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The Relative Age Effect on Physical Fitness of School Children

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Abstract This study aims to investigate the existence of the relative age effect among school children in Perak, Malaysia. A total of 3143 boys and 2700 girls aged seven years old in Perak, Malaysia were involved in this study. Within each year group, four-quarter birth-month groups were formed. There are quarter 1 (Q1), school children born from January to March; Quarter 2 (Q2), from April to June; Quarter 3 (Q3), from July to September; Quarter 4 (Q4), from October to December. They underwent body weight and standing height measurements with fitness tests that included standing broad jump, sit and reach, hand wall toss, and 20-meter run. A one-way ANOVA test with a Tukey post hoc test was used to determine whether there were any significant differences between the birth quartiles and children's physical fitness. Present findings found anthropometrics, leg power, coordination, and speed are different significantly between birth-quartile groups in boys and girls school children. In summary, there is a relative age effect that contributes to children born early in the year having a physical and physiological advantage. There are naturally different levels of fitness depending on age. This information is useful for researchers, teachers, and education policymakers to consider the month of birth, both in terms of practicality and the impact of physical fitness assessment.

Keywords Physical Fitness, Relative Age Effect, School Children, Boys, Girls

1. Introduction

The difference in age in a given group relative to a cut-off point is referred to as Relative Age, and the potential benefit that this difference can produce is referred to as the Relative Age Effect (RAE) [1]. The first studies on RAE were conducted in the field of education. They showed that schoolchildren who were older at the beginning of the school year performed better academically [2]. In sports, the first studies of relative age effects were not the result of applying existing theories to a new setting. For decades, studies of birth advantage and relative age effects tended to describe these phenomena in different contexts, with little attention paid to understanding and predicting the effects through theory. It was not until 2013 that a theoretical model for understanding the relative age effects was proposed. The first model focused on the role that social factors such as parents, coaches, and athletes play in the development and maintenance of relative age effects [3]. Presently afterward, researchers proposed a constraint-based model that incorporated individual, environmental, and task-related constraints to explain relative age effects [4]. Theoretically, grounded research is essential to advance this field, which is why we explicitly stated in our call for proposals that the research is theory-driven.

RAE may be evaluated by birth trimester quarter 1 (Q1), subjects born from January to March; Quarter 2 (Q2), from April to June; Quarter 3 (Q3), from July to September; Quarter 4 (Q4), and from October to December [8,9]. Numerous studies agreed that school children whose relative age is younger than that of their peers have disadvantages such as poorer academic performance [10], weaker physical condition [11], lower participation in sports activities at school [12], a higher percentage of dropouts from sports involvement [13], and a lower probability of being selected in talent identification processes [9]. In the long run, this effect gives an advantage to those born in the first months of a year, purely since they were born earlier, on the grounds that they were trained longer and performed better [14]. RAE may disadvantage younger children, for whom the majority of the content and assessment process is based on physical performance. The presence of RAE in fitness-related tasks in physical education, athletic performance, basic skill mastery, or physical literacy has been found in children [15,16]. They observed significant RAE for boys and girls in both anthropometric scores and fitness data. Thus, in a general sample of school children, significant RAE was found in anthropometrics and physical fitness, and there were RAE differences between genders.

A large body of literature has demonstrated the relative age effect as a secondary factor that indirectly affects athlete success. The RAE may influence talent identification procedures, which are considered key factors for future success. A player is more likely to be talented if they retain desirable anthropometry rather than skill from an early age. Considering that the influence of RAE tends to decrease with age but does not disappear [5,6], the likelihood of high-ability athletes dropping out in the future is very high. Over time, the less mature athletes drop out of the sport because they are not as successful, motivated, or fulfilled by the experience in their younger years of competition [7]. If the selection process favors the more mature athletes, a significant number of players will be denied access to more advanced games simply because they are less mature, not because they are less skilled.

In Malaysia, a previous study found that more players in the national team age groups (U12, U15, U18) were born in the first three months of the year (January to March) than in the last three months (October to December) [17]. This is the result of the way of the selection process which has been done at an early age. The overrepresentation of early-born players suggests that they were selected for their physical advantages and that the organizers may have overlooked skilled but less physically gifted players. Stronger physical attributes may lead to more mature players being selected for national teams and being used more frequently in matches. With increasing access to resources, older players accumulate more training time, work with better coaches, and develop higher levels of self-competence and self-efficacy compared to their younger counterparts [12]. These advantages lead to faster acquisition of sport competence, which explains the overrepresentation of older athletes in certain professional sports. In addition, individuals born in the early quartiles are more likely to persist in athletics due to their ability to actively dominate physical struggles and key performance measures.

To the best of our knowledge, no study has examined the existence of RAE on the fitness status of school-aged children (7 years), the age at which children enter school in Malaysia. At this stage, their skills and performance were continuously evaluated for selection to the high school sports school. In this sense, this study aims to investigate the presence of the relative age effect on physical fitness among school children in Malaysia to gain a better understanding of the influence of RAE in the studied population. The significance of exploring RAE in schools is that it could reduce judgment or biases against students with lower physical ability so that schools can create equal opportunities for all children.

2. Materials and Methods

In this study, an Ex-post facto study was conducted, that is, the study begins after the fact has occurred without intervention by the researcher. Parents were informed that their children's participation was completely voluntary, and they were required to complete an informed consent form for participation. Before the start of each physical test, all participants received clear instructions as well as a warm-up period consisting of 6-8 minutes of general dynamic stretching exercises performed by trained testers. They also received a five-minute briefing on the equipment and procedures for each test. The testing session began with anthropometric assessments followed by fitness testing to prevent possible changes in body composition [18].

2.1. Sample

A total of 5483 year-one school children in Perak, Malaysia participated in this study. They consist of 3143 boys and 2700 girls. Inclusion criteria for the samples are school children aged seven years old, boys and girls, without any health conditions. Participants who were unable to perform physical activities during data collection due to their current health condition were excluded.

2.2. Variables

In this study, anthropometric measurements included body weight and standing height. When measuring body weight, the tester placed the digital scale on a flat surface and verified that the scale read zero (0) before participants stood on it. Shoes, socks, and accessories such as the watch that belonged to the participants were removed. Participants stood upright in the center of the digital scale and faced forward as the tester read the value. The tester recorded the value to the nearest 0.1 kg when the reading on the scale was stable. When measuring standing height, participants stood behind the stadiometer without shoes or socks, with their back and heel in close contact with the stadiometer. Both feet were locked together and both hands were at the side while the tester moved the reading mark closer to the subject's head. Participants took deep breaths while the tester took the reading. The tester's eye consistently stood on the stadiometer reading line and recorded the height to the nearest 0.1 cm.

Based on the literature review, the measurement of general physical fitness, the standing broad jump test, the sit and reach test, and the 20-meter sprint test was included in the EUROFIT physical fitness test battery [19]. In scientific research, the validity and reliability of these instruments have been relevant for many years and are the first choice when choosing a psychometrically robust test instrument for fitness testing [20].

The standing broad jump (SBJ) test is an indirect measure of muscle strength, and because of its simplicity, it has been used predominantly in the developmental literature to measure explosive leg strength in children [21]. It showed reasonable values for validity and reliability ranging among elementary school children. Participants stood behind a line marked on the ground with feet slightly apart. Participants stood in a half-squat position and jumped as far as possible with a preliminary swing. The reading of jumping distance was taken on any back of the shoe when landing. Two-time trials were allowed and the best jumping distance was recorded.

The sit and reach (SAR) test have reasonable validity and reliability scores as measured in elementary school children [22]. The SAR was developed to measure hamstring and low back flexibility in children. Participants were required to sit on the floor with their knees extended and the soles of their bare feet flat against a standard sit-and-reach box attached to a wall. Participants were instructed to place one hand palms down on top of the other and slowly stretch forward as far as possible on the surface of the box, holding the position of maximum flexion for approximately two seconds. The tester held the subject's knee with minimal pressure so that the subject's knees were not raised while pressing the reading mark.

The hand wall toss (HWT) was conducted to measure upper limb coordination using the Bruininks-Oseretsky Test of Motor Proficiency 2 (BOTMP-2) test instrument. The upper limb coordination subtest showed adequate values for reliability and validity with a test-retest reliability coefficient of 0.59 measured in seven to twelve-year-old children and an intercorrelation coefficient of 0.82 measured in seven to eleven-year-old children [23]. A marker was placed at a distance of one meter from the wall. A rectangular square (30 cm × 30 cm) was formed with tape and taped to the wall as a target compartment. The distance between the target compartment and the floor was one meter. Participants stood behind the marked line and faced the wall during the test. Participants threw the tennis ball against the wall in the target compartment with one dominant hand and caught it with both hands. The tennis ball was then thrown back against the wall up to ten times. The number of successful throws caught was recorded.

2.4. Statistical Test

The one-way analysis of variance (ANOVA) is used to determine whether there are statistically significant differences between the means of four independent (unrelated) birth- quartile groups (Q1, Q2, Q3, and Q4). Next, the follow-up test using Tukey's Honest Significant Difference Test was applied to examine the comparison of the means of the quartile groups on all six parameters of physical fitness.

3. Results and Discussion

Table 1 shows the statistics summary of physical fitness among the studied sample. The table describes the minimum values, maximum values, mean and standard deviation of each variable.

3.1. Result

Table 2 shows the result of ANOVA with Tukey post-hoc analysis for birth quartile category comparison. The results of the one-way ANOVA depend on the birth quartile classification. There were differences between the birth quartiles from Q1 to Q4 in the variables of body weight, standing height, standing broad jump, hand wall toss, and speed for both boys and girls. There were no differences in sit and reach between the groups. In other words, there were differences in anthropometry, leg power, coordination, and speed in the studied population. Fig. 1 and Fig. 2 show graphically the boxplot of variables for boys and girls, respectively.

Table 1. Descriptive statistic of variables for boys and girls

	Boys (N=3143)						Girls (N=2700)					
Variable	BW (kg)	SH (cm)	SBJ (cm)	SAT (cm)	HWT (no.)	20MR (s)	BW (kg)	SH (cm)	SBJ (cm)	SAT (cm)	HWT (no.)	20MR (s)
Mean	21.8	119.1	104.3	26.4	6	4.86	21.4	119.1	92.1	26.5	4	5.17
Std. Dev.	3.6	5.3	17.6	4.7	3	0.52	3.5	5.3	15.1	4.5	3	0.53
Minimum	12.0	104.5	54.0	15.0	1	3.53	12.0	104.7	53.0	15.0	1	3.54
Maximum	31.5	133.5	149.0	39.0	10	6.40	31.5	134.0	146.0	39.0	10	6.40

Note: BW (Body Weight); SH (Standing height); SBJ (Standing Broad Jump); SAR (Sit and Reach); HWT (Hand Wall Toss); 20MR (20-meter run)

Table 2. Tukey post hoc test analysis

Gender	Variables	DF	Sum of squares	Mean squares	F	Pr > F	Difference
Boys	Body Weight	3	671.722	223.907	17.686	**<0.0001**	Q1,Q2>Q3,Q4
	Standing Height	3	5151.506	1717.169	64.610	**<0.0001**	Q1>Q2>Q3>Q4
	Standing Broad Jump	3	10386.971	3462.324	11.263	**<0.0001**	Q1,Q2,Q3>Q4
	Sit and Reach	3	45.545	15.182	0.674	0.568	n.s.
	Hand Wall Toss	3	747.090	249.030	34.254	**<0.0001**	Q1,Q2>Q3>Q4
	20-Meter Run	3	9.089	3.030	11.502	**<0.0001**	Q1,Q2,Q3<Q4
Girls	Body Weight	3	776.961	258.987	21.062	**<0.0001**	Q1>Q2,Q3,Q4
	Standing Height	3	3574.145	1191.382	44.834	**<0.0001**	Q1>Q2>Q3,Q4
	Standing Broad Jump	3	3870.874	1290.291	5.677	**0.001**	Q1,Q2>Q3,Q4
	Sit and Reach	3	33.849	11.283	0.551	0.648	n.s.
	Hand Wall Toss	3	297.666	99.222	14.895	**<0.0001**	Q1>Q2>Q3,Q4
	20-Meter Run	3	7.119	2.373	8.405	**<0.0001**	Q1,Q2<Q3,Q4

Note. n.s., not significant

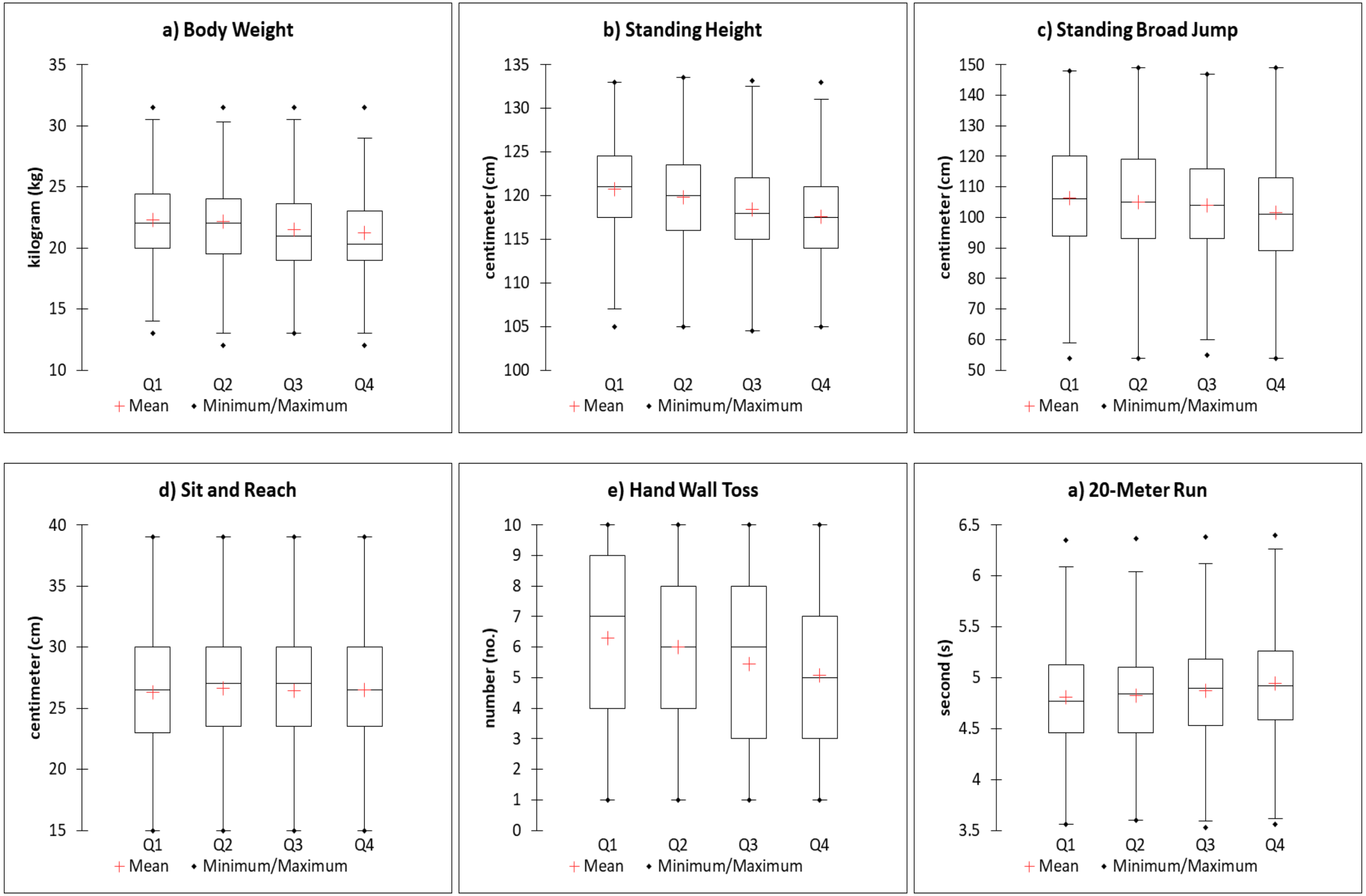

Figure 1. Boxplot of variables for boys

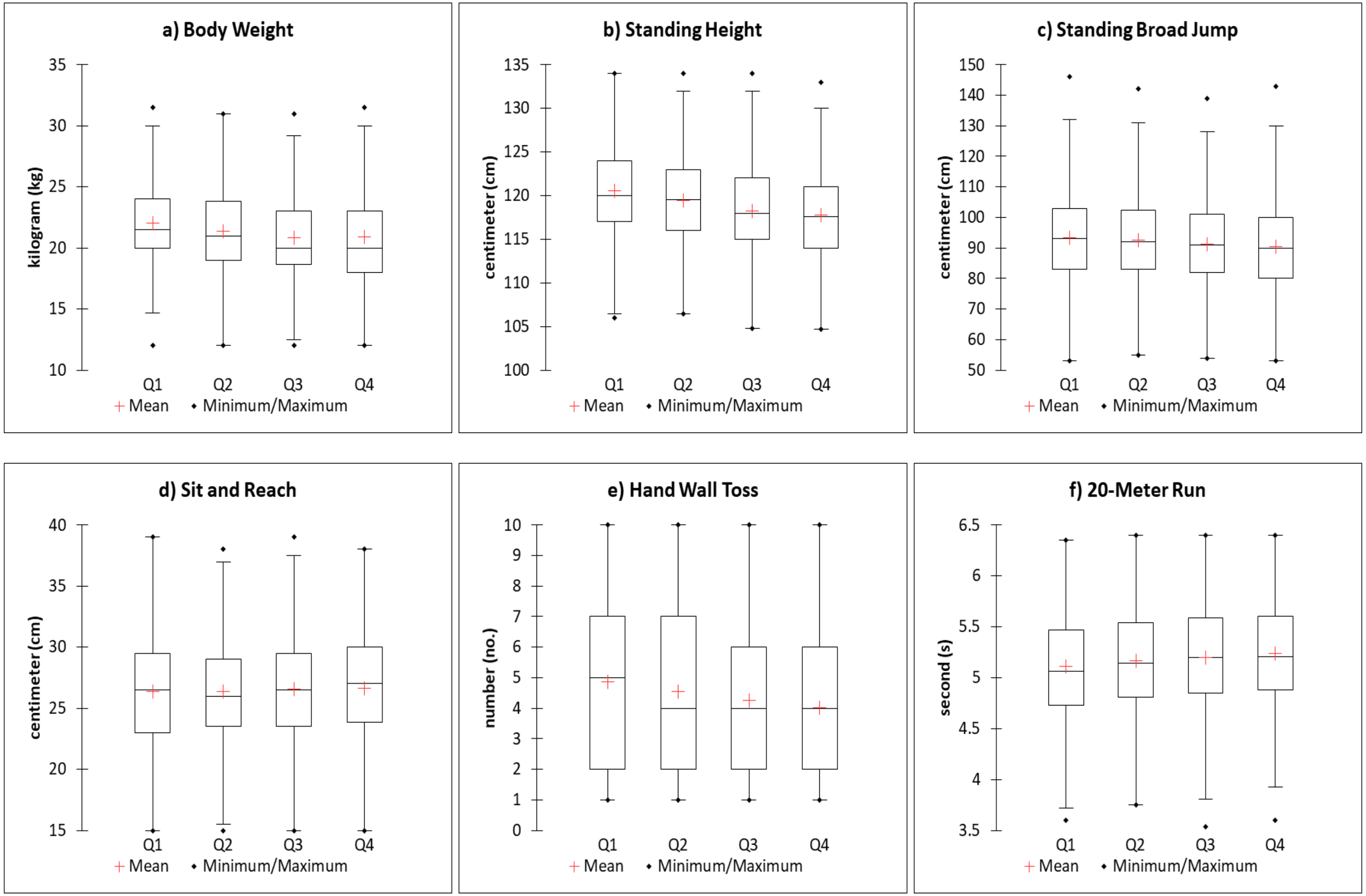

Figure 2. Boxplot of variables for girls

3.2. Discussion

To reiterate, the purpose of this study was to investigate the existence of RAE on the physical fitness of school children in Perak, Malaysia. We hypothesized that the physical fitness of school children born in the first quarter of the year would be higher than those born in the last quarter of the same year. The present result clearly shows the presence of RAE in boys and girls when the studied population was divided into four birth quartile groups. This was in line with previous studies [24] where it was observed that RAE increases with age (7-18 years). Seven-year-old samples may be a crucial stage for selecting the best participants who will succeed as athletes in the future. Therefore, if RAE is ignored at this stage, there is a possibility that talent will be lost. The effect of a cut-off point in boys and girls showed that at least one significant parameter was able to discriminate for each grouping. Since the exact time at which an RAE begins to take effect is still controversial [25,26], this result suggests that the RAE effect occurs mainly in early childhood. RAE may contribute to physical advantages, due to an advanced physical maturity [27,28]. This may also have implications for measured technical ability. First, more mature players are likely to be older and therefore have more game experience and time to develop skills. Second, they may be faster, stronger, and more powerful, which may affect the results of technical drills involving these components. As a consequence, the chronological age system forced the younger participants to compete with older participants from year to year.

Among the studied population, the difference characteristic between participants born in Q1 and Q4 was around ~1.75 kg for body weight, ~3.9 cm for standing height, ~6.6 cm for SBJ, ~0.3 cm for SAR, 1 for HWT, and ~0.18 s for 20MS. Participants in the first age quartile had better scores on all measured fitness tests. Therefore, researchers attributed the RAE solely to the physical advantages of the comparatively older subjects [29]. Analyses focusing on physical maturity seem particularly likely given that a year or two differences in age can indeed make a significant difference in the growth, development, and weight of children in youth sports programs [30]. Although people develop the same pattern of growth and maturation based on age, there are still differences between individuals that need to be considered when assessing or evaluating physical fitness performance, especially in children and adolescents [31]. The study investigates the appropriateness of age grouping of sports competitions, especially among children and adolescents. The finding of significant differences in skeletal age or maturation difference among any birth month group is noteworthy compared to the above asymmetry. Undoubtedly, the size and body mass of the participants born in Q4 were different from those of the other birth quarter groups.

Different trends were reported where there was no clear trend in experience, body size (height and body mass), fitness (sprinting, jumping, and endurance), or ability between players born early in the year and classified as older and younger players born late in the year [32]. Although, the size advantage of some participants in Q4 is not always beneficial to their future because their physical advantage could be a result of their biological maturation. Therefore, practitioners should understand that participants born later in the selection year do not always mature late. Practitioners might consider biological and physical maturation as important components in the selection process, as suggested by the above results and previous study [33].

In this study, the school children indeed tended to mature earlier and had better anthropometric scores and fitness performance than youngers. This trend could affect selection bias in biological maturation, which results in late maturing participants not being selected [34]. Therefore, maturation characteristics affecting RAE should not be ignored. A previous report also examined the growth spurt and found that height increases rapidly in boys after 12 years of age [35]. Since the increase in height is related to skeletal age [36], their findings may indicate a biological maturation spurt in this age range. This simplified Q1 and Q2 participants over-represent Q3 and Q4 participants due to the difference in birth month quarter, rather than their actual abilities.

Those involved in the fitness evaluation of children need to be aware of the contributions of growth and maturation. Greater size, speed, strength, and power can give boys or girls who are older or more mature a competitive advantage. Therefore, it is not surprising that players in elite youth sports programs tend to be older and more physically mature than their peers. Teachers, coaches, or practitioners who do not pay attention to age or maturity contributions are likely to drop out of talent. The physical advantages that age and advanced maturity bring in youth are largely temporary and are reduced or reversed in young adulthood. There is a danger that children who are equally talented but less physically mature at a younger age will be dismissed because of their physical characteristics rather than their potential as adults. On the other hand, players identified as the most talented in youth may not meet adult expectations as their late-maturing peers who continue in the sport catch up in terms of size, strength, and power.

4. Conclusions

In conclusion, there exists a relative age effect that contributes to children born early in the year having a physical and physiological advantage. There are differences in physical, leg power, coordination, and speed between birth-quartile groups. The author emphasizes the importance of exploring RAE in schools, as it could reduce discrimination against students with lower motor skills, allowing the school to create equal opportunities for all children. The authors recommend an alternative platform for the selection process from the bottom up by grouping children by birth quartiles on a quarterly basis. At this stage, younger, late-born children who perform better in birth quartile groups may receive the same opportunities, training, and experience as children who were born early. In the long run, the country will invest in truly talented individuals, and the objective of identifying sports talent among primary school students is well implemented. It is also worth suggesting for the future studies to be conducted on investigating on the athletes pathway towards expertise [37] to gain better knowledge and guidelines to be implemented in the country.

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