ORIGINAL ARTICLE

Modification of the relative age effect on 4-6-year-old schoolchildren's motor competence after an intervention with balance bike

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ABSTRACT

The aims of this study were to explore: 1) the relative age effect (RAE) on aiming and catching (A&C), balance (Bal) and manual dexterity (MD) skills in 4-6-year-old schoolchildren; 2) the effect of the balance bikes program intervention; 3) the effect of this program based on gender. The Movement Assessment Battery for Children-2 (MABC-2) was administered to 50 schoolchildren [26 boys (52%) and 24 girls (48%)], aged between 4 and 5 years (M = 4.46 ; SD = 0.503), from an educational centre in Galicia (Spain), at the beginning and at the end of the intervention program. The results showed that there were statistically significant differences before the application of the intervention program with respect to the quarter of birth in MD (p = .013); A&C (p = .02) and TTS (p < .001) but not in Bal (p = .137). After the intervention, it is observed that the previous differences disappear [MD (p = .755); A&C (p = .806); TTS (p = .507)], in addition, all scores are better than before the application of the intervention program. Regarding gender, no statistically significant effect is observed either before or after applying the intervention program on the variables studied. The results obtained suggest that the application of an intervention using balance bikes could positively influence the improvement of MC in preschool children (boys and girls) and reduce the differences produced by the RAE.
Keywords: Physical education, Quarter of birth, Early childhood, Movement competence, Physical activity programs, Learning to cycle.

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INTRODUCTION

Early childhood is a critical stage in children's motor and cognitive development (Calsamiglia & Loviglio, 2020). In this phase, fundamental motor skills, such as aiming and catching, maintaining balance and developing manual dexterity, are essential for healthy growth and active participation in various physical and sports activities (Leow et al., 2019). Motor competence (MC) in preschool age is an important predictor of motor development during childhood (Clark & Metcalfe, 2002; Stodden et al., 2008). Proof of this is the inclusion of motor coordination as an important content to be developed in educational curricula (López Gallego et al., 2016).

However, relative age, determined by the date of birth in relation to the beginning of the school year (González Aramendi, 2007), can introduce inequalities in the development of these skills, potentially affecting school dropout (Schorer et al., 2011) and future participation in physical activities (Cobley et al., 2008).

Relative age, a phenomenon that describes differences in performance and development between individuals of the same age group due to date of birth, has been the subject of increasing attention in academics and sports (Aune et al., 2018; Roberts & Fairclough, 2012). In the context of physical education in schoolchildren aged 4 to 6 years, the impact of relative age on MC, which encompasses skills such as aiming and catching, balance and manual dexterity, becomes a crucial element to understand and addressed from school (Navarro-Patón, Arufe-Giráldez, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021), since these age groupings imply that in the same class there may be students with up to 12 months of chronological age difference (González Aramendi, 2007), and therefore, possible differences in maturation and experience among its members (Cupeiro et al., 2020). This disparity can generate differences in MC, leading to the perception that some children are more skilled or competent than others, even when the only difference is the date of birth (Brazo-Sayavera et al., 2017), since there is a difference of almost 12 months, the CM could be reinforced for older children, and therefore, for pre-schoolers who are chronologically more mature (Furley & Memmert, 2016). Therefore, the relative age effect (RAE) needs to be addressed in the specific context of physical education and sports programs aimed at preschool children (Navarro-Patón, Arufe-Giráldez, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021).

Preschool sports and physical education programs play a vital role in creating an inclusive and equitable environment for motor development (Gerlach et al., 2018; Herrmann et al., 2015). These programs offer structured opportunities for children to acquire fundamental motor skills, promoting a learning approach based on fun and active participation (Carrillo-López et al., 2018).

Previous studies revealed that children born at the beginning of the school year may have advantages in the development of motor skills compared to their peers born later in the year (Navarro-Patón, Arufe-Giráldez, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021). However, with the application of structured programs (Arufe Giráldez et al., 2021; Mecías-Calvo et al., 2021; Navarro-Patón, Brito-Ballester, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021), this RAE can be reduced. Therefore, it is crucial to evaluate how these programs can mitigate the effects of relative age and ensure that all children have equal opportunities to develop their motor skills.

For all these reasons, the main aim of this research was to systematically explore the RAE on motor competence, specifically in skills such as aiming and catching, balance and manual dexterity, in 4-6-year-old schoolchildren and examine the role of physical education and sports programs in reducing these disparities

through an intervention program using balance bikes. As a secondary aim, we seek to explore and analyse the effect of these programs based on the gender of the participants.

MATERIAL AND METHOD

Design and Participants

In this quasi-experimental study without a control group (Ato et al., 2013), a total of 59 pre-schoolers between 4-5 years old were invited to participate, selected in a non-probabilistic way according to the subjects to whom they had access, from a public educational centre in La Coruña (Galicia, Spain).

Of these 59 participants, 9 were excluded (6 dues to incomplete data), 3 for not being present and participating in the complete development of the research (i.e., initial and final data collection and participation in all sessions of the intervention program). Finally, the sample was made up of 50 pre-schoolers.

Participants were classified according to their quarter of birth [quarter 1 (q1; born January to March); quarter 2 (q2; born from April to June); quarter 3 (q3; born from July to September) and quarter 4 (q4; born from October to December)] and gender group (boys and girls).

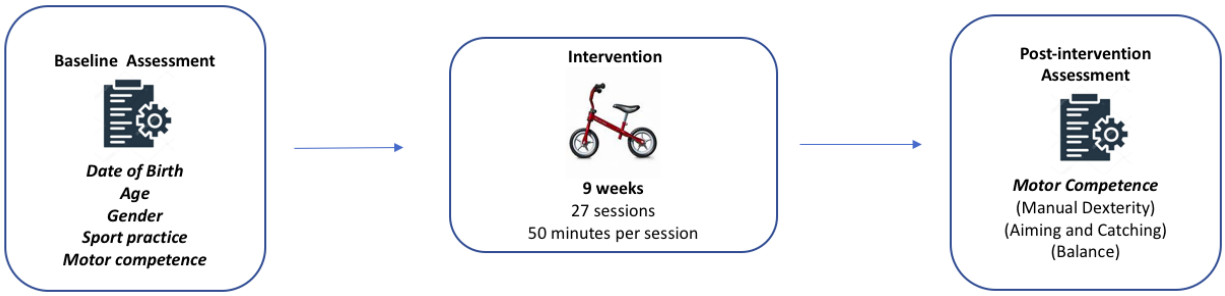

Figure 1. Study design.

The inclusion criteria were: (a) Present signed informed consent from the parents; (b) participate in the entire process (initial assessment, complete intervention program; final assessment); (c) not present an impediment to perform each of the MABC-2 tests.

Instruments

Movement Assessment Battery for Children-2 (MABC-2)

The MABC-2, adapted to the Spanish context (Graupera & Ruiz, 2012), which has been shown to be reliable in identifying changes in motor competence over time in preschool children, was used in this study. The MABC-2 is made up of 8 standardised tests: (1) post coins, (2) threading beads and (3) drawing trail, to calculate manual dexterity (MD); (4) catching bean bag and (5) throwing bean bag onto mat, to calculate aiming and catching skill (A&C); (6) one-leg balance, (7) walking heels raised and (8) jumping on mats, to calculate balance skill (Bal). This tool provides direct and scalar scores for each test, scalar scores for the dimensions with equivalent percentiles, and a total test score (TTS) with its equivalent scalar score and percentile. All direct scores were used for this research.

Intervention program

The duration of the intervention program with balance bikes was 9 weeks (3 sessions/week) and it replaced motor skills classes at school. Each session lasted 50 minutes in which different contents were taught (Table

1). All sessions had the same structure: warm-up or welcome moment (5 min), 6 tasks related to the contents of that session (Table 1; 40 minutes) and a cool-down or farewell moment (5 min). Before the start of each session, the bicycle was adjusted to the anthropometric characteristics of the participants and a helmet was placed and adjusted. All sessions of the program were taught by the main researcher, a graduate in Physical Education, with 15 years of experience as a Physical Education Specialist Teacher in Early Childhood and Primary Education.

Table 1. Contents to work on in the design of the project intervention sessions.

Week	Contents/Sessions
1st	**Information and familiarization** Session 1. Bike mascot, bike parts and basic elements for greater safety Session 2 and 3. Familiarization with the bike. Walking with the bike, getting on and off the bike. Carrying the bike from one side to another (swaying)
2nd	**Control of the exercise bike and first displacements** Session 4, 5 and 6. Get on the bike and move with short steps. Getting on and off the bike
3rd	**Displacements in different directions** Session 7, 8 and 9. Travel by bike from one place to another. Change of direction, turns, dribbling
4th	**Accelerate and brake** Session 10, 11 and 12. Making changes from stopped to started. Acceleration on a straight line. Brake when faced with obstacles
5th	**Displacements with obstacles** Session 13, 14 and 15: Movement avoiding obstacles (cones, cardboard boxes, etc.). Movement through different obstacles, narrow corridors, ramps, descents
6th	**Individual, competitive, cooperative and opposition games** Session 16, 17 and 18: Games of personal improvement, cooperation and opposition
7th	**Games and road education** Session 19, 20 and 21: Games that involve the incorporation of signs and other aspects of road safety education
8th	**Games and road education** Session 22, 23 and 24: Games that involve the incorporation of signs and other aspects of road safety education
9th	**Games and road education** Session 25, 26 and 27: Games that involve the incorporation of signs and other aspects of road safety education

Procedures

The management of the educational institutions and the tutor teachers of the preschool children groups were contacted by the researchers as the first step in explaining the goal of the study. Following clearance from the teachers and administration, the pre-schoolers' parents or legal guardians were notified. This message contained important information such as a confidentiality statement, the ability for parents to voluntarily withdraw their children from the study at any time, and an explanation of the aim, purpose, design, and methods of the study. The necessary sociodemographic data (age and sex) was gathered after the parents' or legal guardians' signed informed consent was accepted. Trained evaluators then used standardised equipment to administer the MABC-2 battery to the pre-schoolers in order to assess them. Wearing casual attire, each pre-schooler underwent an individual assessment in a school room with the evaluators and an administration person in attendance. The students attempted a test where they were rectified by the evaluators before to taking each one. There were no instructions given during the assessment.

After the assessment using the MABC-2 battery, psychomotor experts linked to the educational centre and a team of specialists taught all the program sessions (see intervention program). Once the process was completed, the MABC-2 battery was administered again the day after completing the intervention.

All research was conducted in accordance to Declaration of Helsinki. Research protocol was sent to the Ethics Committee of the national EDUCA platform for review and its approval, being approved with the code number 15/2021.

Statistical analysis

For the statistical treatment of the data, the IBM SPSS Statistics program for Windows, version 25.0, was used. First, descriptive statistics (mean and its standard deviation) were calculated for each dependent variable examined. Secondly, the possible effect of the quarter of birth (Q1; Q2; Q3; Q4) and gender (boy; girl) on the MABC-2 variables (Manual dexterity: MD; Aiming and Catching: A&C; Balance: Bal; and Total test score; TTS) was analysed using a multivariate analysis of variance (MANOVA) and the interaction between both factors using the Bonferroni statistic. Furthermore, the effect size was calculated in terms of eta squared (η^2). The level of significance was set at $p < .05$.

RESULTS

50 preschool children participated in this study [26 boys (52%) and 24 girls (48%)] aged between 4-5 years (M = 4.46; SD = 0.503) who met the inclusion and exclusion criteria. The distribution of the participants was from Q1 [n = 11 (22,0 %)], Q2 [n =12 (24,0%)], Q3 [n = 15 (30,0 %)] and Q4 [n = 12 (24,0 %)], respectively.

Regarding the quarter of birth factor (Table 2), there was a significant main effect in the pre-test on MD ($F_{(3, 42)} = 4.022$, $p = .013$, $\eta^2 = .22$) with lower scores obtained in Q4 compared to Q1 ($p = .030$) and Q2 ($p = .035$). A significant main effect was also found in A&C ($F_{(3, 42)} = 5.730$, $p = .002$, $\eta^2 = .29$), with lower scores in Q4 compared to Q1 ($p = .003$) and Q2 ($p = .015$). Finally, statistically significant differences were found in TTS ($F_{(3, 42)} = 4.022$, $p < .001$, $\eta^2 = .37$), with Q4 scores again lower than those of Q1 ($p < .001$), Q2 ($p = .006$) and Q3 ($p = .034$). The previous differences disappear once the intervention program is applied [MD ($p = .755$); A&C ($p = .806$); TTS ($p = .507$)] in the quarter of birth factor.

Table 2. MABC-2 test total scores based on quarter of birth and gender.

		Q1		**Q2**	
		***Pre* (M;SD)**	***Post* (M;SD)**	***Pre* (M;SD)**	***Post* (M;SD)**
Manual dexterity	*Boys*	26.17;4,75	26.83;2.22	26.57;7.06	25.42;5.65
	Girls	24,06;4.98	25.20;6.09	23.60;5.41	26.40;6.06
	Total	25.45;4.67	26.09;4.25	25.33;6.34	25.83;5.57
Aiming and catching	*Boys*	20.00;5.95	14.16;6.67	17.71;3.49	19.71;6.94
	Girls	22.00;1.00	18.60;5.36	21.60;3.48	17.00;4.52
	Total	20.90;4.39	16.18;6.25	19.33;4.00	18.58;5.97
Balance	*Boys*	32.83;3.55	34.33;2.87	29.71;5.28	34.85;3.62
	Girls	33.60;3.50	31.00;3.80	29.80;2.16	33.60;3.20
	Total	33.18;3.37	32.81;3.60	29.75;4.11	34.33;3.36
Total test Score	*Boys*	79.00;8.00	75.33;8.86	74.00;8.54	80.00;13.34
	Girls	81.00;3.80	77.40;5.59	75.20;10.40	75.00;9.53
	Total	79.90;6.23	76.27;7.28	74.50;8.92	77.91;11.69

		Q3		Q4	
		***Pre* (M;SD)**	***Post* (M;SD)**	***Pre* (M;SD)**	***Post* (M;SD)**
Manual dexterity	*Boys*	23.62;10.18	26.75;8.86	12.80;2.77	17.60;4.15
	Girls	24.42;3.70	24.71;8.07	22.57;4.54	29.71;2.21
	Total	24.00;7.61	25.08;8.26	18.5;6.27	24.66;6.91
Aiming and catching	*Boys*	15.25;5.28	17.00;5.90	14.00;4.18	15.80;6.05
	Girls	18.71;5.18	20.14;6.28	12.28;6.67	19.00;5.91
	Total	16.86;5.35	18.46;6.08	13.00;5.60	17.67;5.92
Balance	*Boys*	28.00;5.50	33.75;1.90	26.00;11.9	27.80;7.01
	Girls	29.28;3.35	32.42;5.12	30.28;4.49	24.85;2.40
	Total	28.60;4.70	33.13;3.68	28.50;8.21	31.91;5.85
Total test Score	*Boys*	66.87;15.69	77.75;11.85	52.80;16.76	61.20;11.00
	Girls	75.28;3.63	77.28;13.18	65.14;9.54	82.14;9,15
	Total	70.80;12.15	75.53;12.03	60.00;13.86	73.41;14.35

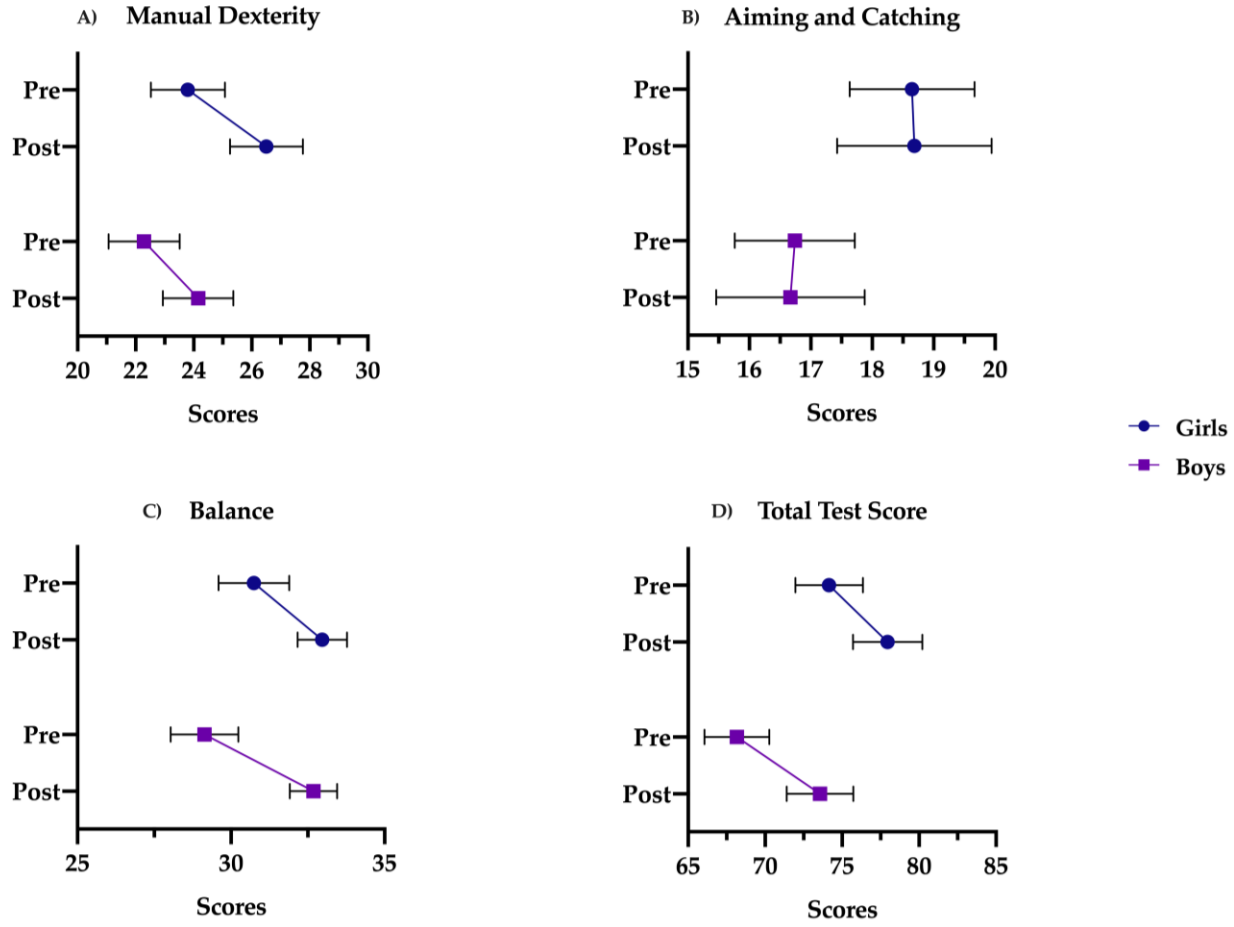

Figure 2. Manual dexterity, aiming and catching, balance and total test scores based on gender.

No statistically significant effect is observed if analysed in terms of the gender factor (Figure 2), both before applying the intervention program [MD (p = .398); A&C (p = .182); Bal (p = .319); TTS (p = .056)], as well as after its application [MD (p = .185); A&C (p = .254); Bal (p = .799); TTS (p = .168)].

Regarding the interaction between the quarter of birth and gender, no significant effect has been found in the interaction of these factors [i.e. (MD (p = .072); A&C (p = .494); Bal (p = .807); TTS (p = .535)]. Once the intervention program was applied, statistically significant differences were found in MD ($F_{(3, 42)}$ = 3.59, p = .021, η^2 = 0.20), Bal ($F_{(3, 42)}$ = 4.11, p = .012, η^2 = 0.23) and TTS ($F_{(3, 42)}$ = 3.26, p = .031, η^2 = 0.19). Regarding MD, there is a statistically significant difference between girls and boys of q4 (p = .009). The scores achieved in girls are higher. In the Bal analysis, statistically significant differences were found, with lower scores for the girls in q4 than for those in q1 (p = .049) and q2 (p = .021). Something similar occurs when comparing girls with boys in Q4 (p = .003), where girls obtain higher scores. Regarding TTS, significant differences are evident, with lower scores, both in the boys of q4 compared to the boys of q2 (p = .031) and between girls and boys of q4 (p = .002).

DISCUSSION

The main aim of this research was to explore how relative age impacts MC, specifically in skills such as aiming and catching, balance, and manual dexterity, in schoolchildren aged 4 to 6 years. Additionally, we sought to examine the role of physical and sports education programs in reducing these disparities through an intervention program that uses balance bikes. As a secondary aim, we sought to explore and analyse the effect of these programs based on the gender of the participants. From the results obtained in this study, we can indicate that an intervention using balance bikes improves the MC and consequently, reduces the RAE in pre-schoolers, and can increase the improvements obtained in the tests of manual dexterity, aiming and catching, and balance (Logan et al., 2012; Van Capelle et al., 2017). Therefore, in response to the second main aim, we can say that this type of programs (specific, planned, and appropriate) helps reduce the disparities found before the intervention (Navarro-Patón, Brito-Ballester, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021). Regarding the secondary objective, the results indicate that the participants in this research did not present significant differences before or after the intervention, but a tendency to increase is observed in the assessments obtained in the MABC-2 after the intervention program.

Before the intervention, there was a RAE in the dimensions of MD, A&C, and consequently TTS, since those born in the first quarter of the year obtained higher scores than those born in the second quarter, who in turn obtained higher scores in these three dimensions than those born in the third quarter, but without significant differences. These findings follow the line of previous studies that indicate that older children (in terms of date of birth) have better average scores in terms of MC than younger children (Henderson et al., 2007) because they have better manual dexterity or aiming and catching (Navarro-Patón, Lago-Ballesteros, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021). These scores were especially distant between those born in the last quarter of the year (q4) and those born in q1, q2, and q3, as demonstrated by the statistical significance. Therefore, we can say that RAE exists in these 3 dimensions studied, as previous studies point out (Navarro-Patón, Arufe-Giráldez, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021). These differences may be due to the interaction between physical characteristics, size, and maturation, due to being born earlier (Dalen et al., 2017), the task performed (balance bikes), and the environment (school environment) in which the task is performed (Newell, 1986), which is sometimes confused with greater capacity (Aune et al., 2018).

After the intervention with the balance bikes, the measurement of all the variables studied (i.e. MD; A&C; Bal and TTS) increased with respect to the initial assessment, to the point that the previous differences disappeared, so it can be said that the applied intervention produces improvements in MC (Morgan et al., 2013) and, therefore, reduces the RAE (Navarro-Patón, Brito-Ballester, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021) in MD, A&C and TTS. In this way, we can argue that specific motor interventions developed and implemented for the age of the participants (Logan et al., 2012), have a positive effect on MC

components (Jiménez-Díaz et al., 2019; Jiménez Díaz et al., 2015; Van Capelle et al., 2017; Wick et al., 2017).

Regarding gender, before the intervention there were no significant differences between boys and girls in any of the variables studied, as has been shown in previous studies (Kokštejn et al., 2017; Li et al., 2023; Navarro-Patón, Arufe-Giráldez, et al., 2021; Navarro-Patón, Lago-Ballesteros, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021; Valtr et al., 2016). Scores on all tests are higher for girls than for boys, as demonstrated by other studies (Li et al., 2023; Navarro-Patón, Arufe-Giráldez, et al., 2021; Navarro-Patón, Lago-Ballesteros, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021).

Once the intervention was performed, the scores of the different variables increased compared to the previous ones, in both girls and boys, although this brief intervention only lasted 9 weeks as in other similar studies with similar results (Mecías-Calvo et al., 2021; Navarro-Patón, Arufe-Giráldez, et al., 2021; Navarro-Patón, Brito-Ballester, et al., 2021). Again, the scores achieved by girls continue to be higher than those of boys (Goodway et al., 2014; Morley et al., 2015; Valentini et al., 2014; Venter et al., 2015), except in Bal where they are similar and differ from previous studies (Bolger et al., 2018; Kelly et al., 2019).

If we analyse the post-test differences, according to the interaction of gender and quarter of birth, the differences that did not exist before the intervention now appear in favour of girls born in q4 in DM, A&C and TTS; and in Bal between boys of q1 and q2, over those born in q4. This may be because a structured MC program can benefit preschool children (both girls and boys) in these skills (Jiménez-Díaz et al., 2019), because improvements in MC occur after a specific intervention in Physical Education, regardless of the gender of the participants and the duration of the program.

In general, a structured MC program based on balance bikes can benefit both boys and girls (Morgan et al., 2013) in their improvement. Taking into account that improvements have been obtained after this intervention of three weekly sessions, for 9 weeks, not following the parameters of other interventions performed previously (Jiménez-Díaz et al., 2019; Van Capelle et al., 2017; Wick et al., 2017), these improvements could be explained by the ceiling effect (Morgan et al., 2013), achieving better performance in the early stages of the intervention (Mecías-Calvo et al., 2021; Navarro-Patón, Brito-Ballester, et al., 2021; Navarro-Patón, Mecías-Calvo, et al., 2021), so a longer intervention time does not imply better performance (Jiménez-Díaz et al., 2019).

As limitations of this research, we would like to indicate that the sample size is not excessively high and, therefore, the results obtained should be taken with caution. Furthermore, not having used a control group does not ensure that the results are exclusively due to the intervention program, since other factors such as maturation could have influenced the results. On the other hand, the results are assessed as soon as the intervention ends, and no follow-up is performed to check what happens to them in the medium or long term.

CONCLUSION

The results of this research contribute to understanding that a structured and short-term intervention program (three weekly sessions for 9 weeks) reduces the RAEs existing before the intervention. Therefore, we can point out that brief interventions like ours, based on balance bikes, can produce improvements in pre-schoolers' MC. Therefore, one of the contributions made by this study could be the need to inform about the formulation of educational and sports policies focused on equity, as well as the adaptation of pedagogical practices in preschool environments of this type, or the promotion of active transportation in schools.

Likewise, the findings of this research could have direct implications for the design and implementation of educational programs that seek to maximise the motor potential of all children, regardless of their relative age. Additionally, the results could influence the training of physical educators and child development professionals, providing specific strategies to address observed disparities and promote an inclusive and nurturing environment.

AUTHOR CONTRIBUTIONS

Conceptualization, R.N.P. and M.M.C.; methodology, R.N.P. and M.M.C.; validation, R.N.P., F.C.P., M.M.C and V.A.G.; formal analysis, R.N.P.; investigation, F.C.P. and V.A.G.; data curation, F.C.P.; writing—original draft preparation, R.N.P., M.M.C. and V.A.G.; writing—review and editing, R.N.P., F.C.P., M.M.C and V.A.G.; visualization, R.N.P., F.C.P., M.M.C and V.A.G.; supervision, R.N.P., M.M.C and V.A.G.; project administration, F.C.P. and V.A.G. All authors have read and agreed to the published version of the manuscript.

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DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

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