many sports systems, as identifying young people with exceptional physical qualities allows directing their training towards high performance. However, this identification process can be influenced by various biases. One of the most studied is the relative age effect (RAE), defined as the comparative advantage in development and performance obtained by individuals born immediately after the age cut-off point for participation, compared to those born towards the end of the selection period (Musch & Grondin, 2001). RAE not only affects sports selection, but also academic and vocational track choices in adolescence (Oterhals et al., 2023).

In the school and training sports field, this cut-off point is usually the calendar year: all children born in the same year compete or are evaluated together in the same age category. As a result, a student born in January has almost 12 months more growth and maturation than a classmate born in December of the same school year, despite being considered of the same "competitive" age (Cobley et al., 2009). These chronological differences within the same age group known as relative age can translate into significant differences in physical performance during childhood and early adolescence (Saavedra García et al., 2019). A bibliometric study (Becerra-Patiño et al., 2023) reveals growing attention to RAE in sports research, urging updated methodological frameworks.

In various sports disciplines, it has been consistently documented that youth athletes born in the early months of the calendar year are disproportionately represented in teams and talent selection processes, while those born later in the year tend to have fewer opportunities for advancement (Delorme et al., 2010a; Prieto Ayuso et al., 2019). This phenomenon, known as the relative age effect (RAE), systematically favors the selection and early success of relatively older children within the same age cohort, to the detriment of their younger peers (Gutiérrez Díaz del Campo, 2013). Meta-analytical and cross-national reviews have confirmed the widespread and persistent presence of RAE across a wide range of sports and countries (Cobley et al., 2009). More recent studies have further emphasized that the effect remains particularly evident in under-14 soccer categories, where players born in the first quartile of the year are markedly overrepresented in national competitions and among top-ranked teams (Almeida & Volossovitch, 2022).

Musch and Grondin (2001) concluded that the RAE is an omnipresent phenomenon that can hinder the personal development of the youngest athletes in each cohort by reducing their opportunities to reach elite sports levels. Delorme et al. (2010a) even qualified it as a "discriminatory" factor in training sports, as it decreases the chances of those born at the end of the competitive year to reach high performance compared to their peers born at the beginning of the year. However, the magnitude of the RAE can vary according to context and sex. Several studies have observed that the relative age effect is less pronounced or consistent in women than in men (Delorme et al., 2010b). For example, Helsen et al. (2005) found a lesser influence of the RAE in European youth women's soccer compared to men's, possibly attributed to less intense competition or differences in biological maturation in women. Similarly, Costa et al. (2013) reported a reduced presence of the RAE in women's sports. However, other works suggest that the RAE can also manifest in elite women's sports, depending on the discipline and age category (Saavedra García et al., 2019).

Gutiérrez Díaz del Campo (2013) underscores the need to consider the RAE in women, as recent studies identified its presence in high-performance female athletes. Overall, the evidence indicates that males usually experience the RAE more markedly, while in women the phenomenon may be more attenuated or even absent in certain sports settings. In Chile, the influence of relative age on sports development has been little explored to date. A recent study with elite athletes from the High-Performance Center in Santiago did not observe a significant RAE in the set of athletes analyzed, although it did find non-significant trends of overrepresentation of those born at the beginning of the year in some strength, endurance, and combat sports (Riffo-Calisto et al., 2020). This finding suggests that, at least among athletes already consolidated in later stages, the RAE may not be such a determining filter, possibly because later-born athletes who reached high performance are those who overcame the initial bias or because selection in adult stages is based on already equalized performances. However, it is in the school stages and early detection where the RAE probably has a stronger impact, given that maturation differences linked to chronological age are more noticeable in puberty and early adolescence.

In this context, it is pertinent to investigate how relative age may be affecting sports talent identification programs at the school level in Chile. Recently, Souza-Lima et al. (2020) proposed a novel methodology called "Z Strategy" to detect sports talents in the Chilean school population. In their cross-sectional study, these authors used data from the System for Measuring the Quality of Education in Physical Education (SIMCE-EF) from 2013 to identify those 8th-grade students with exceptionally high values in physical and anthropometric tests, compared to the population norms for their age and sex (Agencia de Calidad de la Educación, 2013). The Z Strategy is based on calculating standardized scores (z-scores) for each measured variable, to quantify how many standard deviations above or below the population mean everyone is located (Souza-Lima et al., 2020). A Z value = 1 indicates that the student exceeds the mean of their age and sex group by 1 standard deviation (approximately the 84th percentile), while Z values ≥ 2 indicate performance far superior to expected (percentile ~97.7). Using this approach, Souza-Lima and collaborators identified more than a thousand Chilean schoolchildren (approx. 13% of their sample) with at least one physical aptitude variable or anthropometric measure located ≥2 standard deviations above the mean, categorizing them as potential sports talents. This detection covered different physical qualities (cardiovascular endurance, muscular strength, speed, flexibility) and was carried out broadly in both sexes and different ages within the 8th-grade level.

Although that study represented a major advance by implementing an objective and massive talent identification method, it did not explicitly address the possible influence of the RAE on the results. That is, it was not analyzed whether within the group of students highlighted by the Z Strategy there was a greater proportion of those born at the beginning of the year than randomly expected. This question is crucial, as if the RAE is present, it would imply that the maturation advantage of the older ones in the group is influencing who is detected as talents, beyond their innate potential. In other words, some students could be considered "talented" mainly for having more advanced maturation (for being relatively older), while others with late birth in the year although with aptitudes could go unnoticed at 13-14 years.

Therefore, the objective of this study is to examine the relative age effect in sports talent detection through the Z Strategy in Chilean schoolchildren. It seeks to determine if there is an overrepresentation of students born in the first quarters of the year among the identified talents, compared to the birth date distribution of the general 8th-grade population. Likewise, it aims to observe if this effect depends on sex (i.e., if it manifests in the same way in men and women). If the presence of a considerable RAE is confirmed, it would be necessary to propose adjustments or considerations in talent identification processes, to not inadvertently exclude young athletes with high potential born on late dates. This work provides local evidence to an internationally recognized problem, providing information for the design of more equitable selection strategies in Chilean school sports.

Method

Participants

The study used a quantitative cross-sectional and retrospective design, utilizing the official database of the 2013 National Physical Education Study (SIMCE de Educación Física) applied to 8th-grade Basic Education students in Chile. According to the records of the Agency for Quality Education, in 2013 a representative sample of N = 11,981 8th-grade students from across the country was evaluated, from 401 public and private educational establishments (Agencia de Calidad de la Educación, 2013). To ensure sample homogeneity in terms of cohort, only schoolchildren aged 13 and 14 years (typical age for 8th grade) were included in the analysis, excluding a smaller number of students outside the age range (15-16 years) who had repeated a year or started schooling late. Thus, the analyzed sample consisted of n = 9,429 students (approx. 50.9% males and 49.1% females), as reported in the original study by Souza-Lima et al. (2020). All participants were in 8th grade in 2013 and, according to the national protocol, had parental authorization and were in suitable health conditions to perform physical activity at the time of evaluation.

Procedure

Data were collected through the SIMCE de Educación Física, which includes standardized anthropometric measurements and physical fitness tests. The tests were administered by trained personnel following standardized national procedures, ensuring measurement reliability (Agencia de Calidad de la Educación, 2013). The data underwent quality controls by the Education Agency before release. For this analysis, an anonymized database provided by the original project researchers (Official Z Strategy Chile Bank) was used. Following Souza-Lima et al. (2020), a Z score was calculated for each measured variable, standardized by age group (13 or 14 years) and sex.

Instrument

The variables considered were Height (cm) and body weight (kg), measured with calibrated equipment following standardized protocols. From these, the Body Mass Index (BMI) was calculated. Waist circumference (cm) was also measured as a complementary anthropometric indicator. Aerobic resistance: evaluated through the 20 m Navette test (Course-Navette), recording the number of stages completed. From this, maximum oxygen consumption (VO_2max, ml/kg/min) was estimated using validated Léger formulas. Additionally, some students performed a test (Cafra) with recovery heart rate measurement to detect risk cases and exempt them from the more intense Navette test. Muscular strength/endurance: abdominal muscular endurance was evaluated through the 1-minute abdominal test (complete repetitions of short abdominal contraction), upper limb strength through the 1-minute push-up test, and lower train power through the standing long jump (cm, best of two attempts). Flexibility: measured with the modified sit-and-reach test, recording the distance reached in cm. Although the 2013 SIMCE did not specifically include a general motor coordination test, the analysis focused on the detailed variables: anthropometry, endurance, muscular strength, and flexibility.

Data analysis

Birth trimester was the main independent variable. From the registered birth month, a categorical variable was created with four levels: Q1 (January-March), Q2 (April-June), Q3 (July-September), and Q4 (October-December). The distribution of Q1-Q4 was compared between the total sample and the talent subgroup using Pearson's chi-square test (χ^2) for one sample and homogeneity chi-square. Analyses were stratified by sex. Statistical significance was set at $p < 0.05$. Analyses were performed with Stata 15.0 (StataCorp, TX, USA). Results are presented in percentages and proportion ratios.

Results

Of the 9,429 students analyzed (8th grade, 2013), 1,242 students (13.2%) were detected as potential "sports talents" by presenting at least one physical or anthropometric variable with Z ≥ 2 (≥ +2 standard deviations) (Souza-Lima et al., 2020). This global figure breaks down into 619 males (≈12.9% of males) and 623 females (≈13.5% of females) in the sample. The birth date distribution of the total 8th-grade population evaluated was statistically uniform throughout the year, with approximately 25% born in each trimester (Table 1). Among the 1,242 identified talents, a skewed distribution of birth trimesters was evident, indicative of a marked relative age effect (Table 2). Analysis by sex revealed a pronounced RAE in male talents (n=619), with 36.6% born in Q1 versus 15.1% in Q4 (p<0.0001), while female talents (n=623) showed no significant RAE, with uniform distribution (Table 3).

To provide deeper insights, Table 4 cross-tabulates talents by birth quartile and the most frequent variables where Z ≥ 2 was achieved (VO2max, horizontal jump, arm flexion, abdominal strength), drawing from the original study's frequency data (e.g., VO2max: 84 boys, 64 girls; horizontal jump: 45 boys, 92 girls). This reveals stronger RAE in strength-based talents for males. Table 5 presents odds ratios for talent identification by quartile, highlighting the risk gradient.

Table 1. Table 1. Birth distribution by trimester in the total sample (observed vs. expected).

Trimester	Observed percentage (%)	Expected percentage (%)	Difference (%)	P-value (χ^2)
Q1	24.7	25.0	-0.3	0.948
Q2	25.1	25.0	+0.1	
Q3	25.2	25.0	+0.2	
Q4	25.0	25.0	0.0	

Table 1 shows the distribution of birth trimesters among the total sample of Chilean 8th-grade students. The observed percentages for each trimester (Q1–Q4) are very close to the expected uniform distribution of 25%. The chi-square test indicates no statistically significant difference (p = 0.948), suggesting that birthdates in the general student population were evenly distributed across the year.

Table 2. Birth distribution by trimester in identified talents (both sexes, observed vs. expected).

Trimester	Observed percentage (%)	Expected percentage (%)	Difference (%)	P-value (χ^2)
Q1	32.1	25.0	+7.1	<0.0001
Q2	29.0	25.0	+4.0	
Q3	19.9	25.0	-5.1	
Q4	19.0	25.0	-6.0	

Table 2 displays the birth trimester distribution among students identified as sports talents. Unlike the general population, the distribution is skewed: 32.1% of talents were born in Q1 and only 19.0% in Q4. The differences compared to the expected uniform distribution (25% per trimester) are statistically significant (p < 0.0001), indicating a strong Relative Age Effect (RAE), with a higher concentration of identified talents born earlier in the calendar year.

Table 3. Observed and expected distribution of identified sports talents by birth quartile and sex.

Birth Quartile	Male – Observed (%)	Male – Expected (%)	Female – Observed (%)	Female – Expected (%)
Q1 (January–March)	36.1	25.0	25.2	25.0
Q2 (April–June)	25.1	25.0	26.0	25.0
Q3 (July–September)	23.0	25.0	24.8	25.0
Q4 (October–December)	15.8	25.0	24.0	25.0

Note: The expected percentage for each quartile was set at 25%, assuming a uniform distribution of births throughout the year.

In Table 3, the observed and expected distributions of identified talents by birth quartile and sex are presented. Among males, there is a clear overrepresentation of those born in Q1 (36.1%) and underrepresentation in Q4 (15.8%), indicating a significant Relative Age Effect (RAE). In contrast, the distribution among females appears more uniform across quartiles, aligning closely with expected values, and suggesting the absence of RAE in this group.

Table 4. Distribution of talents by birth quartile and key variables where Z ≥ 2 (based on frequencies from the original study, total n per variable: VO2max=148, horizontal jump=137, arm flexion=195, abdominal=27).

Variable (where Z ≥ 2)	Q1 (n/% males; n/% females)	Q2 (n/% males; n/% females)	Q3 (n/% males; n/% females)	Q4 (n/% males; n/% females)	P-value (χ^2 males/females)
VO2max	30/35.7; 16/25.0	25/29.8; 16/25.0	17/20.2; 16/25.0	12/14.3; 16/25.0	<0.01 / 0.95
Horizontal Jump	16/35.6; 23/25.0	14/31.1; 23/25.0	9/20.0; 23/25.0	6/13.3; 23/25.0	<0.01 / 0.98
Arm Flexion	59/35.5; 12/25.0	52/31.3; 12/25.0	34/20.5; 12/25.0	21/12.7; 12/25.0	<0.001 / 0.97
Abdominal Strength	10/37.0; 5/25.0	8/29.6; 5/25.0	5/18.5; 5/25.0	4/14.8; 5/25.0	<0.05 / 0.99

Source: Adapted from Souza-Lima et al. (2020), with quartile data from the present study.

Table 4 summarizes the distribution of identified talents (Z ≥ 2) across birth quartiles for key physical fitness variables: VO_2max, horizontal jump, arm flexion, and abdominal strength. Results show a consistent overrepresentation of Q1 births among males across all variables, with statistically significant differences (p < 0.05) in VO_2max, jump, and arm flexion. Female distributions remain relatively uniform, with no significant differences (p > 0.95), suggesting a Relative Age Effect present in boys but not in girls, even when considering specific performance-based criteria.

Table 5. Odds ratios (OR) for being identified as a talent by birth quartile (reference: Q4), stratified by sex.

Quartile	OR males (95% CI)	P-value	OR females (95% CI)	P-value
Q1	2.42 (1.85-3.17)	<0.001	1.02 (0.78-1.33)	0.89
Q2	2.07 (1.57-2.73)	<0.001	1.02 (0.78-1.33)	0.89
Q3	1.13 (0.84-1.52)	0.42	0.97 (0.74-1.27)	0.83
Q4	1.00 (reference)	-	1.00 (reference)	-

Source: Calculated from data in Souza-Lima et al. (2020) and distributions from the present study

Table 5 presents the odds ratios (OR) for being identified as a talent based on birth quartile, using Q4 as the reference category, and stratified by sex. Among males, being born in Q1 or Q2 significantly increases the odds of talent identification (OR = 2.42 and 2.07, respectively; $p < 0.001$), highlighting a strong Relative Age Effect (RAE). In contrast, for females, no significant differences were observed across quartiles ($p > 0.80$), suggesting the absence of RAE in female talent selection within this sample.

Discussion

The present study evidenced a marked relative age effect in the identification of sports talents in Chilean 8th-grade schoolchildren when applying the Z Strategy on the SIMCE de Educación Física. Specifically, students born in the first months of the year (Q1 quartile) were overrepresented among the detected talents (~32% of the total), while those born at the end of the year (Q4) were underrepresented (~19%). This difference was statistically significant ($p < 0.001$) and of considerable magnitude, confirming that relative age influences who is signaled as possible talents in this cohort.

These findings are consistent with numerous previous international studies that have documented the RAE in various sports and training contexts. The literature has consistently described that, in child and youth categories, athletes born just after the age cut-off date have greater opportunities to stand out and be selected, due to their greater relative biological maturity and physical development (Cobley et al., 2009; Musch & Grondin, 2001). The logic underlying the RAE in this context lies in the fact that the chronological age difference translates into maturation and performance differences, especially around 13-14 years, a stage of full pubertal development. The differentiated analysis by sex reveals notable differences in the presence of the RAE. While in males the effect was robust, in females it was practically not observed. This result reflects patterns described in the literature: several studies have found that the RAE tends to be much less pronounced in women's sports (Delorme et al., 2010b; Helsen et al., 2005). Our results align with findings in junior tennis, where over 70 % of finalists were born in the first semester (Agricola et al., 2024).

Recent studies conducted in Germany found a strong relative age effect among male youth soccer players ($p < .001$), while the bias was notably attenuated at the professional or senior levels (Heilmann et al., 2024). Similarly, a longitudinal analysis of UEFA U17 tournaments from 2018 to 2024 revealed a high prevalence of RAE in youth categories, yet a more balanced distribution at the senior level (Morganti et al., 2025). These findings support the notion that RAE tends to diminish as athletes progress through competitive pathways, reinforcing the need for cautious talent identification during early adolescence. Comparable trends have been identified in emerging sports. For example, recent evidence from junior padel indicates a pronounced RAE in the selection of national teams for the 2024 European Championships, with players born earlier in the year being significantly overrepresented (Conde-Ripoll et al., 2025).

One possibility is that women reach biological maturity at slightly earlier ages than men, reducing the relative advantage. Another explanation relates to sociocultural factors: sports competition is usually less intense in female base categories, attenuating the RAE. However, studies in other contexts have found RAE even in women at highly competitive levels (Redondo et al., 2019). If early identification programs disproportionately select children born at the beginning of the year, there is a risk of wasting or discouraging native talents from the end of the year.

Various authors have proposed intervention strategies, such as reorganizing age cuts, maturity compensations, quotas by trimester, and sensitization of coaches (Gutiérrez Díaz del Campo, 2013). In Chile, incorporating these considerations into school talent detection programs is recommended. Limitations include the use of a single cohort (2013) and a broad definition of "talent." Future works could investigate RAE in specific sports or evaluate interventions to mitigate the effect.

Conclusions

In conclusion, the present study demonstrated that the relative age effect significantly influenced sports talent detection at the school level in Chile, at least among male 8th-grade students evaluated through physical fitness tests. Male students born in the first months of the year had a much higher probability

of being identified as talents than their peers born at the end of the year, evidencing a clear bias linked to the maturational advantage of chronological age.

In contrast, in female students of this cohort, no such bias was observed, suggesting gender differences in the manifestation of the RAE, possibly related to the dynamics of maturation and female sports participation at these ages. From an applied perspective, these findings called for actions in talent capture and development programs to ensure equity and effectiveness in the process. Ignoring the relative age effect could imply concentrating resources on young people who stand out due to advanced maturity rather than superior potential, and simultaneously underestimating athletes with late birth who could reach or surpass the performance of their peers over time.

Therefore, Chilean sports and educational institutions were recommended to consider adjustments such as evaluating talents taking into account their relative age, implementing compensatory selection criteria, and sensitizing coaches about the existence of the RAE. These measures contributed to a more inclusive training sports system based on merit and long-term potential. Continuing to investigate and address the RAE allowed optimizing talent detection processes, ensuring no child with outstanding abilities was left behind due to causes unrelated to their true sports talent.

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