

Laterality and lateralization processes in developmental age: Assessment and results in the post-pandemic era

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Abstract:

The introduction of new technologies and their misuse during the COVID-19 pandemic have led to increased sedentary behavior and reduced participation in sports and physical activities. This trend has been associated, as demonstrated by various studies (Orgilés M. et al., 2020), not only with social issues but also with considerable challenges in individuals' psychomotor development. Therefore, this study aims to evaluate the motor skills and lateralization processes in 8–10-year-old children, one year after the conclusion of the COVID-19 health emergency. A valid and effective instrument was selected for evaluation, namely the MOVIT tests (Cottini, 2003), which allow for both qualitative and quantitative investigation of movement. These tests were administered to a sample of 85 children in the Campania region, recruited through convenience sampling, over a period of approximately three months. This approach enabled the identification of the children's abilities, deficits, and levels of potential development. The evaluation was performed both *ex ante* and *ex post*, with activities designed to enhance the sample's psychomotor level between the two assessments. At the end of the *ex post* evaluation, the data were analyzed, demonstrating that effective instruction on movement and the timely introduction of playful motor activities can lead to a good psychomotor level in children and consolidate the processes of laterality and lateralization. During the pandemic, children's daily routines changed considerably, with increased screen time and reduced physical interaction leading to reduced motor skill development. This study seeks to address these gaps by implementing a structured physical activity program post-pandemic, assessing its impact on lateralization—a critical aspect of psychomotor development. The MOVIT tests provided comprehensive insights into the children's motor capabilities and areas needing improvement. The study's findings underscore the importance of reinstating physical education in daily routines to foster balanced psychomotor development, emphasizing the role of interactive and engaging physical activities in enhancing children's overall growth.

Keywords: Psychomotor skills; Physical activity; Motor learning; Functional prerequisites; Motor proficiency; Behavioral assessment

Introduction

The rapid advancement of technology is causing profound changes in today's society (Perrone et al., 2023), supported by the Covid-19 pandemic, which has set further challenges to a delicate and precarious balance affecting the world of sports science.

After the pandemic is over, it's important to analyze its consequences on sport with particular reference to the developmental age, the most vulnerable and affected age group. In this period, the child explores and consolidates its relationship with the world. The child is vulnerable because if the natural process of motor learning was altered, not insignificant critical consequences could arise.

During the pandemic, in fact, the body lost all forms of free expression and induced new consciousness that showed itself both on personal and affective experience and on school performance. The reduction of physical activity in such circumstances not only affects health, but also affects learning and the development of emotional, cognitive and social skills (Perrone et al., 2023). Children forced into sedentariness, therefore, have changed their eating, sleeping and time spent in front of the screen habits (Ayubi & Komaini, 2021).

The pandemic represented an unprecedented event that radically changed the daily routines of children, imposing a sudden halt to sports and motor activities. This situation has led to growing concerns about the long-term impact of such inactivity on children's psychomotor development. Previous studies (Orgilés M. et al., 2020) have highlighted how a reduction in physical activity can not only impair physical health but also negatively affect learning and the development of emotional, cognitive, and social skills.

Many studies have been conducted around the world to understand the resulting effects. As reported by the study conducted in Indonesia, which tested the motor skills of 4-5 years old children using TGMD-2 and revealed how motor levels had degenerated post-pandemic (Pronoto et al., 2023).

A literature review confirmed that the COVID-19 pandemic significantly impacted children's motor skills due to a lack of physical activity at home and increased sedentary behavior (Ayubi & Komaini, 2021). Additionally, research highlighted that the pandemic led to reduced opportunities for children to engage in fundamental motor skills (FMS), with serious consequences for their physical and mental health (NCBI, 2023). A study by Braksiek and Pahmeier (2024) examined how primary school children's sport self-concept, PA enjoyment, and PA-related mood regulation were related to their physical activity levels during the COVID-19 pandemic. It was found that sport self-concept played a significant role in maintaining children's PA levels, despite the pandemic's challenges, while PA enjoyment and mood regulation were less influential.

An interesting study involving 12 aspiring teachers (4 women and 8 men) in Spain noted the discomfort caused by the forced interruption of frontal physical education lessons during their training (Varea et al., 2022). Using semi-structured interviews, the teachers' difficulty in relating to pupils during physical educational class emerged, as they showed difficulty in moving at a distance without physical contact. This absence caused a decrease in the functioning of the learning process in the pupils.

So, different strategies were adopted, but the need for a return to physical contact between teachers and pupils emerged in order to ensure proper psychomotor development (O'Brien et al., 2020).

The impact of the pandemic was also evident in a study on the physical fitness of primary school children, which found significant declines in motor development due to reduced physical activity during lockdowns (SpringerOpen, 2023). Furthermore, it was noted that prolonged inactivity and restriction of play during the pandemic had detrimental effects on children's fundamental motor skills and overall physical health (NCBI, 2023). The child under natural conditions during growth improves its movement ability then action and perception ability in proportion to the growth of its central nervous system.

The human brain, composed of two hemispheres, which present functional differences, is responsible for the manifestation of the body's laterality; that is, the preference for the use of a certain side over the other for the performance of different daily activities (Cedeño et al., 2019).

Laterality is consolidated through games and situations with physical and motor education around the age of 6-7 years, allowing the body to relate to others and the environment involving eye, hand, foot and ear (Mencarelli, 2012).

So, it had difficulty consolidating during the pandemic.

However, it should not be confused with lateralization because it is a process that refers not only to the dominant and favorite hemisphere of an individual, but also affects the different functions typical of each hemisphere. Specifically, the right hemisphere is devoted to visual, musical, imaginative, intuitive and synthetic thinking; the left hemisphere, on the other hand, is responsible for verbal and logical thinking (Valentini et. al., 2016). In relation to movement, "lateralization affects coordination and mainly hand-eye coordination (which coordinates the stimuli received by the eyes with the movements of the hands) and balance, particularly in the transition from balance in motion to balance in flight (in which the functions of attack and momentum of the dominant limbs and those of support and detachment of the complementary limbs must be perfectly integrated)" (Valentini et. al., 2016, p. 204).

Somatic lateralization is influenced by different factors, including genetics, environmental conditions, and choices related to limb dysfunction. Indeed, in a study carried out on 358 Hong Kong children, it was shown that parental left-side preference can influence their children's laterality, identifying a shared genetic factor that influences the laterality of hands, feet and eyes (Schmitz et al., 2022).

Brain asymmetries also play a key role in the efficiency of inhibitory control in 9-10 years old children as demonstrated in a study conducted by Omont-Lescieux et al. (2023) on 60 right-handed children recruited from French public schools.

Increased cortical activations on the parietal and frontal mesial regions also suggest that an increase in attentional and executive processes is required to inhibit a hand, regardless of its side (Tisseyre et al., 2019).

A study conducted by Badau and Badau (2022) designed and implemented in the physical and sports education and motor assessment process, a program of specific exercises and tests to optimize reaction time using Fitlight technology systems in relation to manual dexterity and laterality of the foot and identification of gender differences concerning the development of reaction speed in 231 children (M=109; F=103) aged 10-11 years.

Through the comparative analysis of the samples and the progresses aimed at optimizing specific reaction times, it emerged that the female gender recorded greater progress at the level of manual laterality, both for the right and left hand, while the male gender recorded significant progress in terms of improving reaction times at the level of right and left foot laterality. When talking about laterality, therefore, a distinction is always made between left- and right-handedness because, in addition to different brain characteristics, there are social prejudices that lead to the belief that being left-handed has a negative connotation (Qo'ldoshev, 2021). Many educators believe that primary school children need different approaches as they manifest reading and writing problems, disorders or deficiencies in the development of visual-spatial perception, visual memory and impaired visual-motor coordination (Qo'ldoshev, 2021). From a motor point of view, left-handers have more difficulty than right-handers in learning skills as they have to adapt the gesture to the left limb. It is therefore important to know their characteristics in order to be able to bring out their peculiarities during training, also because researchers agree that left-handedness is increasing in recent years.

In addition, in sports, left-handers sometimes perform better because they have unpredictable attitudes that are not as prevalent as right-handed athletes (Chu, Chang, & Chu, 2016). Sports in which they predominate include tennis, wrestling, baseball, fencing and volleyball (Faurie, Raymond, & Men, 2016). Hemispheric dominance, however, does not affect the entire side of the body because, for example, the preference of the upper limb may not manifest itself on the same side for the lower limb, and the same goes for the eye and ear. In such a case, one speaks of mixed or cross laterality. When, on the other hand, it is not clearly established and the use of the right and left side alternates in solving a task, we speak of weak laterality. A concrete example is a child who alternates between using his left hand to write on the blackboard and his right hand to write in his notebook.

In sports, too, there can be less lateralization, which can be decisive in certain performances. In football, in fact, athletes who show less lateralization are considered to be more successful in their sports because performing passes and kicks with both feet can increase the success rate (Akpinar, 2022).

In light of these considerations in the post-pandemic context, it is crucial to analyze the consequences of the pandemic on children's physical and motor education, particularly in the developmental age range, which is the most vulnerable and most affected. During this phase, the child explores and consolidates their relationship with the world, and a disruption in the natural process of motor learning can have critical consequences. Therefore, the need to promote the recovery of motor skills lost during the pandemic becomes essential.

Materials and methods

This study aims to evaluate motor skills and lateralization processes in children aged 8 to 10 years, following the end of the pandemic. The research focuses on understanding how forced inactivity has impacted psychomotor development and on the effectiveness of a targeted physical activity program designed to recover motor skills. The contribution starts with some reflections on the potential of motor and sports education, highlighting the possible consequences in terms of involvement and participation and on effective didactic planning to encourage the recovery of lost motor skills in children of developmental age.

In order to offer a theoretical framework capable of providing reflection, interpretation and analysis of the problem-situations emerging from the pandemic, the present study uses a quasi-experimental approach for the detection of laterality and lateralization processes in children.

The first ex-ante evaluation was carried out in February 2023. The sample was administered the MOVIT assessment instrument at a sports complex in the province of Naples. The administration of the selected tests was carried out taking into account the capacity of the complex, so as to guarantee the correct execution of the tests, the availability of the children and the timing of the administration of the various instructions and their integrity in order to guarantee an accurate and precise survey without contamination in the collection of data, according to the test guidelines. It was necessary, in fact, to guarantee anonymity to protect the children's privacy, as they were minors. After the first administration, the test revealed some difficulties in the so-called functional prerequisites, and some methodological paths were subsequently devised to foster the development of the psychomotor components of movement.

Three weekly meetings were held for the two groups for approximately one month, for a total of twelve lessons. The activities were proposed in a playful manner. Play, in fact, is the natural approach the child uses to relate to reality by expressing linguistic, logical, scientific and motor skills. The child's personality, therefore, is determined by the interaction of body, movement and play (Palumbo et al., 2021). After the end of the scheduled meeting period, in March, the outgoing survey was carried out using the same administration criteria as the first one. Therefore, in the developmental period taken into consideration in this work, through an activity strongly marked in a playful sense, the formation of a broad motor base and the evolution of functional prerequisites are promoted.

Laterality, therefore, in developmental age is fundamental in order to relate with the environment and the other, and consequently should not be neglected. It is fundamental because the preference for the use of one side of the body over the other corresponds to a superiority of the contralateral hemisphere in motor control, due to the crossed motor (and sensory) nerve pathways in humans (Prete & Tommasi, 2018) helping them to perform daily tasks. This means that if a person has right-sided dominance, their left hemisphere is more competent than the right hemisphere in either fine motor control, force, or both. Therefore, laterality is a manifestation of a brain imbalance, resulting in more specific competences in relation to the dominant hemisphere (Bondi et al., 2020).

Goal

The aim of the present work is to foster the maximum development of the individual subject's motor function, highlighting residual or potential abilities, his or her motivations and relational characteristics.

It is evident that the aim of the work carried out is to outline the pupil's potential development in the psychomotor area. In fact, in the child's psychomotor evolution, each experienced stage represents his level of maturation, of freedom of action, integrating his knowledge with new acquisitions (Palumbo, 2018).

Sample

The study involved a convenience sample of 85 children, aged 8-10 years (M=48; F=37). The sample was selected according to non-probability sampling.

Of the sample, general information on sports practice was also collected, determining how many children played sports and how many did not. Specifically, 34 children were identified as not practicing motor activity and 51 children as practicing extracurricular motor activity. Most of the sample practiced sport, in particular volleyball.

Instruments

For the purposes of the survey, the instrument used for administration was the MOVIT (Cottini, 2003), as, thanks to it, the educator carries out a qualitative and quantitative assessment of movement, highlighting the pupils' abilities, difficulties and potential (Cottini, 2003). The MOVIT, therefore, consists of four main aspects that allow for an effective and efficient evaluation:

1. The assessment is little influenced by the subjectivity of the observer;
2. The tests that constitute it can be considered as an increasing focus check list aimed at investigating pupils with poor motor skills;
3. It can be proposed in a normal gymnastic activity;
4. It assesses pupils' abilities and difficulties and their potential development.

The MOVIT, is an example of an increasing focus list and allows the systematic observation of the psychomotor area through seven scales related to functional prerequisites that also concern laterality:

For each skill (with the exception of laterality), six defined behavioral indicators (items) of progressively increasing complexity have been identified, which are reported on a special summary sheet upon achievement of the skill under observation and each of them is assessed by five tests.

In addition to the typology of the task, the cards describing the tests assessing the different items clearly define the acceptable levels of performance and the aids applied. Concerning laterality, a form with nine tasks was created, three of which aim to identify hand dominance, three aim to identify feet dominance and three aim to identify eye dominance. Finally, the MOVIT assessment tests are designed to delineate the area of potential development in relation to the psychomotor skills examined.

Results and Discussion

The data obtained from ex ante and ex post surveys of all 85 subjects were analyzed in order to obtain the values of the norms of reference with both ex ante and ex post values derived from the conversion of the total of the weighted scores given in the table by Cottini (2003).

The obtained scores related to the 6 scales, were transformed into standard points, expressed on a medium scale 10 and standard deviation 3. By summing the standard scores obtained in the 6 scales, it was possible to determine the total level of psychomotor skills. The children are considered to present:

- For a total of 2 children a level defined as "high" with scores of 117 and 123;
- For a total of 64 children a level defined as "medium" with scores between 91 and 115;
- For a total of 20 children a level defined as "deficient" with scores between 78 and 84.

As a result of the moving educational programming and the subsequent administration of the MOVIT tests, it was found that:

- No child reached a level defined as "very high".
- 1 out of 85 children confirmed the "high" level by improving their score from 123 to 124;
- 80 children reported a level defined as "medium" with scores between 85 and 112;
- 4 children confirmed a level defined as "deficient" with scores between 82 and 84.

At the end of the ex-post analysis, the most of the samples have an average total level of psychomotor ability. Levels were also achieved thanks to the development of the educational plan, which enhanced the ability especially of those who do not participate in sports. Some children did not pass the deficient level, and others, on the other hand, despite remaining with average scores, scored lower than in the first survey. Important data emerged in the laterality survey. Most of the pupils, in fact, were found to be right-handed and only three children were found to be left-handed. These results, therefore, confirm the preference for using the right rather than the left side of the body (mainly hand and foot), which is present in almost 90 percent of the overall population (Bondi et al., 2020). Another important aspect is the cross and uncertain dominance affecting the foot, hand and eye. In fact, only two children exhibit uncertain laterality and three cross-dominance. Subsequent data analysis was carried out after completing the teaching period aimed at improving the psychomotor area.

The children who had achieved good results in ex ante survey obtained the same results, especially those who played sports, as they had consolidated the psychomotor level for their chronological age.

Data obtained with the MOVIT tool were also analyzed by SPSS (Statistical Package for Social Science) software in order to obtain statistics to summarize, understand, and describe the information contained in the collected data. Significant statistics emerged, comparing data obtained from the various surveys and among the assessed samples. Specifically, between the input assessments initially reported on Excel files for the MOVIT assessments, denoted with "T0" and the output assessments denoted with "T1", in order to verify consistently what emerged from the normative data the progress of the sample, also subjects practicing sports and subjects not practicing any motor-sport activity are also compared.

In the following table (Tab. 1), the results have been categorized into a descriptive statistic comparing the incoming and outgoing psychomotor level of the sample practicing and not practicing sports, then highlighting the number of subjects, Mean and Standard Deviation.

In the comparison between T0 and T1 for the children not practicing sports, it was found that in the T0 entry surveys the mean was M=90.20; in the T1 exit surveys they reach higher levels M=93.29. The 51 practitioners, on the other hand, obtained in the T0 input assessment a mean M=102.35 and in the T1 output survey they reach a level that does not show a significant difference M=102.80. From the data, therefore, it appears that the subjects not practicing sports motor activity, thanks to the treatment activity reached the levels of the group practicing sports, thus leading to an increase in psychomotor level.

Table 1 – Descriptive statistics of practicing and not practicing sport student

		N	Mean	Std deviation
T0_PSYCHOMOTOR ABILITY LEVEL	NO	34	90,20	10,49
	YES	51	102,35	4,63
	Total	85	97,49	9,58
T1_PSYCHOMOTOR ABILITY LEVEL _A	NO	34	93,29	9,46
	YES	51	102,80	4,03
	Total	85	99	8,17

Also interesting is the descriptive on gender analysis (Tab. 2) by level of psychomotor ability, in that the male gender, indicated by “M”, obtained a better mean than their female counterparts indicated by “F”, in both the T0 and T1 surveys. Specifically, the female gender (n=46) obtained a mean M=96.32 in the T0 assessment, which increases to M=97.78 in the T1 assessment. On the other hand, the male gender (n=39) obtained more significant mean differences as in the T0 assessment the mean was M=98.87 and an increase to M=100.43 was shown.

Table 2 - Descriptive statistics by gender.

		N	Mean	Std deviation
T0_PSYCHOMOTOR ABILITY LEVEL	F	46	96,32	10,56
	M	39	98,87	8,20
	Total	85	97,49	9,58
T1_PSYCHOMOTOR ABILITY LEVEL _A	F	46	97,78	8,68
	M	39	100,43	7,39
	Total	85	99	8,17

Reviewing the ANOVA statistic reveals a slightly significant p value (,000) between T0 and T1 of the psychomotor ability level of the groups as shown in the table (Tab. 3).

Table 3 – ANOVA statistics between groups

		Sum of squares	df	Mean of squares	F	Sig.
T0_PSYCHOMOTOR ABILITY LEVEL	Between groups	3010,04	1	3010,04	53,07	,000
	Within groups	4707,20	83	56,71		
	Total	7717,24	84			
T1_PSYCHOMOTOR ABILITY LEVEL _A	Between groups	1844,90	1	1844,90	40,58	,000
	Within groups	3773,09	83	45,45		
	Total	5618	84			

Regarding the values comparing the means by age group, in the incoming T0 survey, for the 43 8-year-old subjects there are M=96.25 values, for the 28 9-year-old subjects M=98.14 and for the 14 10-year-old subjects M=100 values. This results in a total mean of M=97.49 for the 85 subjects analyzed (Tab. 4). In the T1 outgoing surveys 8-year-old subjects confirm, thanks to treatment activity, an increase in M=98.44 values, same increase also for 9-year-old subjects with an average of M=99.35. For the 10-year-old subjects although they found high values in both pre and post test, this still confirms that already the prior motor experience determines more reliable results (M=100).

Table 4 – Descriptive statistics by age group.

	N	Mean	Std deviation
T0_ PSYCHOMOTOR ABILITY LEVEL	8	43	96,25
	9	28	98,14
	10	14	100
	Total	85	97,49
T1_ PSYCHOMOTOR ABILITY LEVEL_A	8	43	98,44
	9	28	99,35
	10	14	100
	Total	85	99

In conclusion, data comparing the mean T0 and T1 by sport practice (Fig. 1) are also reported, confirming that the practicing champions have a higher level of psychomotor skills than the non-practicing samples but achieved lower individual growth in psychomotor skills than the non-practicing samples.

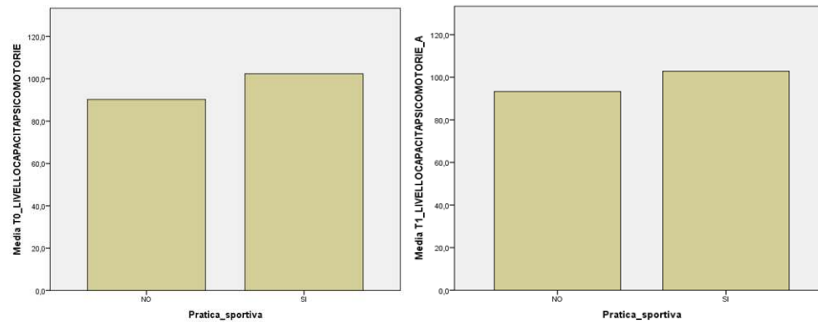


Figure 1 - Comparison by sport practice

Conclusions

This study highlights the significant impact that the COVID-19 pandemic had on children’s psychomotor development, largely due to increased sedentary behavior and decreased physical activity. The findings reveal that while most children showed a good psychomotor level despite pandemic-related inactivity, those who engaged in regular sports activities before and during the pandemic exhibited better motor skills and laterality development compared to their non-active peers.

For organizations involved in child development, physical education, or sports programming, these findings underscore the urgent need to reintegrate and emphasize physical activities in children’s daily routines. Companies specializing in educational tools, physical activity programs, or child development resources should consider the following implications:

1. Incorporation of Structured Physical Activities: Develop and promote structured physical activity programs designed to enhance motor skills and psychomotor development. Programs should be engaging and adapted to cater to various developmental stages and needs.
2. Use of Comprehensive Assessment Tools: The effectiveness of tools like the MOVIT for evaluating psychomotor skills should be highlighted. Investing in or providing access to reliable assessment tools can help educators and parents better understand and support children’s development.
3. Support for Sports Participation: Encourage and facilitate increased sports participation among children. Given that children who were already involved in sports exhibited better psychomotor outcomes, supporting extracurricular sports and physical activities can be a strategic focus.
4. Educational Content Development: Create educational materials and programs that address the gaps identified in motor skills due to pandemic-induced inactivity. Content should be designed to be both educational and engaging to maximize its effectiveness.

The study’s results suggest that targeted interventions can significantly improve children’s psychomotor skills following periods of inactivity. Future work should focus on:

1. Long-Term Impact Studies: Investigate the long-term effects of the pandemic on children’s psychomotor development to better understand the persistence of these effects and the effectiveness of various interventions over time.
2. Customized Programs for Diverse Needs: Develop tailored physical activity programs that address the specific needs of different age groups, skill levels, and developmental stages, particularly those who have experienced significant delays in motor skill development.
3. Integration with Educational Policies: Advocate for the integration of physical education and motor skill development into educational policies and curriculums to ensure that all children benefit from structured physical activity as part of their daily routines.

4. Parental and Educator Training: Provide training for parents and educators on the importance of physical activity and how to effectively support and promote motor skill development at home and in educational settings.

By addressing these areas, companies and organizations can contribute to the well-being and development of children, helping them recover from pandemic-related setbacks and fostering a more balanced and healthy approach to growth and learning.

Authors Contributions

Amato G., Graduated in Motor-sports Evaluation Sciences and Sports Analysis and Planning Techniques for Disabled People, research field: Materials and methods; Goal; Sample; Instruments; Conclusions.

Pallonetto L., Researcher in Methods and Didactics of Motor Activities (SSD M-EDF / 01), at the Department of Human Sciences, Philosophy and Education of the University of Salerno, research field: Introduction; Results and Discussions.

Palumbo C., Associate professor of Methods and Didactics of Motor Activities (SSD M-EDF / 01), at the Department of Human Sciences, Philosophy and Education of the University of Salerno, as a Scientific Curator.

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