Journal of Physical Activity and Health, (Ahead of Print)
https://doi.org/10.1123/jpah.2024-0484

Human Kinetics
PUBLIC HEALTH PRACTICE

Improving Motor Competence of Children: The "Super Quinas" Intervention Program in Portuguese Primary Schools

Luis P. Rodrigues,[1,2] Rita Cordovil,[3,4] Júlio A. Costa,[5] André Seabra,[5] José Guilherme,[5,6] Susana Vale,[7] Carlos Luz,[8,9] Fábio Flôres,[10,11,12] Maria João Lagoa,[13,14] Gabriela Almeida,[11,15] Vítor P. Lopes,[16] Cristiana Mercê,[2,17] Pedro Tiago Esteves,[2,18] Sara Santos,[14,19] Vanda Correia,[2,20] João Serrano,[2,21] Rui Mendes,[2,22] Rui Matos,[14,23] Vânia Loureiro,[2,24,25] Carlos Neto,[3] and MCA Research Team

[1]Instituto Politécnico de Viana do Castelo, Superior Desporto e Lazer de Melgaço, MELGAÇO; [2]Sport Physical activity and health Research & INnovation cenTer (SPRINT); [3]Faculdade de Motricidade Humana, Universidade de Lisboa; [4]CIPER, Faculdade de Motricidade Humana, Universidade de Lisboa, Lisboa, Portugal; [5]Portugal Football School, Portuguese Football Federation, FPF, Oeiras, Portugal; [6]Centre of Research, Education, Innovation and Intervention in Sport, Faculty of Sport, University of Porto, Porto, Portugal; [7]Instituto Politécnico do Porto, Escola Superior de Educação do Porto; [8]Escola Superior de Educação de Lisboa, Instituto Politécnico de Lisboa; [9]CIDEI - Center for studies in Education and Innovation; [10]Insight: Piaget Research Center for Ecological Development, Piaget Institute, Portugal; [11]Comprehensive Health Research Centre (CHRC), Universidade de Évora,, Portugal; [12]Centro de Investigação em Educação e Psicologia (CIEP), Universidade de Évora, Portugal; [13]University of Maia, UMAIA, Portugal; [14]Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, Portugal; [15]Departamento de Desporto e Saúde, Escola de Saúde e Desenvolvimento Humano, Universidade de Évora, Portugal; [16]Instituto Politécnico de Bragança, Campus de Santa Apolónia, Bragança, Portugal; [17]Escola Superior de Desporto de Rio Maior, Instituto Politécnico de Santarém, Rio Maior, Portugal; [18]Instituto Politécnico da Guarda; [19]Department of Sports Sciences, Exercise and Health, University of Trás- os-Montes and Alto Douro, Vila Real, Portugal; [20]Escola Superior de Educação e Comunicação, Universidade do Algarve; [21]Escola Superior de Educação de Castelo Branco; [22]Instituto Politécnico de Coimbra; [23]ESECS- Polytechnic of Leiria, Leiria, Portugal; [24]Instituto Politécnico de Beja, Escola Superior de Educação, Portugal; [25]ISAMB, Faculdade de Medicina, Universidade de Lisboa, Portugal

Objectives: The objective of this study was to describe the effects of an extra hour of a structured motor program on the motor competence (MC) of children 6–10 years old.. ***Design:*** The need for movement interventions to enhance MC among school-aged children has gained vital importance in the last years, given the negative secular trends reported. Hence, the Portuguese Football Federation organized an intervention program on MC to be implemented on the extracurricular time of the Portuguese primary schools: the Super Quinas program. ***Methods***: Thirty-nine schools from all of Portugal were assigned to intervention and control condition, with a total of 1034 children (6–10 y old) completing all the program (77.7%). The Super Quinas intervention comprised of 1 hour of activity per week, led by a physical educator teacher during extracurricular activities for 12 wees. MC was assessed using the Motor Competence Assessment (MCA) before and at the end of the program (January and April 2023). Normative results of the MCA were used to compare changes between pre and posttest according to experimental or control condition. ***Results:*** Results showed a general improvement ($P \le .001$) for all subscales (Locomotor, Manipulative, Stability) and total MCA. More importantly, the experimental group showed significant and positive differences, when compared with the control group, in the Stability ($P = .007$), Manipulative ($P = .015$), and total MCA results ($P = .018$) after controlling for gender, age, and baseline effect. ***Conclusions:*** The Super Quinas intervention program proved that adding 1 hour of structured movement program to the regular primary school schedule can lead to greater development of MC in school-age children.

Keywords: physical education, motor development, sports interventions, public health

Key Points

- Implementing an hour of organized motor stimulation daily in primary schools can significantly improve the motor competence of children.
- A standardized national motor program with adaptable, preorganized activities and materials can effectively enhance the motor competence development of Portuguese primary school children.

The names and affiliations of the MCA Research Team are recognized as authorships and listed in the Acknowledgments section.
Rodrigues https://orcid.org/0000-0002-6804-3600
Cordovil https://orcid.org/0000-0002-4907-7186
Seabra https://orcid.org/0000-0002-6788-4555
Vale https://orcid.org/0000-0002-1703-9361
Luz https://orcid.org/0000-0002-9126-5375
Flôres https://orcid.org/0000-0003-3469-3725
João Lagoa https://orcid.org/0000-0001-8843-090X
Almeida https://orcid.org/0000-0002-6716-2114
Lopes https://orcid.org/0000-0003-1599-2180
Mercê https://orcid.org/0000-0001-5146-6597
Esteves https://orcid.org/0000-0002-4675-2959
Santos https://orcid.org/0000-0002-4090-5790
Correia https://orcid.org/0000-0003-2457-8256
Serrano https://orcid.org/0000-0001-5112-4984
Mendes https://orcid.org/0000-0002-2433-5193
Matos https://orcid.org/0000-0002-2034-0585
Loureiro https://orcid.org/0000-0003-2458-3004
Costa jahdc@hotmail.com is corresponding author, https://orcid.org/0000-0002-8225-8667

Motor competence (MC) relates to the development and performance of human movement throughout the life span, with a clear emphasis on childhood. MC is described as the ability to master a wide variety of activities and motor tasks, including proficiency in gross motor skills (stability, locomotor, and manipulative) and its underlying mechanisms, such as motor coordination and control.[1] In the dynamic landscape of childhood development, the acquisition and refinement of MC play a pivotal role in shaping a child's overall well-being and success. The period between 6 and 10 years is a critical time when children engage in a myriad of physical and motor activities, such as organized sports that require enhanced MC.[2,3]

The development and acquisition of MC proved to be associated with physical and psychological health, social-emotional functioning, cognition/achievement, and sports participation.[4–6] Adequate levels of MC are deemed to facilitate learning of new skills and overall proficiency on motor tasks throughout the lifespan,[1,7,8] promoting healthier and more active lifestyles.[9]

Among school-aged children, typically ranging from 6 to 10 years old, the need for targeted interventions to enhance MC has gained paramount importance, especially considering the observed secular trends that show a concerning decline in motor skills among pediatric populations. Numerous studies have illuminated this worrisome trend, highlighting the detrimental impact of modern societal changes on children's physical development.[10–13] Several factors have been linked to diminished MC, namely low levels of physical activity, lack of physical fitness, unhealthy weight status, and an increase in sedentary behaviors, often exacerbated by prolonged screen time and decreased engagement in movement activities.[14–17] This decline in MC not only affects a child's ability to engage in physical activities but also extends its influence on physical literacy, cognitive functions, academic performance, and social interactions.[6,18]

Movement program interventions emerge as a proactive strategy to counteract this secular decline in MC,[19] particularly in school settings where all children can profit from their benefits. These interventions, organized according to evidence-based practices, can offer a very needed structured opportunity to improve children's motor skill development[20] within the school environment and curricula, aiming to revert the negative trend on MC development of pediatric populations.

In Portugal, children are no exception, and time and opportunity for developing MC during childhood years are scarce. Portuguese children usually start their daily schedule at primary school at 8.30 or 9.00 hours and finish around 17.00 or 17.30 hours, meaning they spend about 8.5 hours at school every day. In the Portuguese curriculum, each classroom should have 1 to 2 hours per week of physical education, and the last 2 hours (15.30–17.30 PM) are filled with extracurricular activities named AECs (ie, music, physical activity, foreign languages, drama, arts, etc).

Aware of the need for children to engage in meaningful movement activities, the Portuguese Football Federation organized and proposed an intervention program on MC to be implemented into the primary schools' extracurricular time: the Super Quinas program. The expectation was that the implementation of an organized movement program, focusing on all components of MC (stability, locomotor, and manipulative) would have a positive impact on the children's MC development, independent of the school setting. This study reports the results on the MC of 6- to 10-years-old children after the implementation of the Super Quinas intervention program in 31 primary schools from all counties of Portugal.

Material and Methods

Sample

Primary schools from all 18 counties in continental Portugal and the 2 Portuguese Autonomous Regions (Madeira and Azores) were invited to participate in the Super Quinas program. Thirty-nine schools volunteered for the program and their classes were assigned to the intervention and control condition. After obtaining the permission of the schools' administrations, all parents received and returned the informed consent form for their child(ren). A total of 1330 children were initially involved in the program, and 1034 (77.7%) completed all of the intervention program and testing. After removing inconsistencies (extreme statistical outliers) and errors from data, only participants with at least one full assessment on one of the Motor Competence Assessment (MCA) subscales were retained in the sample. In the end, the intervention group consisted of 549 children (497 with all the assessments completed), with a mean age 8.2 (1.25) years and 57% of boys, and the control group (CG) consisted of 486 children (443 with all the assessments completed, with a mean age of 8.1 (1.21), and 53% of boys). All 18 counties in continental Portugal and the 2 Portuguese Autonomous Regions (Madeira and Azores) were represented in both the intervention and CGs. Children with motor, developmental, or health problems were not excluded from the program nor from the motor assessments, but their data were not included in the final database.

MC (MCA battery), growth (height and weight), and demographic variables were collected but only the first was used in this study. In order to have more specific information on the results of the program, a more thorough research was conducted in one of the schools (Sintra), with more detailed data on sociodemographic collected, and the use of accelerometers to assess sedentary time, physical activity intensities, and sleep time.[21]

The Ethics Committee of the Portuguese Football Federation approved the study (nr. CEPFS 17.2022).

Description of the Super Quinas Program

The Super Quinas intervention program comprised of 1 hour of activity per week that occurred during the 60 minutes planned for Physical Activities at extracurricular time (AECs), which lasted for 12 weeks, from January to April 2023. This session added to the usual weekly 1-hour lesson of physical education (PE) that schools already had in place, and replaced the extracurricular hour of physical activity. In summary, children from the experimental group (EG) participated in 120 minutes of structured movement practice per week (60 min of the curricular PE lesson plus 60 min of the Super Quinas intervention program) and the CG took part only in the curricular PE time of 60 minutes per week, and 60 minutes of other extracurricular activities during the AECs. The main difference between the 2 groups was that during the extracurricular hour the EG was involved in the Super Quinas intervention program, and the CG had nonplanned movement activities (playful movements and games), different from school to school.

The Super Quinas intervention program was planned by the Portuguese Football Federation with the help of university motor development specialists with the goal of being possible to implement in any school of Portugal. The structure of the lesson plans and materials used on the Super Quinas lessons were similar for all classes in the EG. A kit with all the material was distributed to the schools in the program, and a written plan for each session was organized by a group of MC experts. The organization, structure, and planification of the sessions were explained and discussed in a special workshop with the teachers who participated in the Super Quinas program. All teachers in the program had a BSc or a MSc in PE.

All the sessions were divided into 3 parts: the first part was focused on the individual development of fundamental motor skills; the second part on small team games; and the third part on big games involving all participants. During all sessions, exercises used intended to work at the individual level, on the relationship between the child and the object (ball) and on the association body object peers. Lesson plans can be found at: https://www.fpf.pt/Portals/0/IT/Programa_Bola_Magica_09.pdf?ver=2024-02-05-171048-840.

Motor Competence Assessment

To evaluate the effects of the intervention, all participants were assessed on their MC level using the MCA[22,23] before the beginning of the program (January 2023) and at the end (April 2023). The normative results of the MCA for age and sex were used to compare changes in MC between the 2 moments.[23]

The MCA has 3 subscales, Stability, Locomotor, and Manipulative, each of them with 2 tests (Stability: lateral jumps and shifting platforms; Locomotor: standing long jump and 4 × 10-m shuttle run; and Manipulative: ball kicking velocity and ball throwing velocity). All results are measured in a quantitative scale (ie, distance, time, number of executions, or velocity), without a ceiling effect related to age, or sex (for full description, see Rodrigues et al[23]). Literature describes the tests reliability as ranging from good to excellent,[24–27] and the values of the intraclass correlation coefficient found varied from .90 (shuttle run, ball kicking velocity, and ball throwing velocity in time 2) to .96 (standing long jump in time 1).

Raw test results are transformed into normative (percentile) results by sex and age in a 6-month interval. These results were averaged to calculate the Subscales and Total MCA values[7] also represented in a percentile scale (0–100).

A general warm-up was conducted before the testing. The testing setting was organized in small groups (5 participants per task) and trained examiners administered the tests. A proficient demonstration and a verbal explanation of each test were provided before each test for each group. A test trial was always provided to the participants. Examiners instructed all participants to perform each task at their maximum, and motivational feedback was provided during the testing. All data collection was supervised by one of the authors of this study and registered on an individual sheet. The final database was searched for outliers and/or inconsistencies that could have originated by observation or registration errors. Possible errors were confirmed in the participant individual sheet and corrected, or erased when the error was obvious.

Data Analysis

Data (test results, subscales scores, and total MCA scores) were checked for normality, by observation of the Q-Q plots and the asymmetry indices (skewness and kurtosis). Outlier values were checked for potential errors, and corrected, or deleted if it was the case. All participants with at least one full assessment on one of the MCA subscales were retained in the sample with the purpose of using all the information possible about the 3 MC components.

Univariate changes within each subscale and total MCA for the EG and CG were tested using repeated-measures analysis of variance. Average changes and respective confidence intervals were used to describe the group change represented in percentile values. For these analyses, all participants with complete test results at the variable tested (locomotor, manipulative, stability, or total MCA) were used, which resulted in different number of participants per analysis.

To further compare differences in change between EG and CG, a repeated-measures analysis of covariance was used, using each participant's decimal age, and the initial value on each subscale, or total MCA, as covariates. This process allowed us to account for the possible effect of age (months), and of the baseline value of the variables tested.

To maximize information, statistical tests were made using all the participants with complete data relative to each analysis.

Table 1 Descriptive Results and Univariate Tests for Repeated Measures for the Intervention and Control Groups for Each Subscale and Total MCA

	Stability	Locomotor	Manipulative	Total MCA
Intervention	n = 525	n = 544	n = 523	n = 497
PRE, mean (SD)	45.9 (23.7)	61.2 (25.8)	52.8 (26.5)*	53.9 (20.1)
POST, mean (SD)	59.1.0 (25.6)*	64.9 (25.5)	55.7 (24.6)*	60.1 (20.0)*
POST–PRE, mean (CI)	13.2 (11.7–14.7)	3.68 (2.2–5.2)	3.0 (0.1–5.0)	6.1 (5.0–7.3)
	$F \pm 1524 = 296$	$F \pm 1543 = 22.4$	$F \pm 1522 = 8.15$	$F \pm 1496 = 111.3$
	$P \leq .001$	$P \leq .001$	$P = .004$	$P \leq .001$
	ETA = .361	ETA = .040	ETA = .015	ETA = .183
Control	n = 473	n = 445	n = 470	n = 443
PRE, mean (SD)	44.4 (24.3)	60.6 (24)	49.1 (28.2)*	51.5 (19.3)
POST, mean (SD)	54.9 ± 24.3*	63.1 ± 25	51.1 ± 26.3*	56.4 ± 19.2*
POST–PRE, mean (CI)	10.5 (9.0–12.1)	2.6 (0.9–4.3)	2.0 (−0.3–4.3)	4.9 (3.7–6.1)
	$F \pm 1472 = 174$	$F \pm 1444 = 8.8$	$F \pm 1469 = 2.89$	$F \pm 1442 = 65.8$
	$P \leq .001$	$P = .003$	$P = .089$	$P \leq .001$
	ETA = .270	ETA = .019	ETA = .006	ETA = .130

Abbreviations: CI, confidence intervals for the mean difference; MCA, Motor Competence Assessment.
*Significant differences ($P < .05$) between experimental group and control group at the specific moment.

Table 2 Repeated-Measures ANCOVA With Group (EC or CG) and Sex (Boy or Girl) as Factors Tested, Using Decimal Age and Baseline Values as Covariates

	Stability	Locomotor	Manipulative	Total MCA
N Intervention	525	544	523	497
N Control	473	445	470	443
Time	$P \leq .001$	$P \leq .001$	$P \leq .001$	$P \leq .001$
	Eta = .027	Eta = .046	Eta = .051	Eta = .034
Group × time	$P = .007$	$P = .198$	$P = .015$	$P = .018$
	Eta = .007	Eta = .002	Eta = .006	Eta = .006
Sex × time	$P = .293$	$P = .815$	$P = .367$	$P = .410$
	Eta = .001	Eta = .000	Eta = .001	Eta = .001
Decimal age COV	$P = .702$	$P = .024$	$P = .037$	$P = .654$
	Eta = .000	Eta = .005	Eta = .004	Eta = .000
Baseline COV	$P \leq .001$	$P \leq .001$	$P \leq .001$	$P \leq .001$
	Eta = .089	Eta = .137	Eta = .273	Eta = .105

Abbreviations: ANCOVA, analysis of covariance; CG, control group; COV, covariate; EG, experimental group; MCA, Motor Competence Assessment; Group, EG or CG; Sex, boy or girl.

Results

Descriptive statistics for the subscales and total MCA, along with the comparison between the 2 evaluation moments (PRE and POST) are presented in Table 1. Average values for each subscale and total MCA at baseline were around percentile 50, as expected (percentile 53.9 for total MCA), and an increment was found after 12 weeks (percentile 56.4 for total MCA). Significant differences between EG and CG were found for Manipulative subscale both for PRE and POST moments, and for Stability, and Total MCA on the POST evaluation.

Significant changes within groups (EG and CG) after 12 weeks were found for all subscales and total MCA in the EG; and for Stability, Locomotor, and total MCA in the CG. Based on the average changes and respective 95% CIs values shown in Table 1, we found that the biggest increment was in Stability (13.2 percentile points for EG, and 10.5 for CG), followed by the Total MCA (6.1—EG; 4.9—CG). In all cases, the mean percentile change was higher in the EG enrolled in the Super Quinas intervention.

Because baseline was not the same for each participant, and that could influence the amount of change on the results, we tested all participants together controlling for the baseline value of the subscale. Furthermore, and since the normalization intervals of the MCA use a 6-month period, decimal age was also used as a covariate in the analysis.

Results (Table 2) showed a general effect of time ($P \leq .001$) for all subscales and total MCA, with results improving at the POST evaluation, but the EG showed significant and positive differences, when compared with the CG, in the Stability ($P = .007$), Manipulative ($P = .015$), and total MCA results ($P = .018$).

Sex had no effect on the trajectories of change of the participants (all $P > .05$). The estimated changes found for each subscale and total MCA are shown in Figure 1.

Discussion

The main results of the study were 2-fold: (1) participants, independent of being in the experimental or CG, have progressed in their MC along the 12 weeks, with the sole exception of the CG on the manipulative category and (2) participants in the EG of the Super Quinas program showed significantly better trajectories of change in their MC than their peers in the CG, except for the locomotor subscale where no differences were found between groups.

Overall, these results confirm the effectiveness of the Super Quinas intervention program to increment the MC of 6- to 10-years-old children.

In regard to the first conclusion, the increase in MC by the EG was naturally expected. A recent meta-analysis of the effect of interventions to promote motor skills competence with typically developing children showed a general significant improvement with a big effect size for overall fundamental motor skills scores, and for object control skills, and a moderate effect for locomotor skills.[28] Relative to balance skills, the number of programs that assessed them was small (only 3), but significative changes were found. Our results showed some differences, given that the biggest improvement was found in the Stability subscale ($\eta^2 = 0.36$), followed by the Locomotor ($\eta^2 = 0.04$) and Manipulative ($\eta^2 = 0.02$) subscales. Total MCA showed a moderate effect ($\eta^2 = 0.10$). We should stress that Zhang et al[28] systematic review counted only with studies that used qualitative instruments to assess MC (mostly the Test of Gross Motor Development [TGMD]), and these instruments have recently been found as less reliable to interstudy comparisons.[29] In the literature, we can find different effects found for Locomotor, Manipulative, and Total scores, depending mostly on the type of intervention program. Rudd et al[30] found a significative improvement in manipulative skills after a gymnastics program, but not on locomotor or total quotient scores, using the TGMD. Chan et al[31] only found improvements on Locomotor and total TGMD, but not on object control, when a fundamental motor skills intervention was in place. Bolger et al[32] found no effects of a physical activity program on the 2 subscales of TGMD and total motor quotient, but they found a significative effect on all TGMD scores when a fundamental motor skills program was used. Zhang and Cheung[33] also found significant improvements on all TGMD scores after a motor skills program based on the dynamic systems theory.

Another aspect of our study was the significant increase in MC of the CG, a result that has been reported in the literature.[31,34] In this case, the reason why the CG showed improvements in its percentile

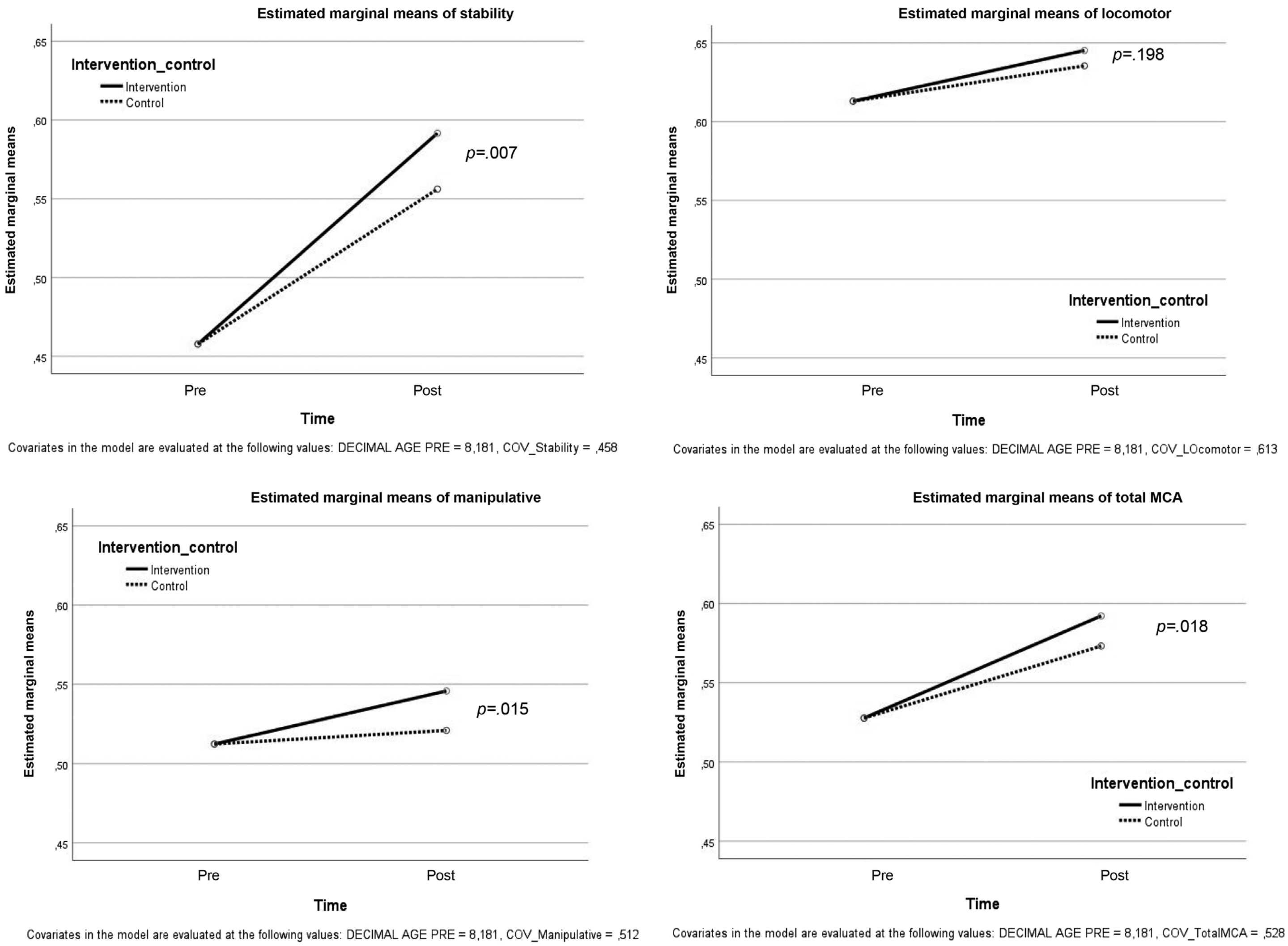

Figure 1 — Representation of the estimated marginal means of the subscales and total MCA for the EG and CG groups before and after the Super Quinas intervention program. CG indicates control group; EG, experimental group; MCA, motor competence assessment.

classification may be related to the amount of motor stimulation provided in regular PE sessions and in the extracurricular AEC. In Portugal, PE sessions are mandatory at primary school level, and both experimental and control groups had one weekly hour of PE during these 12 weeks. Furthermore, for the extracurricular time, the CG also had Physical Activities sessions supervised by physical activity teachers, consisting of ludic movement games and general sports activities. This stimulation opportunity may have been able to improve the MC of all participants. This argument is also coherent with the fact that no significant changes were found for the Manipulative subscales in the CG, since manipulative stimulation might not occur as frequently in PE, giving the lack of materials and space constraints in some Primary Schools.

Another explanation for the general improvement of MC in the second assessment, even for the participants with no intervention, might be the learning effect of the MCA tests. Since the interval between assessments was only 12 weeks, maybe a persistence of a learning effect could happen. This possibility was tested by comparing the results of the second evaluation of the CG participants with other CG participants that did not participate in the first evaluation. As already mentioned, a total of 1330 children were initially involved in the program, and 1034 completed all of the program and testing. Therefore, the rationale was that if a learning effect was effective, then the CG participants that were involved in the 2 assessments should be better in the second assessment than the ones that only participated on the second assessment. The results showed that, except for the shifting platform test where the second group performed better than the ones with previous knowledge of the test, there were no differences between the results on the other 5 MCA tests. This seems to show that the possible learning effect was not important and therefore the changes found in the second moment in the CG are probably more related to the mandatory PE lessons. The moment where the first assessment took place might also justify the better results in the POST test, even for the CG. The PRE test assessment was conducted immediately after Christmas vacation (17 d break), whereas POST test assessment occurred after 12 weeks of practice of PE. In fact, school has an important role in the development of MC in primary school children, and periods without school negatively impact children's MC,[35] physical activity, and body weight.[36]

Relative to the comparison between the experimental and the CG changes for the 2 moments, we can see in Table 1 that the EG always showed higher improvement for all MCA subscales and Total. The subscale that showed the bigger improvement along the 12 weeks of the program was Stability for both EG and CG, probably because the initial values were the lowest (with averages of 45.9 and 44.4, respectively).

When testing the differences in improvement between the 2 groups (Table 2 and Figure 1), we found that the EG surpassed the CG for all measures except for the Locomotor component. The reason could be that locomotor skills are the most prevalent in children's activities, providing enough stimulation, regardless of whether the child was in the EG or not. In fact, both groups' average values were above the 60th percentile on the Locomotor subscale before the implementation of the program. Similar to our results in a recent review on the effect of intervention programs to promote fundamental motor skills among typically developing children, authors concluded that interventions on object control skills had a more significant effect size than those targeting locomotor skills.[28]

Results from motor intervention programs in schools have widely shown the efficacy of this strategy to improve MC of children. Nonetheless, no study[28] has included the MC baseline values on the analysis, which can bias the results, since the starting point it was not the same for all participants. In our study, the baseline values were included as covariable, making the changes independent of where each participant was at the starting date.

These results are also in line with a previous published analysis of a subgroup of 38 children who underwent more specific tests (ie, physical activity levels, sleep, body composition, aerobic fitness, and MC) for a detailed analysis of the impact of this intervention project.[21] Findings indicate that, in this specific subsample, the EG showed significant improvements in physical activity levels, sleep, body composition, aerobic fitness, and MC in children aged 9–10 years.[21]

Limitations to this study should be acknowledged. The lack of maturational and body composition information poses a potential gap in understanding how maturation and morphology may have influenced MC development among the participants. Second, neither the extra school physical activities nor the habitual physical activity was assessed or included in the analyses, which can influence the results. Another limitation of the study is the lack of comprehensive data on individual participation intensity during program activities and daily physical activities.

The study's strengths include the number of participants in the study, and its national representation, which enhances the study credibility and increases the generalizability of the findings to a broader population. Tracking these children in the future is necessary to gain insight into their MC trajectories as they progress into adolescence and adulthood. Differences in results between counties should also be explored in future studies.

Conclusions

In conclusion, children who participated in the Super Quinas program significantly improved their MC percentile scores, meaning that they changed their relative position according to age and sex. The Super Quinas program proved to be effective to improve MC among primary school children. This study underscores the significance of school-based initiatives as key factors influencing MC of primary school children. Programs like the Super Quinas play a vital role and should be scaled up whenever possible, as fostering good MC during childhood increases the likelihood of children pursuing healthier developmental pathways throughout their lifespan.

Practical Implications

- One hour of organized movement stimulation can improve the MC of primary school children.
- An organized program of motor stimulation using the same preorganized activities and similar materials can be adapted to be used with success in every primary school in Portugal.
- The trajectories of MC development of Portuguese children can be enhanced using a national intervention motor program adapted for the use on every Portuguese primary school.

Acknowledgments

The MCA Research Team includes the following author groups: *Instituto Politécnico de Viana do Castelo, Escola Superior Desporto e Lazer de Melgaço*; *Sport Physical activity and health Research & INnovation cenTer (SPRINT)*: Ana Silva, Bruno Silva, Rui Silva. *CIPER, Faculdade de Motricidade Humana, Universidade de Lisboa, Lisboa, Portugal: Carolina Burnay. Faculdade de Educação Física e Fisioterapia, Universidade Federal de Uberlândia, Uberlândia 38400-678, Brasil*: Jadiane Dionísio. *Escola Superior de Saúde de Alcoitão: Cristina de Sá. Faculdade de Motricidade Humana, Universidade de Lisboa: Joana Vilar Pereira. ESECS-Polytechnic of Leiria, 2411-901 Leiria, Portugal*; *Research Center in Sport, Health, and Human Development (CIDESD), 5000-558 Vila Real, Portugal*: Nuno Amaro, Miguel Jacinto, Luís Coelho, Raul Antunes, Diogo Monteiro. *Life Quality Research Centre (CIEQV), 2400-901 Leiria, Portugal; Faculdad de Ciencia del Deporte, Universidad de Extremadura, 10003 Cáceres, Spain*: Nataniel Lopes, Paulino Rosa. *Instituto Politécnico de Coimbra; Sport Physical activity and health Research & INnovation cenTer (SPRINT)*: Ricardo Gomes. *Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-223 Bragança, Portugal*: Álvaro Fortunato. *Escola Superior de Desporto de Rio Maior, Instituto Politécnico de Santarém, Rio Maior, Portugal; Sport Physical activity and health Research & INnovation cenTer (SPRINT)*: Marco Branco. *Universidade do Algarve; Sport Physical activity and health Research & INnovation cenTer (SPRINT)*: Dalmo Machado. *Instituto Politécnico de Castelo Branco; Sport Physical activity and health Research & INnovation cenTer (SPRINT)*: Jorge Santos, Miguel Rebelo, Samuel Honório. *Instituto Politécnico de Beja; Sport Physical activity and health Research & INovation cenTer (SPRINT):* Margarida Gomes, Bebiana Sabino, Pedro Bento, Paulo Paixão, Luis Murta. The Portuguese Football Federation provided financial support and technical assistance for all the organization of the Super Quinas program and evaluation. The authors would like to thank all the primary schools involved in the study, along with the teachers, and/or monitors responsible for the Super Quinas sessions. A special thanks to the management staff of the Portuguese Football Federation particularly to the project manager Manuel Costa. **Author Contributions:** *Drafted the initial Super Quinas program*: Neto, Seabra and Guilherme. *Responsible for the Super Quinas program design and planification*: Seabra, Costa, Guilherme, Cordovil and Vale. *Research design and methodological options*: Rodrigues, Cordovil, Costa, Seabra, Guilherme, Vale and Neto. *Organized the MCA Research Team and the data collection at schools*: Rodrigues, Cordovil, Vale, Luz, Flôres, Lagoa, Almeida, Lopes, Mercê, Esteves, Santos, Serrano, Mendes and Loureiro. *Responsible for the database construction, results analysis, and initial writing of the manuscript*: Rodrigues, Cordovil and Costa. *Writing of the manuscript and approved the final text:* All authors. *Data collection at primary schools:* The members of the MCA Research Team. **Declaration**

of Generative AI and AI-Assisted Technologies in the Writing Process: During the preparation of this work, the authors used the Open ChatGPT to compose small parts of the text, and to translate it into English language. After using this tool, the authors reviewed and edited the content, as needed, and take full responsibility for the content of the publication.

References

1. Rodrigues LP, Cordovil R, Luz C, Lopes VP. Model invariance of the Motor Competence Assessment (MCA) from early childhood to young adulthood. *J Sports Sci*. 2021;39:2353–2360. doi:10.1080/02640414.2021.1932290
2. Gabbard C. *Lifelong Motor Development*. 7th ed. Wolters Kluwer; 2018.
3. Gallahue DL, Ozmun JC. *Understanding Motor Development: Infants, Children, Adolescents, Adults*. Madison, Wis.: Brown & Benchmark Publication; 1989.
4. Lopes VP, Maia JAR, Rodrigues LP, Malina R. Motor coordination, physical activity and fitness as predictors of longitudinal change in adiposity during childhood. *Eur J Sport Sci*. 2011;12(4):384–391. doi:10.1080/17461391.2011.566368
5. Lopes L, Santos R, Pereira B, Lopes VP. Associations between gross motor coordination and academic achievement in elementary school children. *Hum Mov Sci*. 2013;32(1):9–20. doi:10.1016/j.humov.2012.05.005
6. Barnett LM, Webster EK, Hulteen RM, et al. Through the looking glass: a systematic review of longitudinal evidence, providing new insight for motor competence and health. *Sports Med*. 2021;52:875–920. doi:10.1007/s40279-021-01516-8
7. Rodrigues LP, Cordovil R, Luz C, Lopes VP, Pombo A. Estimation of the best method for the calculation of the subscales and total scores of the Motor Competence Assessment (MCA). *J Sport Exerc Psychol*. 2022;44:S23.
8. Robinson LE, Stodden DF, Barnett LM, et al. Motor competence and its effect on positive developmental trajectories of health. *Sports Med*. 2015;45(9):1273–1284. doi:10.1007/s40279-015-0351-6
9. Stodden D, Goodway J, Langendorfer S, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest*. 2008;60(2):290–306. doi:10.1080/00336297.2008.10483582
10. Booth ML, Okely T, McLellan L, et al. Mastery of fundamental motor skills among New South Wales school students: prevalence and sociodemographic distribution. *J Sci Med Sport*. 1999;2(2):93–105. doi:10.1016/S1440-2440(99)80189-3
11. van Beurden E, Zask A, Barnett LM, Dietrich UC. Fundamental movement skills–how do primary school children perform? The "Move it Groove it" program in rural Australia. *J Sci Med Sport*. 2002;5(3):244–252. doi:10.1016/S1440-2440(02)80010-X
12. Mukherjee S, Ting Jamie LC, Fong LH. Fundamental motor skill proficiency of 6- to 9-year-old Singaporean children. *Percept Motor Skills*. 2017;124(3):584–600. doi:10.1177/0031512517703005
13. Koeppel M, Eckert K, Huber G. Trends in gross body coordination and cardiorespiratory fitness-a hierarchical Bayesian analysis of 35 000 2nd graders. *Scand J Med Sci Sports*. 2022;32(6):1026–1040. doi:10.1111/sms.14146
14. Lopes L, Santos R, Pereira B, Lopes VP. Associations between sedentary behavior and motor coordination in children. *Am J Hum Biol*. 2012;24(6):746–752. doi:10.1002/ajhb.22310
15. Hardy LL, Ding D, Peralta LR, Mihrshahi S, Merom D. Association between sitting, screen time, fitness domains, and fundamental motor skills in children aged 5-16 years: cross-sectional population study. *J Phys Act Health*. 2018;15(12):933–940. doi:10.1123/jpah.2017-0620
16. Lopes VP, Stodden DF, Bianchi MM, Maia JA, Rodrigues LP. Correlation between BMI and motor coordination in children. *J Sci Med Sport*. 2012;15(1):38–43. doi:10.1016/j.jsams.2011.07.005
17. Rodrigues L, Stodden D, Lopes V. Developmental pathways of change in health-related fitness and motor competence are related to obesity development in childhood. *J Sport Exerc Psychol*. 2013;35:71.
18. Donnelly JE, Hillman CH, Castelli D, et al. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Med Sci Sports Exerc*. 2016;48(6):1197–1222. doi:10.1249/MSS.0000000000000901
19. Morgan PJ, Barnett LM, Cliff DP, et al. Fundamental movement skill interventions in youth: a systematic review and meta-analysis. *Pediatrics*. 2013;132(5):e1361–e1383. doi:10.1542/peds.2013-1167
20. Lorås H. The effects of physical education on motor competence in children and adolescents: a systematic review and meta-analysis. *Sports*. 2020;8(6):88. doi:10.3390/sports8060088
21. Costa JA, Vale S, Cordovil R, et al. A school-based physical activity intervention in primary school: effects on physical activity, sleep, aerobic fitness, and motor competence. *Front Public Health*. 2024;12:1365782. doi:10.3389/fpubh.2024.1365782
22. Luz C, Rodrigues LP, Almeida G, Cordovil R. Development and validation of a model of motor competence in children and adolescents. *J Sci Med Sport*. 2016;19(7):568–572. doi:10.1016/j.jsams.2015.07.005
23. Rodrigues LP, Luz C, Cordovil R, et al. Normative values of the motor competence assessment (MCA) from 3 to 23 years of age. *J Sci Med Sport*. 2019;22:1038–1043. doi:10.1016/j.jsams.2019.05.009
24. American Alliance for Health, Physical Education, and Recreation. *AAHPER Youth Fitness Test Manual*. 1975.
25. Fernandez-Santos JR, Ruiz JR, Cohen DD, Gonzalez-Montesinos JL, Castro-Piñero J. Reliability and validity of tests to assess lower-body muscular power in children. *J Strength Cond Res*. 2015;29(8):2277–2285. doi:10.1519/JSC.0000000000000864
26. Iivonen S, Kaarina Sääkslahti A, Laukkanen A. A review of studies using the Körperkoordinationstest für Kinder (KTK). *Eur J Adapt Phys Act*. 2015;8(2):18–36. doi:10.5507/euj.2015.006
27. Moreira JPA, Lopes MC, Miranda-Júnior MV, Valentini NC, Lage GM, Albuquerque MR. Körperkoordinationstest Für Kinder (KTK) for Brazilian children and adolescents: factor analysis, invariance and factor score. *Front Psychol*. 2019;10:2524. doi:10.3389/fpsyg.2019.02524
28. Zhang D, Soh KG, Chan YM, Zaremohzzabieh Z. Effect of intervention programs to promote fundamental motor skills among typically developing children: a systematic review and meta-analysis. *Child Youth Ser Rev*. 2024;156:107320. doi:10.1016/j.childyouth.2023.107320
29. Hulteen RM, True L, Kroc E. Trust the "process"? When fundamental motor skill scores are reliably unreliable. *Meas Phys Educ Exerc Sci*. 2023;27(4):391–402. doi:10.1080/1091367X.2023.2199126
30. Rudd JR, Barnett LM, Farrow D, Berry J, Borkoles E, Polman R. The impact of gymnastics on children's physical self-concept and movement skill development in primary schools. *Meas Phys Educ Exerc Sci*. 2017;21(2):92–100. doi:10.1080/1091367X.2016.1273225
31. Chan CHS, Ha ASC, Ng JYY, Lubans DR. The A + FMS cluster randomized controlled trial: an assessment-based intervention on fundamental movement skills and psychosocial outcomes in primary schoolchildren. *J Sci Med Sport*. 2019;22(8):935–940. doi:10.1016/j.jsams.2019.05.002
32. Bolger LE, Bolger LA, O'Neill C, et al. The effectiveness of two interventions on fundamental movement skill proficiency among a

cohort of Irish primary school children. *J Mot Learn Develop*. 2019; 7(2):153–179. doi:10.1123/jmld.2018-0011

33. Zhang L, Cheung P. Making a difference in PE lessons: using a low organized games approach to teach fundamental motor skills in China. *Int J Environ Res Public Health*. 2019;16(23):4618. doi:10.3390/ijerph16234618
34. Duncan MJ, Eyre ELJ, Oxford SW. The effects of 10-week integrated neuromuscular training on fundamental movement skills and physical self-efficacy in 6–7-year-old children. *J Strength Cond Res*. 2018; 32(12):3348–3356. doi:10.1519/JSC.0000000000001859
35. Pombo A, Luz C, de Sa C, Rodrigues LP, Cordovil R. Effects of the COVID-19 lockdown on Portuguese children's motor competence. *Children*. 2021;8(3):199. doi:10.3390/children8030199
36. Cooper J, Tokar T. Changes in body weight and markers of health following short-term vacations (811.14). *FASEB J*. 2014;28(suppl 1): 811–814. doi:10.1096/fasebj.28.1_supplement.811.14