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Background, rationale, and methodological overview of the REACT project—return-to-action on growth, motor development, and health after the COVID-19 pandemic in primary school children

Sara Pereira[1,2] | **Peter T. Katzmarzyk**[3] | **Donald Hedeker**[4] | **Tiago V. Barreira**[5] | **Rui Garganta**[1] | **Cláudio Farias**[1] | **Fernando Garbeloto**[1] | **Go Tani**[6] | **Jean-Philippe Chaput**[7] | **David F. Stodden**[8] | **José Maia**[1]

[1]Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, Porto, Portugal
[2]Research Center in Sport, Physical Education, and Exercise and Health (CIDEFES), Faculty of Physical Education and Sports, Lusófona University, Lisbon, Portugal
[3]Pennington Biomedical Research Center, Baton Rouge, Louisiana, USA
[4]Department of Public Health Sciences, University of Chicago, Chicago, Illinois, USA
[5]Department of Exercise Science, Syracuse University, Syracuse, New York, USA
[6]Motor Behavior Laboratory, School of Physical Education and Sports, University of São Paulo, São Paulo, Brazil
[7]Healthy Active Living and Obesity Research Group, Children's Hospital of Eastern Ontario Research Institute, Ottawa, Ontario, Canada
[8]Department of Physical Education, University of South Carolina, Columbia, South Carolina, USA

Correspondence
Sara Pereira, Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, 4200-450 Porto, Portugal.
Email: sarasp@fade.up.pt

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Abstract

Objectives: The REACT project was designed around two main aims: (1) to assess children's growth and motor development after the COVID-19 pandemic and (2) to follow their fundamental movement skills' developmental trajectories over 18 months using a novel technological device (Meu Educativo®) in their physical education classes. In this introductory article, the first of the Journal's special issue dedicated to REACT, our goal was to present the project rationale, its methodology, training and certification of the team, statistical approach, quality control, governance, and study management.

Methods: We sampled 1000 children (6–10 years of age) from 25 of the 32 primary schools in Matosinhos, northern Portugal. The protocol included a set of variables clustered around the child (growth, physical fitness, fundamental movement skills, and health behaviors), family (demographics, socioeconomic status, parental support for sports participation and physical activity), school (policies and practices for health behaviors, infrastructure for physical education and sports practices), and neighborhood and home environments (safety, sidewalks, sports facilities, as well as children electronic devices and play equipment at home). A set of standard protocols were implemented in REACT together with a rigorous system of training and certification of all members of the research team. This was complemented with a pilot study to assess, in loco, the quality of data acquisition, data entry, and control.

Discussion: Results from REACT will provide school administrators and teachers with novel and far-reaching information related to children's growth and motor development as well as health behaviors after the COVID-19 pandemic. It will also provide city-hall education officials with insight regarding children's physical fitness, fundamental movement skills, and sports practices that will be of great importance in devising novel intervention programs to increase health-enhancing physical activity, and combat sedentariness and obesity. Finally, it will offer parents a wealth of information regarding their children's growth, motor development, and health.

1 | BACKGROUND AND RATIONALE

This is the introductory article of this special issue of the *American Journal of Human Biology* dedicated to the REACT project (Return-to-school after the COVID-19 pandemic: what families, physical education teachers, and communities need to know about children's growth, motor development, and their resultant health behaviors). In this article, the "building blocks" of REACT are presented so that the reader may appreciate its background and rationale, the intricacies of its design, extensive set of variables, statistical approach, data quality control processes, and governance. Further, we present the REACT specific aims which combine state-of-the-art statistical approaches—multilevel and structural equation models with observed and latent variables—with an important network of themes. The articles in this special issue address a number of topics, including (1) the use of the general linear model to link fundamental movement skills, physical activity, and sleep; (2) the joint multivariate correlates of BMI and motor performance; (3) school and familial factors related to children's different motor development levels using multilevel modeling; (4) the Stodden et al. conceptual model, tested using a structural equation modeling approach with "reciprocal causation"; (5) a new tool specifically designed to assess fundamental movement skills is presented together with its validity and reliability, and (6) objectively derived physical activity and sedentary behavior estimates and their relationship with physical development markers—fundamental movement skills and physical fitness components. While REACT is designed as a longitudinal study, this special issue focuses on analyses using the baseline cross-sectional data.

It is well acknowledged that individual and environmental factors influence children's growth and motor development resulting in a complex, dynamic, and interrelated process that impacts their lives (Gabbard, 2021; Goodway et al., 2021). Further, there is evidence showing that fundamental movement skills, physical fitness, and physical activity develop concomitantly (Barnett et al., 2022), that is, children with higher proficiency levels in their movement skills are more likely to be physically fit and engage in a variety of physical activities, which is an important facet of their healthy lifestyles (Jaakkola et al., 2019). Alternatively, previous studies revealed that the cluster of physical inactivity, unhealthy diet, higher sedentary time and poor sleep negatively impacts children's growth and motor development that cascade, negatively impacting lifespan health trajectories (Chaput et al., 2016; Janssen & LeBlanc, 2010; Tremblay et al., 2011). One unfortunate output of this negative spiral is the development of overweight and obesity in children (Stodden et al., 2008), which prompted researchers to further investigate the complex net of relations among these traits (den Uil et al., 2023). The Stodden et al. (2008) model aims to clarify this complexity, and a recent paper showed how "much ground we still have to labor" (Barnett et al., 2022), especially with limitations in longitudinal data. Additionally, since children grow and develop within their family orbit and in the broader context of their schools and built environments, Bronfenbrenner's bioecological model for human development also provides insight to understand the unfolding of these intertwined relationships (Bronfenbrenner, 1979).

In 2020, the world faced an unexpected challenge with the COVID-19 pandemic affecting millions of children's growth and development, but with generally unknown degrees of impact. With severe lockdown restrictions, children were particularly impacted in many different ways. They could no longer attend their daily school education programs, were not allowed to participate in physical education classes, play freely in the playgrounds and engage in sports activities. This interruption in their daily routines negatively impacted their health-related behaviors, including decreased physical activity and increased sedentary behaviors. For example, a scoping review by Paterson et al. (2021) reported a consistent decline in physical activity time alongside increases in screen time and sedentary behavior during the first year of the COVID-19 outbreak. They also reported changes in sleep routines but with greater variability between studies. More recently, a review by Scapaticci et al. (2022) showed that COVID-19 lockdowns brought unbalanced diets leading to an increased risk of both overweight and underweight, increases in sedentary behaviors, and also negatively impacted mental health via increased social isolation, addiction to screens, and decreased educational experiences and health care.

Children's "forced" adoption of unhealthy lifestyle behaviors during this period, especially a less active lifestyle, may have influenced their motor development, especially their fundamental movement skills as context-specific practice opportunities were severely hindered. For example, Abe et al. (2022) compared fundamental movement skills before and during the COVID-19 pandemic in preschool children and showed lower levels during the pandemic, especially in object control skills. A similar trend was observed in a sample of Portuguese primary school children by Pombo et al. (2021). Additionally, in a follow-up study, Carballo-Fazanes et al. (2022) showed that children had lower motor competence in March 2020 (after the first lockdown) relative to their 2018 levels.

There is no doubt that the pandemic restrictions impacted children's life trajectories in many unforeseen ways that need to be further investigated, especially their growth and motor development expressed in terms of motor performance, that is, children's ability to effectively develop and perform a range of movement skills whose outcome can be accessed via product-oriented outcomes (i.e., quantitatively how fast they run or how long they jump), and/or their movement coordination patterns (which qualitative development stage a child demonstrates) in manipulation and locomotor skills) This is the foremost task of the REACT project. The REACT project's main goals are to: (1) assess children's growth and motor development after the COVID-19 pandemic; and (2) follow the developmental trajectories of children's fundamental movement skills over 18 months using a novel technological device (Meu Educativo®) in their physical education (PE) classes. The specific aims of REACT are to: (1) extensively describe children's physical growth and motor development status after the pandemic that will allow us to; (2) identify age- and sex-risk groups in terms of overweight and obesity; (3) map children's physical fitness; (4) describe children's adherence to the WHO 2020 physical activity and sedentary behavior recommendations; (5) analyze how family environments, physical and built environments, and school contexts, relate to children's physical growth and motor development; and (6) examine change and stability in children's growth and motor development over an 18-month period of follow-up.

In this article, our goals are to provide: (1) a brief description of the study site in terms of its geographical location, social background, COVID-19 story, and educational structure; (2) the overall REACT design with its multiple facets; (3) the sample size and its division by age and sex; (4) the child- and context-level variables (school, families and built environment); (5) the statistical analysis approach, and (6) the study governance and management. With these goals in mind, this article "sets the stage" for those who will handle, in different ways and approaches, REACT's wealth of data.

2 | MATERIALS AND METHODS

2.1 | The site—Matosinhos

Matosinhos (geographical coordinates: 41°11′ N 8°42′ O) is located in the north of mainland Portugal by the Atlantic Ocean. Matosinhos, together with the cities of Porto and Vila Nova de Gaia, forms the Atlantic front, and is the second most population-urbanized center of the Porto metropolitan area. Matosinhos has an area of 62.4 km^2 and in 2019–2020, the population size was 175 357, resulting in 2810 inhabitants·km^{-2} and is among the 10 most populated cities (ninth position) in Portugal. Children and adolescents (aged 0–14 years) make up 16.2% of the total population in the city.

Data from 2019 revealed that the average monthly salary in Matosinhos was 1285 Euros, which is a little higher than the average monthly income in Portugal as a whole (1170 Euros); furthermore, 25.5% of the labor force has a college degree, and the average life expectancy is 84.8 years in men and 86.1 years in women. During the lockdown, there was an unprecedent downfall of the economic activities of the region with drastic implications for families, such that the city-hall prepared an emergency fund of 1 million Euros to help families in need (Matosinhos city-hall, 2020).

Given its proximity to the Atlantic Ocean, Matosinhos has one of the most important harbor infrastructures in the country named "Porto de Leixões" which influences the local gastronomy, sports, economic, and touristic activities.

2.1.1 | COVID-19: A very short history

The first COVID-19 case reported in Portugal occurred on March 2, 2020. On March 12, the Portuguese prime minister announced the first school lockdown, given the rapidly increasing number of COVID-19 cases. On March 30, the Matosinhos Mayor activated a contingency plan to mitigate the spread of the infections. During this month, the north of Portugal was the most infected region in the country. In September 2020, the central government announced schools' opening to normal activities. However, the number of new infections increased exponentially and on January 18, 2021, a new lockdown began. In April 2021, the primary schools reopened their activities, but in January 2022, a new lockdown occurred for 15 days. After that, schools have maintained their regular functioning with new rules especially regarding social distancing in children activities.

2.1.2 | Educational structure

The city of Matosinhos sprawls through 10 parishes which group themselves into four clusters (Figure 1). In these four clusters, the 32 existing primary schools are assembled this way: cluster 1 = 5 schools, cluster 2 = 10 schools, cluster 3 = 11 schools, and cluster 4 = 6 schools. In the 2021–2022 school year, 4691 primary school children were distributed across the 32 schools based on their parents' housing proximity.

In all Portuguese primary schools, education is free in the public sector and is mandatory for all children ages 6–10 years. Further, teachers follow an educational program issued by the Portuguese Ministry of Education (Direção-geral da educação, 2012). There is an extracurricular program named "Enrichment Curricular Activities" of which Physical Education is a major part (Maria & Nunes, 2007). This program is offered to every child across the country, but participation is not

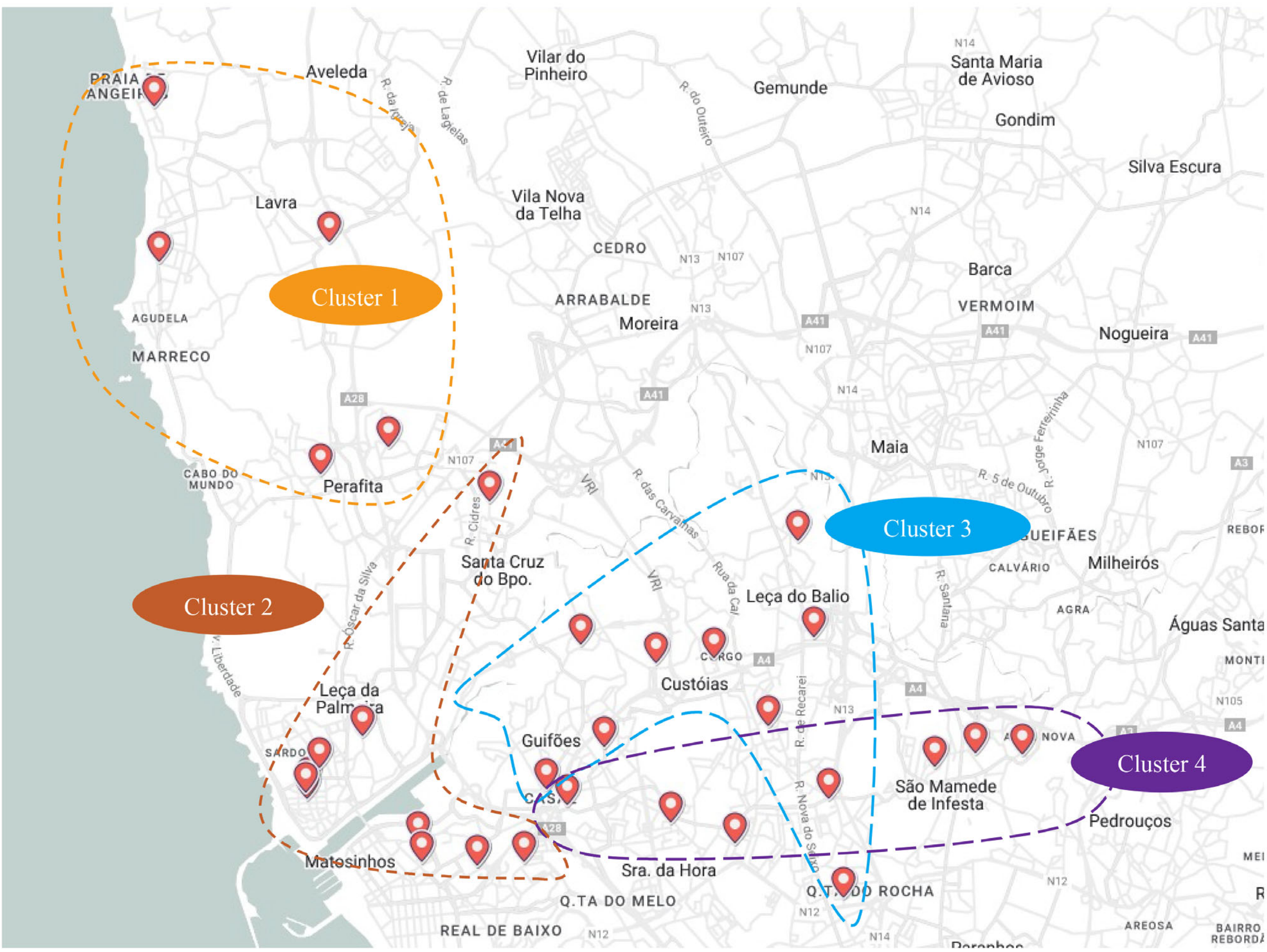

FIGURE 1 Distribution of schools by parish clusters in Matosinhos (please note that in some clusters there are a few schools which are located relatively close that their dots are superimposed).

obligatory. In Matosinhos, almost 99% of all children participate in the program. Beyond the main characteristics of this program (see http://www.dge.mec.pt/sites/default/files/Curriculo/Aprendizagens_Essenciais/1_ciclo/anexo1_ef.pdf), and given the geographical location of Matosinhos, available sports infrastructure, and equipment and personnel, the city-hall Education Department also offers children other activities like swimming, rope skipping, surf, bodyboard, and roller skating at no cost to families.

2.2 | REACT design

Originally, REACT had a two-step sequential strategy to fulfill its specific aims. For specific aims 1–5, we relied on a cross-sectional study design. For specific aim 6, we have a short-term longitudinal design in which the same children would be followed for 18 months with consecutive assessments every 6 months (Figure 2). As REACT was unfolding, and by the end of June 2022, a decision was made by the Matosinhos city-hall officials that it would be of great interest, in educational terms, to have two more data waves. Therefore, besides fundamental movement skills' variables which had 6-month data waves, the core of all variables will be collected during the 2022–2023, and 2023–2024 school years. This afforded a mixed-longitudinal design with different entries of new children, as well as exits in each academic year.

For example, in the 2022–2023 school year, 250 new children entered the study; those from the First, Second, and Third grades from 2021 to 2022 advanced 1 year in the 2022–2023 school year. Further, 2021–2022 fourth graders will leave the study by the end of the school year, and the same will happen to 2022–2023 Fourth graders (see Figure 3).

All participating children had written informed consent from their parents, and the project was approved by the city-hall General Assembly, the Directors of the nine school clusters, the Ethics Committee of the Faculty of Sports (CEFADE 29, 2021), as well as by the General Education Directorate–Ministry of Education (process 0796700008).

2.3 | Sample

2.3.1 | Study sample

First, 25 out of the 32 primary schools were randomly selected to be included in the study; then, approximately 1000 children (aged 6–10 years) from a total of 4691 enrolled in all schools were randomly selected from their respective grade levels to participate (see Table 1).

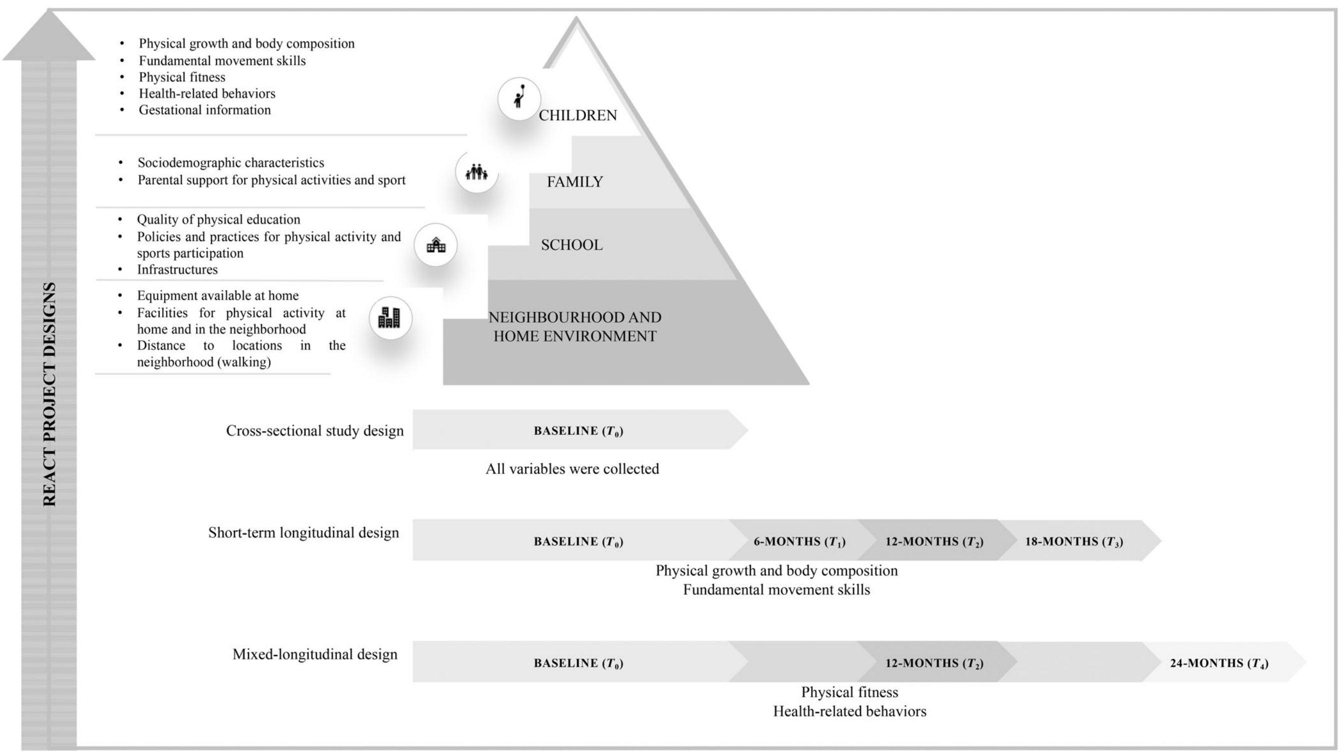

FIGURE 2 REACT project designs with its levels of variables.

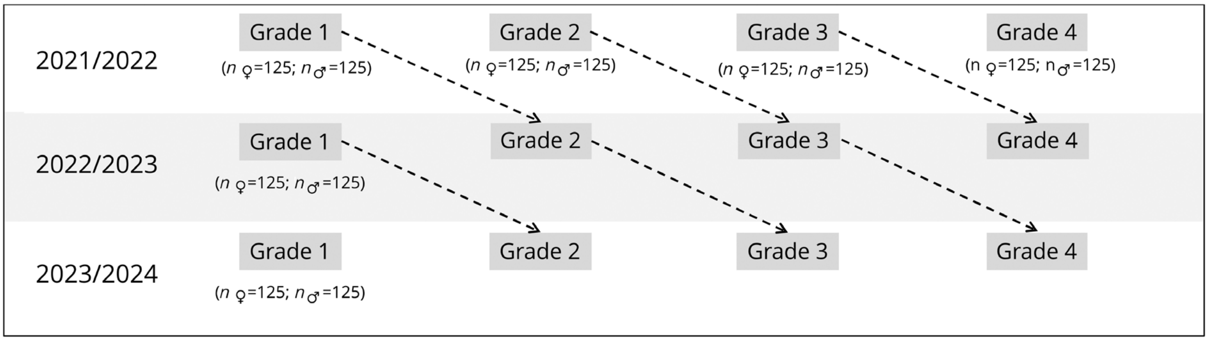

FIGURE 3 REACT waves design.

TABLE 1 Distribution of children in the REACT project by school year and sex.

	Grade 1	Grade 2	Grade 3	Grade 4	Total
	***n* (%)**	***n* (%)**	***n* (%)**	***n* (%)**	***N* (%)**
Girls	139 (53.7)	137 (48.8)	145 (52.5)	142 (53.0)	563 (51.9)
Boys	120 (46.3)	144 (51.2)	131 (47.5)	126 (47.0)	521 (48.1)

Children without permission from parents or legal guardians, and those with physical disabilities that limited their ability to perform all assessments were excluded. Meetings were held with school directors to recruit participants and to present the outline of the project, its aims, and expected outcomes. Further, we also organized an international congress in November 2021 at Matosinhos city-hall entitled "Children's growth and development: mirrors of society" to discuss REACT's importance, as well as the national and international impact of the research project.

2.3.2 | Statistical power

In terms of sample size estimation, we first present power for examining associations of children's growth and motor development. With a sample size of 1000 children (≈20% of the total population), we can detect correlations of $r \geq 0.10$, with power in excess of 0.80 for a two-tailed alpha $= 0.05$ hypothesis test. This is classified as a small effect size (Cohen (1988) to assess within-subject associations of children's growth and motor development variables. Second, for comparisons between subgroups of children (e.g., comparing motor development of 500 vs. 500 children) we have power in excess of 0.80 (for a two-tailed .05 test) to detect an effect size of 0.20 (mean difference divided by the standard deviation). This is equivalent to a small effect size, which will provide us with adequate statistical power to detect differences between groups of children. For unbalanced group comparisons (e.g., 200 vs. 800), the detectable effect size is 0.25, which is still in the meaningful range. These *apriori* statistics allow comparison at one timepoint, which provides a conservative estimate for our longitudinal modeling across time. Thus, we have adequate statistical power for both detection of meaningful associations with motor development, and also for modeling subject-level group comparisons of motor development at a single timepoint and also across timepoints.

2.4 | Measurements

2.4.1 | Child-level variables

Physical growth and body composition

To assess physical growth and body composition we are using a battery of anthropometric measurements. Stature (Seca 213 stadiometer, Germany) and sitting height (Seca 213 stadiometer, Germany) are measured to the nearest 0.1 cm with children in the standard anthropometric position, barefoot, and their heads to the Frankfurt plane (Lohman et al. 1988). For sitting height, children are seated on a 40 cm high bench with their hands resting on their thighs. Waist circumference is measured with a flexible steel tape (Holtain, UK) with a precision of 0.1 cm at the midpoint between the edge of the lower rib and the upper iliac crest during normal breathing. Each of these measurements is taken two times, and if a difference of more than 0.5 cm occurs, a third measurement is taken. The average of the two closest measurements is used for analysis.

Body mass is measured with a portable bioimpedance scale (*Tanita*® BC-553) with subjects barefoot and in the standing position according to manufacturer's suggestions. Further, from the scale we also obtain data on %body fat as well as lean body mass (kg) based on the device manufacturer's built-in algorithms. Two measurements are taken, and if a difference of more than 0.5 kg or 2.0% is obtained, a third measurement is taken. The average of the two closest measurements will be used in all analyses.

Using body mass and stature, the Body Mass Index (BMI) is calculated [BMI=Weight (kg)/height (m^2)]. From this formula, we will classify children as overweight or with obesity from WHO reference cut-points (de Onis et al., 2007). Finally, waist-to-height and the sitting height-to-height ratio [(sitting height/height) × 100] are also calculated.

Fundamental movement skills

Fundamental movement skills measures include various locomotor, object manipulation, and one stability skill (Gabbard, 2021; Goodway et al., 2021). These types of skills are labeled fundamental because they are the "building blocks" for the acquisition of more complex skills and are used in a variety of physical activities, games and sports (Clark & Metcalfe, 2002). In the REACT project, fundamental movement skills (FMS) are assessed with a new digital platform named "Meu Educativo®". Very briefly, the platform was designed to assess six object manipulation skills (striking a stationary ball, stationary dribble, kick, catch, overhand throw, and underhand roll), seven locomotor skills (run, gallop, hop, leap, horizontal jump, vertical jump, and slide) and one stability skill. The platform is very intuitive and allows for rating children in three different levels: explorer (beginner performance), adventurous (intermediate performance), and wizard (advanced performance). Although the platform is rather novel, data already collected using this assessment method demonstrates adequate validity and reliability. In addition, PE teachers reported high practicality in using the application during their classes. The platform was mainly developed to be practical for PE teachers to assess motor skill performance in schools. For example, a single teacher is able to assess five motor skills for a class of ∼30 students in a single class (∼40 min). The results (individually based) are automatically generated by the platform and sent to teachers and parents.

In the REACT project, five object control skills were assessed: stationary dribble, kick, catch, overhand throw, and underhand roll. These object control skills were chosen because they are part of the content of the PE program across the four primary school years taught in Matosinhos.

Physical fitness

Physical fitness (PF) has been broadly defined as a state of being reflecting a person's ability to perform specific exercises and daily living functions that are related to health outcomes (IOM, 2012). Three major PF components were considered in REACT:

- Motor component: (i) 50-yard dash test (running speed) with children instructed to run the distance as fast as possible without slowing down until crossing the finish line. Children are allowed two trials, with 4–5 min rest, and the best time considered (data expressed in seconds as well as $m{\cdot}s^{-1}$); and (ii) shuttle-run test (agility) with children instructed to run back and forth, 2 times, over a distance of 9.14 m. First, from the starting line, children run the distance and pick a wooden block (5.8 cm by 5.8 cm by 10.5 cm), then run back to the starting line and drop the first block beyond the starting line; then run back again, pick the second block and run to the starting line as fast as possible. Two trials are administered with 4–5 min rest, and the best time is used for data analysis (data expressed in seconds as well as $m{\cdot}s^{-1}$). These tests are from the American Alliance for Health, Physical Education, Recreation and Dance test battery (AAHPERD, 1976)
- Musculoskeletal component: (i) standing long jump test (explosive leg power) from AAHPERD (1976) with children jumping as far as possible, from a starting line, and landing on both feet; three trials are allowed and the best distance (in cm) is used for data analysis; and (ii) handgrip test (maximal static strength) from Eurofit (Council of Europe, 1988) test battery. Children are instructed to squeeze the hand grip dynamometer (Takei 5401 Digital, Japan) with maximal effort for at least 2 s, with both hands and the arm not touching the body. Two trials are allowed with a short rest (2–3 min), and the best result is used (in kg^f)
- Cardiorespiratory endurance component: the 20-m shuttle run test, also known as pacer, is used according to the Fitnessgram protocol (Welk & Meredith, 2008). Children ran from side to side at a 20 m distance. Participants start at a speed of 8.5 $km{\cdot}h^{-1}$, and every minute there is an increase of 0.5 $km{\cdot}h^{-1}$. Every increase was flagged with audio signals emitted from a prerecorded sound. Each child continues the test until they could no longer maintain the pace according to the protocol. The final number of laps is recorded.

Health-related behaviors

A set of information regarding physical activity, sedentary behaviors, sleep time, sports participation and diet are collected.

- Physical activity, sedentary time, and sleep are accelerometry-determined with the ActiGraph wGT3X-BT accelerometer (ActiGraph LLC, USA). The device is attached to the child's wrist with a woven nylon wristband, as suggested by the manufacturer. An information sheet is sent to all parents/guardians/care givers regarding the use of the accelerometer with research team contact information provided if they had questions/concerns or needed to get in touch with the research team. All children are encouraged to wear the device 24 h/day during 7 consecutive days, with two weekend days included, plus an initial day of familiarization and a final day when retrieving the device. In total children wear the accelerometer for 9 consecutive days. All children are allowed to remove the device when bathing and swimming, or during their sports practices if necessary. The research team verify the quality of the data (a minimum of 4 valid days with at least 10 h of wear time) using the ActiLife software (version 6.13.4; ActiGraph LLC, USA).

- Data are also collected from parents about child transportation to and from school, as well as the amount of time to get to school. Notwithstanding the ActiGraph information regarding sleep, we also ask parents about their child's sleeping habits, namely the time (hours and minutes) their children go to bed and wake-up during the school days as well as during the week-end days. Further, parents also rate their children's sleep quality based on a Likert scale: (1) very good; (2) good; (3) reasonably bad; (4) very bad.
- Parents are asked to report on their children's screen time. We use a questionnaire to assess time (in hours) spent during weekdays and weekends watching TV, playing non-active video games, and using a computer, tablet, or smartphone. All responses are categorized into six response options: (1) not watching; (2) less than 1 h; (3) 1–2 h; (4) 2–3 h; (5) 4–5 h; and (6) 5 h or more.
- Sports participation is obtained from a questionnaire sent to parents regarding their child's past and current sports involvement, including the chosen sport, number of practice hours per day, which days of the week, as well as the number of days per week. They are also asked about the distance from home to the sports' club, transportation means (active transportation vs. motorized), and if their child participates in official competitions specific to their age.
- Dietary habits are obtained via a food frequency questionnaire including various typical Portuguese food items. Parents are asked about 24 types of children's food consumed weekly. A Likert scale is used, and the answer options were: (1) never; (2) less than once per week; (3) once per week; (4) 2–4 days per week; (5) 5–6 days per week; (6) once a day every day; and (7) more than once a day. Moreover, a question about breakfast is asked, and parents answer about the frequency of the child eating breakfast during the week and on weekends. Additionally, there is a set of questions regarding emotional eating.

All data obtained from parents use an adapted Portuguese version of the ISCOLE (Katzmarzyk et al., 2013) questionnaires regarding children's dietary behaviors and lifestyle, which were also tested in Portuguese children in the GMDC-Vouzela study (Reyes et al., 2018).

Gestational information

Mothers are asked questions regarding their child's length and weight at birth, gestational time, the presence of gestational diabetes, if the child was breastfed, and in the case of a positive answer, at which age the child stopped this type of feeding.

2.4.2 | Context-related variables

Family environment

Family environment is divided into several components, each with a specific questionnaire adapted from the ISCOLE research project (Katzmarzyk et al., 2013) and the GMDC-Vouzela study (Reyes et al., 2018):

- A demographic questionnaire included questions regarding family residence location by postal code, number of siblings, household number, and parents' level of schooling.
- Family socioeconomic status is obtained from the Portuguese school social support system issued by the Ministry of Education directives. Families are divided into three levels according to an index derived from families' annual income: level A (up to 3072 €·year^{-1}) where children get support for books and meals (breakfast whenever needed, and lunch at school); level B (3,072–6143 €·year^{-1}), with half of the level-A reimbursement value; and level C (index >6143 €·year^{-1}) with children receiving no school support. Additionally, data about the number of cars as well as the number of electronic devices in the household were obtained.
- Parental support for sports and physical activities is obtained using a questionnaire about parents' perception of the support they provide their children in their sports and/or physical activities. Four questions are formulated: (1) do you watch your child participate in physical activity or sports; (2) do you encourage your child to do sports or physical activity; (3) do you provide transport to a place where your child can do physical activity or play sports; and (4) do you do physical activities and/or play sports with your child. All answers ranged from 1 (never) to 5 (all days).

All questionnaires are self-administered by parents.

School environment

Information about policies and practices for health behaviors, physical infrastructure, equipment for physical education, and physical education classes are obtained using an objective audit, a modified and locally adapted version of the healthy eating and physical activity modules of the healthy school planner designed by the Joint Consortium for School Health and also used in the ISCOLE project (Katzmarzyk et al., 2013). Additionally, the total number of students and teachers in each school is obtained. This questionnaire is answered by each school principal.

Neighborhood and home environment

The home and neighborhood environment characteristics are assessed and divided into six domains from an adapted ISCOLE questionnaire (Katzmarzyk et al., 2013).

1. Neighbors' response to everyday situations. Five items are asked on how likely a neighbor would respond to, or act, using the following options: (1) very unlikely; (2) unlikely; (3) neither likely nor unlikely; (4) likely; (5) very likely.
2. Child's electronic devices. Information was obtained regarding the availability of such devices in the child's bedroom (TV, computer, videogame system), and/or for their personal use (smartphone, hand-held videogame players and music system).
3. Play equipment availability at home. Questions regarding equipment availability and use of equipment at home for children to participate in different physical activities (e.g., bike, basketball backboard, swimming pool, roller skating, balls, etc.), and its frequency of use by the child were answered: (1) not available; (2) available but not used; (3) once a month or less; (4) once every 2 weeks; (5) once a week or more.
4. Facilities for physical activity at home and in the neighborhood. A set of questions regarding how often during the past year, the child has been physically active in places at home or in the neighborhood was also asked (13 items, e.g., inside the home, in a garden, in a small park, on the beach, etc.). Answers options range from never to four or more times per week.
5. Distance to locations in the neighborhood. The time needed to get from home to some places (walking) was asked, such as shops, restaurants, parks, schools, beach, etc.
6. Availability of places in a short distance by walking (10–15 min). Seventeen items were asked that are available in a short walk (10–15 min). Answers options are: (1) strongly disagree; (2) somewhat disagree; (3) somewhat agree; (4) strongly agree.

2.5 | Staff training, certification, and pilot study

Before data collection, a set of procedures was implemented to improve the quality of the testing team as well as the data reliability (Figure 4): (1) training and

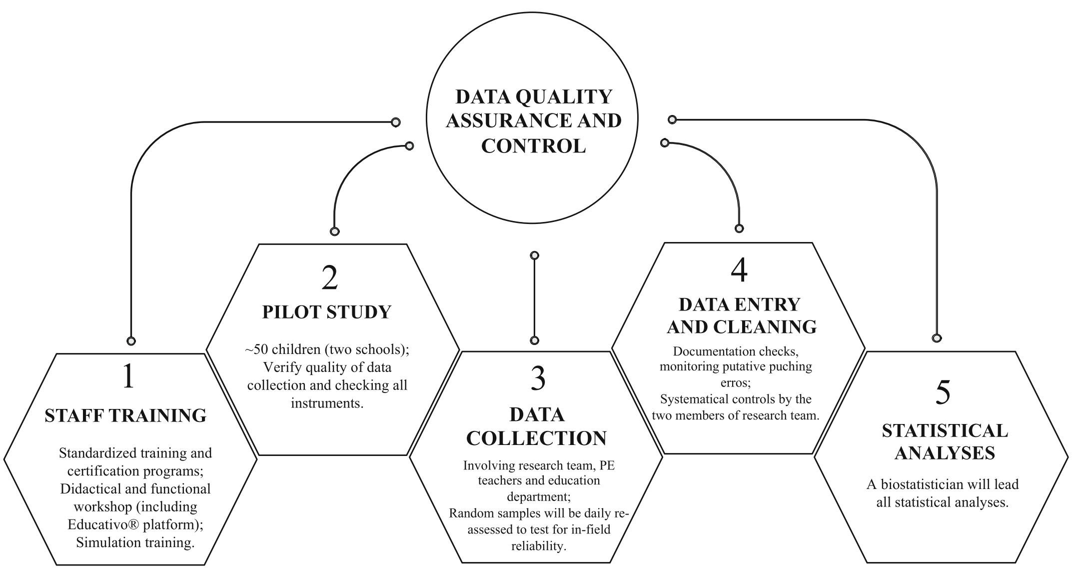

FIGURE 4 Diagram of REACT quality control program with its five facets: staff training, pilot study, data collection, data entry and cleaning, and statistical analyses.

certification of all data collectors and research team members by the main investigators; and (2) conducting a pilot study with 50 children from two schools (25 students per school). This hands-on testing provided a learning opportunity to help ensure the success of all assessments in the study, namely: (1) data collection, preparation and organization; (2) testing all protocols in loco; (3) instruments, sample recruitment, strategies and time allotted to each study domain; (4) identification of putative problems with the methodologies used, and providing supplemental training whenever necessary to secure high-quality data collection; and (5) verification of data entry and cleaning so that we have sound and highly reliable data for statistical analysis.

2.6 | Statistical analysis

Children's growth and motor development, the prevalence of overweight/obesity, physical fitness, and health-related behaviors will be summarized separately by sex and age, within and across schools. General linear models, which allow for many kinds of outcome variable types, including covariate-adjustments, will be used to analyze the relationships between growth and motor development as well as individual (overweight/obesity, health behaviors and physical fitness) and contextual influences, that is, from families, schools, and communities. Multilevel random-effects models with children nested within schools will be used to account for the hierarchical data, and to examine the degree of variability present at the child and school levels. Finally, change and stability in growth and motor development will be modeled using tracking statistics. Here, longitudinal models will allow us to examine and compare growth and motor development trends across time, treating time using random subject polynomial trend parameters. Thus, we will examine and explain the heterogeneity in growth and motor development. Missing data will be treated with appropriate statistical techniques. The significance level will be set at $p < .05$ with adjustments for multiple testing.

3 | GOVERNANCE AND STUDY MANAGEMENT

A schematic representation of REACT governance is provided in Figure 5. The two PI's manage and supervise the entire process, ensuring that all timelines regarding the beginning and completion of each task are fulfilled so that milestones can be reached in a timely manner. They prepare all reports to be sent to the funding agency and

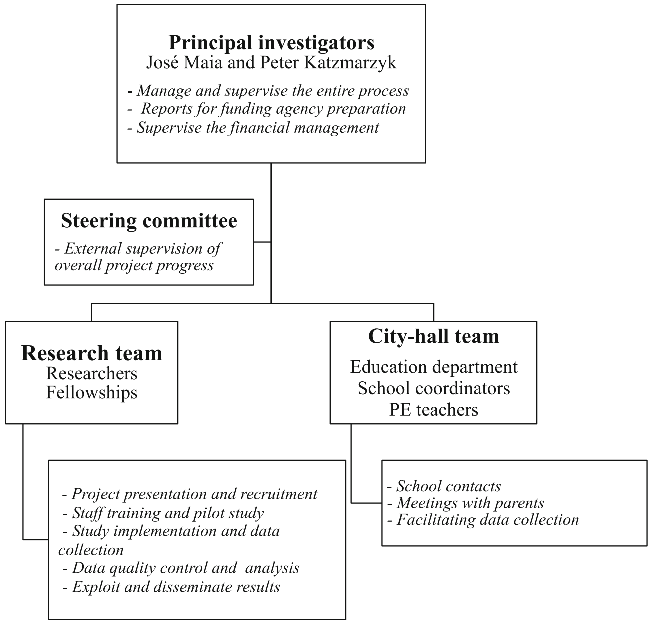

FIGURE 5 Flowchart diagram of the REACT project's governance and management, including the roles of the principal investigators, steering committee, research team, and city-hall team.

also supervise the financial management of the project along with Faculdade de Desporto da Universidade do Porto (College of Sport, University of Porto) administrative staff support. Additionally, the two members of the steering committee will ensure external supervision throughout the implementation of the project.

The PI's and other research team members organize and conduct the presentation of the research project as well as recruitment. All have extensive experience in projects involving children in different cities and countries. Due to their extensive experience in collecting data in population-based studies, other team members will be responsible for preparing the standardized training and certification programs for staff, including intensive training sessions at Faculdade de Desporto da Universidade do Porto during 3–5 days including fellow researchers and Physical Education teachers.

Research team members are also responsible for facilitating all necessary links between the research team and PE teachers, while overseeing all data collection and quality checking of data entry by fellow researchers. A biostatistician will lead all statistical analyses. The entire research team will work toward preparing and presenting abstracts/oral communications for national and international scientific events and original articles to be submitted in peer-reviewed papers. All research team members will have regular video conference meetings and maintain regular contact with the PE teachers.

4 | DISCUSSION

The REACT project was planned to investigate the effects of COVID-19 lockdowns in children's physical growth and motor development. There is no doubt that these lockdowns negatively impacted their daily routines, especially in the context of their schools as well as in their manifold physical activities and sports participation. In a sense, children's lives "were suspended" during these periods. Also, REACT is implemented in strict collaboration with the education department of Matosinhos city-hall, school directors and administrators, class teachers as well as PE teachers. Given its very broad scope, REACT also encompasses aspects of the bioecological theory (Bronfenbrenner, 1979) with its nested levels of information—children, families, schools, and built environments. REACT methodologies are grounded on a series of tasks embedded in strict standardization of measurement protocols, rigorous training of its research members, as well as accreditation of the assessment team. A series of quality control protocols were implemented to guarantee accurate and reliable data acquisition at all levels. Additionally, given the study's high potential in educational terms, city-hall officials insisted on its follow-up. This way we moved from a single wave of data collection to three consecutive waves, that is, from the core cross-sectional design to a mixed-longitudinal design which raises, to another level, research opportunities, and challenges. Finally, data sets from REACT will provide ample opportunities for students to develop their education during their Master and PhD training.

Notwithstanding the REACT project's scope and breadth, it is mandatory that its strengths as well as weaknesses be addressed. Major strengths include: (1) the large sample size and its representativeness in terms of children nested within schools across parishes; (2) the standardization of all measurement protocols and quality control procedures; (3) the use of device-based measurements to assess physical activity, sedentariness, and sleep; (4) the use of a novel technology, "Meu Educativo®," to help physical education teachers in planning children's movement skills development as well as its assessments; (5) the reliance on higher-order measurements to provide extensive information about the school, family and built-environment contexts; (6) the formal adherence of the city-hall mayor and its educational department, together with school officials and children's teachers; (7) the detailed reports sent to parents and school teachers about the children's physical growth status, movement skills development and physical fitness; (8) the high potential of its follow-up; (9) the inevitability of designing and implementing new intervention programs to address some of the most challenging results, and (10) the potential to mobilize stakeholders and other resources in order to ensure the provision of quality Physical Education to primary school children. Notwithstanding these strong points, it is important to stress that REACT was solely implemented in Matosinhos, a single city in the north of Portugal, that by no means is representative of the whole country (mainland and autonomous regions of Madeira and Azores). Some of the measures used in this study are still crude, namely those related to dietary assessments. Although the city-hall has a small team of specialists in nutrition, it would be almost impossible to assess 1000 children with direct interviews. It would also be of interest, in 9 and 10 year-old children with obesity, to assess their cardio-metabolic health, and also involve their parents given that these traits tend to show familial resemblance (Pereira et al., 2019). We do not have any information on how children and their parents dealt, psychologically, with the unforeseen problems of the several lockdowns, nor with the financial difficulties caused by unemployment that originated from the pandemic. Yet, we see no special reason why information from REACT may not be useful to other Portuguese regions, especially teachers, school administrators, and those involved in designing new ways and programs of tackling the many problems primary school children faced with the lockdowns.

In summary, REACT's baseline data will certainly help to disentangle the complex network of correlates driving children's differences in physical growth, fundamental movement skills, physical fitness and activity, sedentariness and sleep, as well as their overweight and obesity prevalences after the COVID-19 lockdowns. Further, the follow-up will certainly bring new light on the dynamics of these relationships 3 years after children release from the lockdowns.

AUTHOR CONTRIBUTIONS

Conceptualization: Sara Pereira, Peter T. Katzmarzyk and José Maia; Funding acquisition: José Maia; Investigation: Sara Pereira, Rui Garganta, Cláudio Farias, Fernando Garbeloto, and José Maia; Methodology: Sara Pereira, Peter T. Katzmarzyk, Donald Hedeker, and José Maia; Project administration: Peter T. Katzmarzyk and José Maia; Supervision: Jean-Philippe Chaput and David F. Stodden; Writing—original draft preparation: Sara Pereira, Peter T. Katzmarzyk and José Maia; Writing—review and editing: Donald Hedeker, Tiago V. Barreira, Rui Garganta, Cláudio Farias, Fernando Garbeloto, Go Tani, Jean-Philippe Chaput, and David F. Stodden.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ORCID

Sara Pereira https://orcid.org/0000-0002-4661-3879
Peter T. Katzmarzyk https://orcid.org/0000-0002-9280-6022
Donald Hedeker https://orcid.org/0000-0001-8134-6094
Tiago V. Barreira https://orcid.org/0000-0001-7108-3374
Cláudio Farias https://orcid.org/0000-0002-1364-0539
Fernando Garbeloto https://orcid.org/0000-0001-8024-909X
Go Tani https://orcid.org/0000-0002-6517-5472
Jean-Philippe Chaput https://orcid.org/0000-0002-5607-5736
David F. Stodden https://orcid.org/0000-0003-1988-1701
José Maia https://orcid.org/0000-0002-3273-0046

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