Preprints.org

Article

Not peer-reviewed version

The Influences of Psychomotor Behaviors on Learning Some Swimming Styles (Front Crawl, Backstroke) in 6–9-Year-Old Children

Renato Gabriel Petrea , Cristina-Elena Moraru , Ileana Monica Popovici , Ilie Cătălin Știrbu , Liliana Elisabeta Radu , Marin Chirazi , Cristian Mihail Rus , Alexandru Oprean , Oana Rusu *

Posted Date: 12 July 2023

doi: 10.20944/preprints202307.0823.v1

Keywords: children; manual dexterity; body schema; laterality; static balance; buoyancy; swimming; learning process

Article

The Influences of Psychomotor Behaviors on Learning Some Swimming Styles (Front Crawl, Backstroke) in 6–9-Year-Old Children

Renato-Gabriel Petrea [1,2], Cristina-Elena Moraru [2], Ileana-Monica Popovici [2], Ilie-Cătălin Știrbu [2], Liliana-Elisabeta Radu [2], Marin Chirazi [2], Cristian-Mihail Rus [2], Alexandru Oprean [2] and Oana Rusu [2,*]

[1] Doctoral School in Sports and Physical Education Science, Faculty of Physical Education and Sport, "Alexandru Ioan Cuza" University of Iași, 507184 Iași, Romania, renato.petrea@uaic.ro

[2] Faculty of Physical Education and Sport, "Alexandru Ioan Cuza" University of Iași, 507184 Iași, Romania, gimcristinamoraru@yahoo.com (M.C.E.), ilenuca_popovici@yahoo.com (P.I.M.), cstirbu@uaic.ro (Ș.I.C.), liliradu2004@yahoo.com (R.L.E.), chirazim@yahoo.com (C.M.), cristian.rus@uaic.ro (R.C.M.), alexandruoprean@yahoo.com (O.A.)

* Correspondence: broana@uaic.ro

Abstract: The aim of the study was to identify the existence of positive relationships between certain psychomotor behaviors, which we consider specific to swimming, and learning the execution technique of some styles (front crawl and backstroke). The study was carried out during 10 months, including 76 children (40 boys and 36 girls) aged between 6-9 years who practice recreational swimming in a Romanian city. Several tests were used: Tapping test for manual dexterity and laterality, the Goudenough test for body schema, the Flamingo test for static balance, the horizontal buoyancy-test for body balance on the water. Results indicated better ratings on all psychomotor behaviors analyzed by gender (in favor of girls compared to boys), except for laterality. The levels of all analyzed psychomotor behaviors are directly proportional to the age of the subjects. Also, moderate positive correlations of manual dexterity (rs = 0.63 in front crawl; rs = 0.57 in backstroke) and strong correlations were identified for body scheme, laterality, static balance and buoyancy, coordination with the learning of the two styles of swimming (r or rs between 0.77 and 0.85). In conclusion, psychomotor behaviors can be predictors for learning swimming styles.

Keywords: children; manual dexterity; body schema; laterality; static balance; buoyancy; swimming; learning process

1. Introduction

Psychomotricity can be defined, in general, as any motor action that is under the influence of mental processes, its two sides, motor and mental, representing a unitary whole. It is dependent on the sensory, perceptive and cognitive functions, on the reception of information (analyzers) and on the appropriate execution of the response act, which determines a personal, individualized behavior [1–5]. Other authors [6–8] established that psychomotricity responds to human needs according to the processes of education, re-education or therapy and can be seen as a whole system based on movement (the act motor) and mental functions, conditioned both by the interaction between individuals (children-children, children-adults) and by the connection between the growth process and the education system, with effects on proper social integration [9].

Studies on motor behavior are really important because the motor part is dominant in all the activities that an individual performs. Psychomotricity can be influenced in the first years of life, up to 11-12 years [10], being the research topic even after this age, for people with behavioral or mental disorders. In this case, depending on the severity of the neuromotor disorder, psychomotricity can be a concern for the whole life [11].

The process of learning swimming styles is achieved through psychomotor development. A wide variety of motor skills are learned through everyday tasks (walking, running, throwing,

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

catching, etc.), while swimming involves covering distances in water, in landscaped pools or open water, through one of four specific styles: front crawl, backstroke, breaststroke or butterfly. The acquisition of new motor skills performed on land or in water causes the reorganization of the primary motor cortex, which is positively associated with the formation of motor memory.

Motor learning can be defined as "a set of processes associated with practice or experience that led to relatively permanent changes in skilled movement ability" [12]. Studies have highlighted coaches' intentions to integrate approaches based on scientific information into sports practice [13–15]. However, the diversity and complexity of the coaching job has determined that a large part of coaches rely on the knowledge they have accumulated in practice - from coaching experience [13,16–21].

The ISLAM model [22] was used in the practical activities at the pool for learning the techniques of swimming (front crawl and backstroke styles), which consists of the following stages: I = training (the coach transmits the information theoretical); S = retention (children should theoretically retain certain information); L = learning (motor learning of front crawl and backstroke styles); A = analysis (the coach identifies the mistakes made by the students during the learning process and helps them to become aware of the mistakes; photos and videos can be used for analysis); M = measurement (measuring and evaluating children at certain time intervals to see the level of execution of the 2 swimming styles).

Identifying variables that predict swimming performance is one of the main goals of the swimming "science" community [23,24]. There are studies that show that it is possible to improve performance by manipulating anthropometric, biomechanical, hydrodynamic and energetic variables [25–30]. Some programs to identify and track swimming talent, from children to elite adult swimmers, regularly include such tests [31].-Studies on the identification of variables that contribute to the learning of swimming styles have not been identified in the literature.

1.1. Conduits of Psychomotricity and Their Manifestation in Swimming

The different definitions of psychomotricity [6,32–39] refer to a classification of its components, but also a theoretical approach from different perspectives of its manifestation (education, re-education or therapy).

From the perspective of the Cattell-Horn-Carroll (abbreviated CHC) theory [40–43], the structure of cognitive ability includes 16 constructs (broad abilities) among which the psychomotor abilities involved are also identified in performing motor actions (movement of fingers, hands, feet, etc.) with precision, coordination or strength. These broad skills are made up of 8 narrow skills, such as static strength, manual dexterity, finger dexterity, limb coordination, precision control, aiming, overall body balance.

The elements of psychomotricity influence the optimal manifestation of the individual who practices sports both during training and in official competitions. In the process of learning and practicing swimming, we consider the following to be representative: body scheme, laterality, balance, spatio-temporal organization, coordination and manual dexterity.

Body schema is understood as an image or mental representation of one's own body and its differentiation from space and surrounding objects, in different static or dynamic situations [44,45]. It is built little by little thanks to sensory, sensory and kinesthetic acquisitions, and being progressively integrated into the child's cognitive life. De Meur & Staes [46] identified stages in the emerging and development of the body schema in the chronological evolution of the individual's age. Intentional motor actions depend on the representation of the body at the level of the central nervous system (body schema), and body schema disturbances have been presented in various studies as the main subject for motor impairments [47], for illusions that the affected body part belongs to another person [48].

In the learning process of swimming, the body scheme is considered an important goal of psychomotor development that will be very useful in this instructive-educational process. The optimal child's age to start learning swimming styles is five years, at this age, the child has already discovered his own body, knew his body parts and strengthened his body-spatial orientation. Through swimming, practiced in an organized way after the age of five (up to this age it was an adaptation to the aquatic environment and learning some basic movements), children develop their

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

spatial-body organization which will contribute fully to an execution as possible proper swimming technique.

Laterality is a phenomenon of sensory and motor asymmetry, being genetically inherited [49–52] and based on a certain functional organization of brain structures [53]. It is caused by the dominant function of a cerebral hemisphere, a function that determines the inequality of the right and left halves of the body [32,54,55]. In the structure of locomotion, laterality introduces a specialization and a complementary relationship between body segments during activity, the most obvious being at the level of the limbs (hand and foot) and corresponds to the preference for using the right side of the body rather than the left [56]. The defining of the development direction of the dominant part (hand and foot laterality) is achieved during childhood, the reinforcement of the preference of the dominant hand, in terms of fine motor skills, occurring between 6 and 11 years [53,57], clearly influenced by the environment we live in [58–61].

In recent years, an increasing number of studies have mentioned laterality in relation to technical, behavioral, physical and tactical factors in sport [62,63], but without going into depth on this topic or offering specific tools. Laterality refers not only to left-right preference [64,65], but also to how an athlete directs his body in space [66,67].

In swimming, laterality can be shown by a better technical execution or greater efficiency in the rowing process of one segment compared to the other (for example, the right-hand paddles more efficiently than the left hand or vice versa). This can also happen in the lower limbs, and the effect of these actions is shown by oscillations of the body from the direction of travel. Also, laterality can be important when the child is learning front crawl style breathing. Most of the time, turning the head, in order to inhale, is done in the learning stage, on the side on which the child has the dominant hand. In the methodology of learning swimming styles, the coaches can let the children choose for themselves the side on which they will do the inspiration, but they must also pay attention to the laterality that the child has.

Balance is often used in association with terms like stability and postural control. Despite the widespread use of the term, there is no universally accepted definition of human balance [68–73].

Postural control is a prerequisite for maintaining multiple postures in various activities [74,75]. However, balance control has been identified as being associated with three broad categories of human activity [69,76]: a) maintaining a specific posture (e.g.: standing apart with arms outstretched laterally; standing on one leg and with the other bent at the knee joint; starting position from block start in swimming events, etc.); b) voluntary movement performed in daily activities (motor acts that happen between two balance positions); c) the reaction to an external disturbance (for example: contact with an opponent during a game of handball or soccer, slipping of a foot during a change of direction, etc.). These classifications encompass the acts and motor actions that lead to maintaining, achieving or restoring the center of gravity (line of gravity) in the support base [77,78].

Each sport involves specific motor skills that require specific postures and movements to be completed [79–81]. Balance is an important factor in many athletic skills, but the relationship between results in sports competitions and balance is not yet fully understood [82,83]. A lower level of balance is associated with injuries such as sprains and tears of muscles, tendons and ligaments [77,84,85].

Body balance in water (buoyancy) - not only determines whether the body "sinks or floats in water", but also determines the body's stability/balance of the body in the fluid. Depending on the locations of the center of gravity (CG) and center of buoyancy (CB), the body can be stable, neutral, or unstable in water [86]. Barbosa et al. [87] identified the hydrostatic profile of swimmers as the ability to float, buoyancy and the hydrodynamic profile of swimmers as the ability to "glide" on water, which can be determined by buoyancy and various drag forces. Some studies suggest that artificially increasing buoyancy can improve swimming performance and that subjects who naturally have a higher amount of body fat may have an innate advantage in swimming performance [88].

In the learning process of swimming, the body balance on the water is important and manifests itself in two ways. On the transverse axis of the trunk, the loss of balance occurs laterally (left - right) (see the position of the shoulder blades in the positions of the front crawl and backstroke). This happens in the styles: front crawl - marker is given by the position of the shoulder blades because the learning position is lying face down with the head in the water- and backstroke - marker is given by the position of the shoulders because the learning position is lying dorsally with the head in the water. On the longitudinal plane of the trunk, the loss of balance is determined by the immersion ("falling") of the legs in the water, especially in the breaststroke and butterfly procedures due to the extension of the head and trunk, to ensure breathing, but also imposed by the regulation (in the case of the breaststroke).

Spatio-temporal organization. Space is perceived and constructed mentally as a result of perceiving positions, directions, distances and displacements (Tasset, 1980, cited by [46]). *Spatial organization* starts from the sensory-motor level of the perceptions related to action and based on the knowledge of the body scheme and the "left-right" concepts [33]. De Meur & Staes [33] state that taking age into account, spatial structure is formed in four stages. In any sports competition, the space is delimited by regulation. In the process of learning to swim, the perception of space is important because we are dealing with the aquatic environment and the positioning of the body in the face or dorsal position (with the head in the water), which, at some moments, can lead to the loss of spatial orientation. The child needs to learn to maintain the linear direction of travel and also the correct positioning within the corridor.

The *temporal structure* represents the ability of a person to place himself according to the sequence of events, the duration of the intervals, the rhythm, the cyclical repetition of some periods of time and the irreversibility of time, realized in four stages [33]. The accurate perception of time is achieved through the interaction of the visual, auditory, kinesthetic analyzer and through the mediation of this interaction by thinking [38]. Time estimation is often subject to errors. The duration of small intervals is often overestimated and the duration of long intervals is underestimated.

In some sports competitions, the time is not predetermined (points are accumulated in tennis, volleyball, badminton, etc. or measured in metric units in ski jumping, jumps and throws in athletics), in others, the rules clearly specify the playing interval (football - 90 minutes, rugby - 80 minutes, handball - 60 minutes, basketball - 40 minutes, etc.), and in others, events are timed (for example, events in sports swimming, running in athletics, speed skating, cycling etc.). In the learning process of swimming, the perception of time is important for the acquisition of some details of coordination (for example, the upper and lower limbs in the breaststroke) and for certain aspects of tactics during the competition events.

Coordination includes oculo-motor and general dynamic coordination, and consists in the ability to associate movements in order to ensure efficient motor acts [10,38,89–91]. In order for movement to be adapted to a purpose, it must occur harmoniously in time and space, so it must be coordinated [92–94]. Eye-motor coordination is the basis on which prehension is built (the act of grasping with the fingers). Hand-eye coordination is developed and refined with positive effects in the control and improvement of gestures [6].

The *general dynamic coordination* is achieved with the help of motor skills supporting strength, speed, resistance, flexibility. Coordination of movements occurs only through constant repetition and gradually develops as the child grows. Control of coordinated activity is achieved through the feedback mechanism of proprioception and subcortical centers. Movement coordination can be trained and remarkable results can be achieved for athletes and musicians.

Manual dexterity. The hand is the most active and interactive part of the upper extremity. Hand dexterity is a term used to explain a range of different hand and finger skills and performances [42,94,96]. These skills include reaction time, hand preference (dominant), wrist flexion speed, finger touch speed, aiming; hand stability and arm stability [97]. 4 factors are most relevant to hand dexterity assessment: hand stability, following contours, aiming, reaching/pointing as quickly as possible for a set period of time. Kuloor [98] suggests that dexterity is a psychomotor skill by which small muscle groups are coordinated in performing movements that usually involve the synchronization of hands and fingers with the visual analyzer – the eyes, and can also be considered an oculomotor coordination.

Coordination is a very important component in learning to swim. The execution technique of the four swimming styles (front crawl, backstroke, breaststroke and butterfly) is based on coordination details of the upper limbs among themselves, of the lower limbs with each other and of all the limbs as a whole [94,99–101,103]. To these, the twisting or extension movements of the head are added to allow inspiration to be achieved.

2. Materials and Methods

2.1. Aim and Hypotheses

The *aim* of this study was to identify the relationship between psychomotor behaviors and learning the execution technique of some swimming styles (front crawl and backstroke).

Two main working hypotheses were formulated, each with 6 secondary hypotheses.

Hypotheses H1: There is a positive relationship between psychomotor behaviors and front crawl style learning.
Hypotheses H2: There is a positive relationship between psychomotor behaviors and backstroke style learning.

2.2. Research Variables

The study was carried out between October 2021 and July 2022, the population being 428 children practicing leisure swimming (beginner level) at one of the swimming pools of the city and metropolitan area of Iași, Romania. The research subjects are represented by 76 children (17.75% of the population), aged between 6 and 9.11 years (M = 7.2 years), distributed according to the gender variable (40 boys (52.6%), 36 girls (47.4%) and age (19 (25%) for each category: 6.0 - 6.11 years, 7-7.11 years, 8-8.11 years, 9-9.11 years), for which one of the parents expressed their consent and signed it, and who participated and completed all the tests included in the study.

The research subjects followed a program of two lessons per week, lasting 60-75 minutes each, following a program that included different exercises structured by learning stages for the two swimming styles, front crawl and backstroke.

The study was conducted in accordance with the Oviedo Convention of 1997 and the Helsinki Declaration of 1964, with the approval of the Ethics Committee of the Faculty (protocol code 13bis/ March 30ty 2021). Subjects were informed, with prior written consent obtained from a parent or guardian for each child.

2.3. Measurement and Evaluation of Variables

All the tests used in the process of measuring and evaluating the variables (independent and dependent) were carried out in the same swimming pool in the city (25m long, working corridor - 2.5m, water temperature 26-28^0 C). Specific tests were used for each variable, which required specific equipment, prior instruction, individual subject testing, measurement and evaluation (reference to rating standards). The testing was carried out without time pressure in execution, being evaluated by two trainers (an inter-rater fidelity test was also performed). The details of the testing for each variable are described in Appendix A.

2.3. Statistical Analyses

The results from this research were stored and processed using IBM SPSS 20 software (IBM Corp, Armonk, NY, USA). Descriptive statistical analyzes allowed checking the condition of normal data distribution, by calculating the Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) coefficients. To check the correlation between the variables, there were calculated the Pearson coefficient (*r*) for variables with parametric normal distribution and the Spearman coefficient (*rs*) for variables with non-parametric non-normal distribution. The t-test for independent samples was calculated to check for statistical differences between variables. The confidence interval taken into account was 95%.

3. Results

3.1. Descriptive Statistical Analysis

On the Tapping test, which measured the independent variable - manual dexterity, the results indicate an arithmetic mean (M) of 74.08 centiles (M = 73.38 for boys; M = 74.86 for girls) and a standard deviation (SD) of ±10.09 (SD = ±10.21 for boys; SD = ±10.03 for girls), with normal values around the mean being between 63.99 and 84.17 percentiles (between 63.17 and 83.59 for boys; between 64.83 and 84.89 for girls). The standard error of the mean (ES) for the whole group is ES=±1.15 centiles, for boys ES=±1.61 and for girls, ES=±1.67. Depending on the gender variable, the data show

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

that girls have better manual dexterity than boys by 1.48 percentiles. According to the age variable, we note that the research subjects recorded the following values of manual dexterity: at 9 years M = 82.37 centiles (SD = ±7.14); at 8 years M = 78.68 centiles (SD = ±3.05); at 7 years M = 72.63 centiles (SD = ±5.22); at 6 years M = 62.63 centiles (SD = ±10.05) (see Appendix B, Table 1).

The results of the Goodenough test (the "little man" test), used to measure the independent variable - body schema, indicate an arithmetic mean (M) of 19.20 points (M = 18.65 for boys; M = 19.81 for girls) and a standard deviation (SD) of ±3.57 (SD = ±3.59 for boys; SD = ±3.48 for girls), the normal values around the mean being between 15.63 and 22.77 points (between 15.06 and 22.24 in boys; between 16.33 and 23.29 in girls). The standard error of the mean (ES) at the group level is ES=±0.41 pct, for boys, ES'±0.56, for girls, ES=±0.58. For the gender variable, it is found that girls have a better body image than boys with 1.16 points. For the age variable, we find that the research subjects have the following body image values: at 9 years M = 24.22 pct (SD = ±2.10); at 8 years M = 20.78 points (SD = ±0.97); at 7 years M = 18.89 points (SD = ±0.60); at 6 years M = 15.33 points (SD = ±1) (see Appendix B, Table 2).

The descriptive statistical analysis of the results obtained when testing the laterality of the hand, shows us that within the study sample we have 67 subjects out of 76 (88.2%) who have the dominant right hand and 9 subjects (11.8%) who have the dominant left-hand. Regarding the lower limb, the statistical percentages are the same: 88.2% (67 subjects out of 76) have the dominant right lower limb and 11.8% (9 subjects) have the dominant left leg. Of the right-dominant, 36 (53.73%) are boys, and 31 (46.27%) are girls, while, of the left-dominant, 4 (44.44%) are boys, and 5 (55.56%) are girls (see Appendix B, Tables 3 and 4).

Of the 67 right-dominant subjects, 16 (23.88%) are 6 years old; 19 (28.36%) are 7 years old; 17 (25.37%) are 8 years old; and 15 (22.39%) are 9 years old. Among the subjects who are left-dominant, we have the following age distribution: 3 (33.33%) children are 6 years old, 2 (22.22%) are 8 years old, and 4 (44.45% are 9 years, no subjects aged 7 years (see Appendix B, Table 5).

The descriptive statistical analysis of the results obtained in the Flamingo test, which measured the independent variable - static balance, shows an arithmetic mean (M) of 11.84 sec. (M = 11.20 in boys; M = 12.54 in girls) and a standard deviation (SD) of ±2.08 (SD = ±2.12 in boys; SD = ±1.82 in girls), the values normal around the average being between 9.76 and 13.92 seconds (between 9.08 and 13.32 in boys; between 10.72 and 14.36 in girls). The standard error of the mean (ES) is for the whole group ES=±0.23 seconds, for boys, ES=±0.33; for girls, ES=±0.30. According to the age variable, we find that the research subjects have the following values of the static balance: at 9 years M = 14.06 sec. (SD = ±0.85); at 8 years M = 12.86 sec. (SD = ±1.21); at 7 years M = 10.89 sec. (SD = ±1.40); at 6 years M = 9.53 sec. (SD = ±1.04) (see Appendix B, Table 6).

The descriptive statistical analysis of the results obtained in the buoyancy test, used for the measurement of the independent variable - body balance on the water, indicates an arithmetic mean (M) of 18.48 sec. (M = 17.79 in boys; M = 19.24 in girls) and a standard deviation (SD) of ±2.10 (SD = ±1.74 for boys; SD = ±2.23 for girls), the values normal around the average being between 16.38 and 20.58 sec. (between 16.05 and 19.53 for boys; between 17.01 and 21.47 for girls). The standard error of the mean (ES) for the entire group is ES=±0.24 sec., for boys, ES±0.27, for girls, ES=±0.37. Depending on their age, the research subjects recorded the following values of body balance on water: at 9 years M = 20.92 sec. (SD = ±1.38); at 8 years M = 19.14 sec. (SD = ±1.26); at 7 years M = 17.79 sec. (SD = ±1.03); at 6 years M = 16.05 sec. (SD = ±0.64) (see Appendix B, Table 7).

The descriptive statistical analysis of the results obtained in the coordination tests, used to measure the independent variable - the coordination of the body segments and the body as a whole, indicated an arithmetic mean (M) of 12.09 points (M = 11.58 in boys; M = 12.67 in girls) and a standard deviation (SD) of ±2.11 (SD = ±2.38 for boys; SD = ±1.62 for girls), with normal values around the mean being between 9.98 and 14 .20 percent (between 9.20 and 13.96 for boys; between 11.05 and 14.29 for girls). For the whole group the standard error of the mean ES= ±0.24 points, for boys, ES=±0.37, and for girls ES=±0.27. According to the age variable, the research subjects recorded the following values of segmental and general body coordination: at 9 years M = 14.21 points (SD = ±1.03); at 8 years M = 13.11 points (SD = ±1.04); at 7 years M = 11.63 points (SD = ±1.06); at 6 years M = 9.42 points (SD = ±1.34) (see Appendix B, Table 8).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

3.2. Inferential Statistical Analysis - Hypothesis Testing

Checking the condition of normality of the eight variables analyzed in the study was performed using the Kolmogorov-Smirnov and Shapiro-Wilk statistical tests. The obtained values show that four of them have a normal distribution: body schema, body balance on water, front crawl style technique and learning swimming technique. The other four have a distribution that does not meet the condition of normality: manual dexterity, static balance, coordination, backstroke style technique (see Table 9).

Table 9. Tests for checking the condition of normality on data distribution.

Research variables	Kolmogorov-Smirnov			Shapiro-Wilk			Distribution
	K-S	df	Sig.	S-W	df	Sig.	
Manual dexterity	.146	76	.000	.926	76	.000	not normal
Body schema	.096	76	.078	.979	76	.248	normal
Static balance	.104	76	.040	.964	76	.031	not normal
Body balance on the water	.092	76	.176	.968	76	.054	normal
Coordination	.127	76	.004	.958	76	.013	not normal
Front crawl style technique	.101	76	.053	.974	76	.118	normal
Backstroke style technique	.123	76	.006	.956	76	.010	not normal
DV – swimming styles learning	.077	76	.200*	.981	76	.299	normal

To test the hypotheses, the Person correlation coefficient (*r*) was used for variables with normal, parametric distributions and the Spearman coefficient (*rs*) for variables with not-normal, non-parametric distributions. According to [103,104], the interpretation of the obtained values of *r*/*rs* was carried out as follows: between 0.01 - 0.09 - negligible positive relationship; *r*/*rs* between 0.10 - 0.39 - weak positive relationship; *r*/*rs* between 0.40 - 0.69 - moderate positive relationship; *r*/*rs* between 0.70 - 0.89 strong positive relationship; *r*/*rs* between 0.90 - 1.00 very strong positive relationship. When r has a negative value, we use the same interpretation range with the specification that the association is negative. In addition, due to the inconsistency of the correlation coefficient, the coefficient of determination (the square of the correlation coefficient r^2) was also calculated [104].

Hypothesis H1: There is a positive relationship between psychomotor behaviors and front crawl style technique learning.

Hypotheses derived from hypothesis H1:

H1a: There is a positive relationship between manual dexterity and front crawl style technique learning.

H1b: There is a positive relationship between body schema and front crawl style technique learning.

H1c: There is a significant statistical difference regarding laterality (between right-handers and left-handers) in front crawl style technique learning.

H1d: There is a positive relationship between static balance and front crawl style technique learning.

H1e: There is a positive relationship between body balance on the water (buoyancy) and front crawl style technique learning.

H1f: There is a positive relationship between general coordination and front crawl style technique learning.

Testing hypothesis H1a. Manual dexterity, as the independent variable, has a non-normal distribution of results, and technical execution of front crawl style, as the dependent variable, has a normal distribution. The obtained value of the Spearman coefficient (rs = 0.63, p=0.001) suggests that there is a positive, statistically significant association of moderate intensity between the two variables. The value of the coefficient of determination (r^2 = 0.40) shows us that 40% of the variation in front crawl style technique learning can be "explained" by the relationship with the manual dexterity variable. Therefore, hypothesis H1a is confirmed.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

Testing hypothesis H1b. Both variables, the body scheme and the technical execution of the front crawl style, have a normal distribution (of continuous probability) of the results, the value of the Pearson correlation coefficient (r = 0.80, p= 0.001) suggests that we have a positive relationship between the two variables, statistically significant. The coefficient of determination (r^2 = 0.64) shows that 64% of the variation in front crawl style technique learning can be "explained" by the relationship with the body schema variable. Thus, hypothesis H1b is confirmed.

Testing the hypothesis H1c. To test this hypothesis, we initially verified the existence of significant differences between the arithmetic means obtained when learning the front crawl style for both hand laterality and foot laterality, using the t-test for independent samples. The arithmetic mean of the values obtained in the technical execution of the front crawl style for the subjects who have the dominant right-hand (M = 20.76; SD = ±2.05) is not significantly lower (t = -0.61; df = 74; p = 0.53) than that of left-dominant subjects (M = 21.22; SD = ± 2.43). The arithmetic mean of the values obtained during the technical execution of the front crawl style for the subjects who have the dominant right-leg (M = 20.78; SD = ±2.06) is not significantly lower (t = -0.44; df = 74; p = 0.65) than that of left-leg dominant subjects (M = 21.11; SD = ± 2.36). Hypothesis H1c is rejected.

Testing the hypothesis H1d. Static balance, as the independent variable, has a non-normal distribution of results, and front crawl style technical execution, as the dependent variable, has a normal distribution. As a result, to verify the relationship between these two variables we used the Spearman correlation coefficient (rs = 0.82, p=0.001), which leads us to appreciate that there is a positive, statistically significant association of strong intensity. The coefficient of determination (r^2 = 0.67) indicates that 67% of the variation in front crawl style technique learning can be "explained" by the relationship with the static balance variable. Thus, hypothesis H1d is confirmed.

Testing hypothesis H1e. Both variables, the balance of the body on the water (buoyancy) and the technical execution of the front crawl style, have a normal (continuous probability) distribution of results. The obtained value of the Pearson coefficient (r = 0.78, p=0.001) indicates the existence of a positive, statistically significant association of strong intensity between the two variables. The coefficient of determination (r^2 = 0.61) indicates that 61% of the variation in front crawl technique learning can be "explained" by the relationship with the variable body balance on the water. Hypothesis H1e is confirmed.

Testing the hypothesis H1f. General coordination, as the independent variable, has a non-normal distribution of results, and front crawl technique, as the dependent variable, has a normal distribution. The Spearman coefficient suggests a positive, statistically significant association of strong intensity (rs = 0.81, p=0.001) between the two variables. The coefficient of determination (r^2 = 0.65) indicates that 65% of the variation in front crawl technique learning can be "explained" by association with the general coordination variable. Hypothesis H1f is confirmed.

In summary, the statistical values obtained show us the level of association, statistically significant, between the independent variables and the dependent variable, which leads us to confirm hypothesis H1 (see Table 10).

Table 10. The correlations between the independent variables and the technical execution of the front crawl e style.

Independent variables	Dependent variable	Coefficient of correlation	Association level	Sig.
Manual dexterity	Technical execution of front crawl style	rs = 0,63	moderate	p = 0,001
Body schema		r = 0,80	strong	
Static balance		rs = 0,82	strong	
Body balance on the water		r = 0,78	strong	
General coordination		rs = 0,81	strong	

Hypothesis H2: There is a positive relationship between psychomotor behaviors and backstroke style technique learning.

Hypotheses derived from hypothesis H2:

 doi:10.20944/preprints202307.0823.v1

H2a: There is a positive relationship between manual dexterity and backstroke style technique learning.

H2b: There is a positive relationship between body schema and backstroke style technique learning.

H2c: There is a significant statistical difference regarding laterality (between right-handers and left-handers) in backstroke style technique learning.

H2d: There is a positive relationship between static balance and backstroke style technique learning.

H2e: There is a positive relationship between body balance on the water (buoyancy) and backstroke style technique learning.

H2f: There is a positive relationship between general coordination and backstroke style technique learning.

Testing the hypothesis H2a. The two invoked variables have non-normal distributions, which led us to calculate the Spearman correlation coefficient. The value of the Spearman correlation coefficient (*rs* = 0.57, p=0.001) shows that there is a positive association, statistically significant, of moderate intensity, between manual dexterity, as the independent variable, and learning the backstroke execution technique, as the dependent variable, there being a less than 1 in 1000 probability of obtaining a *rs* = 0.63 under conditions where there would be no correlation between the two variables. The coefficient of determination ($r^2 = 0.32$) indicates that 32% of the variation in backstroke technique learning can be "explained" by association with the manual dexterity variable. Hypothesis H2a is confirmed.

Testing hypothesis H2b. Body schema, as the independent variable, has a normal distribution of results. In contrast, backstroke execution technique, as the dependent variable, has a non-normal (non-continuous probability) distribution of outcomes. The Spearman correlation coefficient (*r* = 0.77, p=0.001) suggests the existence of a positive, statistically significant, strong association between the two variables. The obtained value of the coefficient of determination ($r^2 = 0.59$) shows that 59% of the variation in the learning of the process execution technique can be "explained" by the association with the body schema variable. Therefore, we can state that hypothesis H2b is confirmed.

Testing hypothesis H2c. To test this hypothesis, we verified the existence of significant differences between the arithmetic means obtained when learning the backstroke technique, both for the laterality of the hand and for the laterality of the foot, using the t-test for independent samples. The arithmetic mean of the values obtained in the execution technique of the back procedure for children who have the dominant right hand (M = 20.93; SD = ±1.69) is not significantly lower (t = -0.49; df = 74; p = 0.62) than that of left-handed children (M = 21.22; SD = ± 1.71). The arithmetic mean of the values obtained in the backstroke execution technique for children who have the dominant right leg (M = 20.96; SD = ±1.71) is not significantly lower (t = -0.74; df = 74; p = 0.94) than that of children who have the dominant left leg (M = 21.00; SD = ± 1.58). Hypothesis H2c is rejected.

Testing hypothesis H2d. Both variables, static balance and backstroke execution technique, have a non-normal (non-continuous probability) distribution of results. The Spearman correlation coefficient (*rs* = 0.81, p<0.001) suggests a positive, strong, statistically significant relationship between the two variables. The coefficient of determination ($r^2 = 0.65$) shows us that 65% of the variation in learning the backstroke execution technique can be "explained" by association with the static balance variable. Hypothesis H2d is confirmed.

Testing hypothesis H2e. The balance of the body on the water (buoyancy), as the independent variable, has a normal (Gaussian) distribution of the results, and the execution technique of the backstroke style, as the dependent variable, has a non-normal distribution of the results. The Spearman correlation coefficient (*rs* = 0.85, p<0.001) indicates the existence of a positive, strong, statistically significant relationship. The coefficient of determination obtained ($r^2 = 0.72$) suggests that 72% of the variation in backstroke technique learning can be "explained" by the relationship with the variable body balance on the water. Thus, hypothesis H2e is confirmed.

Testing the hypothesis H2f. Both variables, general coordination and backstroke execution technique, have a non-normal distribution of results. The Spearman correlation coefficient (*rs* = 0.78, p<0.001) shows the existence of a positive, strong and statistically significant relationship between the variables. The value of the coefficient of determination ($r^2 = 0.61$) suggests that 61% of the variation in backhand technique learning can be "explained" by the relationship with the general coordination variable. Therefore, hypothesis H2f is confirmed.

In summary, the statistical values obtained show us the level of association, statistically significant, between the independent variables and the dependent variable, leading us to confirm hypothesis H1 (see Table 11).

Table 23. The correlations between the independent variables and the technical execution of the backstroke style.

Independent variables	Dependent variable	Coefficient of correlation	Level of association	Sig.
Manual dexterity	Technical execution of backstroke style	rs = 0,57	moderate	p = 0,001
Body schema		rs = 0,77	strong	
Static balance		rs = 0,81	strong	
Body balance on the water		rs = 0,85	strong	
General coordination		rs = 0,78	strong	

4. Discussion

In this study we aimed to verify the influences of some psychomotor behaviors (manual dexterity, body scheme, laterality, static balance, body balance on the water, general coordination) in the process of learning the execution technique for two styles of swimming, front crawl and backstroke.

The results of the study for the "Tapping" test suggest that the subjects register a good level of manual dexterity, being in agreement with the values obtained in other studies [34,105–107]. The better level recorded in girls compared to boys is also confirmed by the study of Junaid & Fellowes [108], who observed that in children between 6 and 8 years old, boys develop ball skills earlier than girls and that girls acquire dexterity manual before the boys. The age of the subjects, between 4-15 years, also influences the level of manual dexterity, as suggested by other studies [109].

The values obtained for the assessment of the body schema indicate a good level for the whole sample, better in girls compared to boys. These results are in agreement with previous studies [110–112]. Significant statistical differences were revealed between girls and boys aged between 5 and 8 years for the body schema, measured by the Draw-a-Person test [113]. Thus, girls seem to have more knowledge about body dimensions (e.g., tall, short, thin, fat, etc.) or a greater ability to judge their body in terms of size and shape compared to boys [114]. León et al. [114] also highlights the interdependence between age and body schema in children between 4-15 years. Children's judgments about the sizes of body segments and the body as a whole - the body schema - improve with age, and the period 6-9 years is the one in which the image of one's own body in space and time takes shape. At preschool ages, body image is unstable, and children's cognitive limitations could explain the lack of a good body schema representation.

Regarding laterality, there are predominantly more right-hand and foot-dominant subjects than left-hand-dominant subjects. The results, depending on the gender, indicate more right-dominant boys than girls, while left-dominant girls are in a higher percentage than boys. Geschwind & Miller [60] state that approximately 8-10% of the world's population is strongly left-handed, and more than 90% are right-handed, an aspect that is also found among the subjects of this research. And in other studies, this aspect of the laterality of the limbs is confirmed, about 90% of the total population of the world has the dominant laterality expressed on the right side [56,115]. In the literature, no significant performance differences of laterality (right-handed vs. left-handed) were found according to the gender variable [53,56]. The gender variable does not influence the manifestation of laterality.

According to the age variable, that right-dominant subjects are in close proportions, while, among left-dominant subjects, no 7-year-old subject is identified, most being 9-year-old (44,45 %). The aspects that determine laterality are individual and complex, and appear throughout the psycho-biological development process of each individual [116]. There are studies that show that laterality is manifested from prenatal life [117]. Sensory and motor demands lead humans to develop a motor asymmetry based on a lateral dominance that, once established, remains consistent throughout the lifespan [117,118].

Laterality was invoked in the present research in order to make a comparison between children with laterality on the right side and those on the left side in the process of learning sports swimming procedures. In recent years, an increasing number of studies have mentioned laterality in relation to technical, behavioral, physical and tactical factors in sport [62,63], but without going into depth on this topic or offering specific tools.

From our study it emerged that subjects with laterality on the right side would learn better the execution technique of the two swimming styles, front crawl and backstroke, compared to those with laterality on the left side, but the differences between the means are not statistically significant. Both hypotheses regarding the laterality, both regarding the hand and the foot, in learning the technique of the front crawl and backstroke styles, were disproved ($p > 0.05$).

Laterality refers not only to left-right preference [64–66], but also to the way an athlete directs his body in space [66,67], which we did not address in this study.

In the literature, lower limb laterality is shown to be a better predictor of sports performance than upper limb laterality [53]. It is also known that approximately 90% of the adult population is right-handed dominant, and the remaining 10% are left-handed, an aspect that is also found in the study sample of this research. What is less understood is how laterality develops and at what age adult-like patterns of laterality emerge [54].

The results obtained in the Flamingo test, which measured static balance, indicate a good level of it, better in girls compared to boys. The results are consistent with the synthesis of Schedler et al. [119] who concluded that for subjects aged 6–18 years, girls perform better than boys in demonstrating static balance, and boys perform slightly better than girls in demonstrating dynamic balance and pro-active balance. And in our study, girls have better static balance than boys by 1.34 seconds. Our results suggest that the older the age, the better the level of balance. Schedler et al. [119,120] identified that adolescents (14-18 years) have better balance performance (static, dynamic and proactive) than children (6-13 years). In other studies [121,122] it was found that teenagers have better postural control than children and contradict certain theories that claim that body balance is defined around the age of ten. Human balance maturity is not completed in childhood and may last until adolescence or young adulthood [119]. The age period between 6-8 years is considered a transitional phase in the development of postural control, when balance performance increases sharply, which has been attributed to better sensory and motor manifestation, as well as changes in postural control strategies [123,124].

The values obtained in the water body balance test suggest that girls register a better level compared to boys. McLean & Hinrichs [125] concluded, based on a study identifying the distance (d) between the center of gravity (CG) and the center of buoyancy (CF) in male and female swimmers aged 18-19 years, that girls have this much smaller distance compared to boys and, implicitly, better buoyancy. Depending on the locations of the CG and the CF, the body can be either stable, neutral, or unstable [86]. The body is stable when it remains at the surface of the water, it is neutral when it balances somewhere in the water mass, and unstable when it sinks completely. And in our study, girls have better buoyancy than boys, this is shown by maintaining the balance of the body on the water for 1.45 seconds longer. In swimming, anthropometry affects hydrostatics and hydrodynamics; hydrostatics and hydrodynamics influence biomechanics (execution technique); biomechanics influences the energy resources; and energetic resources influence swimming performance [23].

Although differences by age are recorded in the study, we did not identify research showing that this variable is a predictor of body balance on water (buoyancy) and therefore able to compare results.

In our study, the difference in the level of coordination according to gender is in favor of girls, by 1.09 points. Regarding the manifestation of segmental and general body coordination by gender, Battaglia et al. [126] concluded that there were significant differences in motor quotient scores between girls and boys. These results are similar to those reported in other studies that showed significant differences in motor skills between boys and girls, in favor of boys [127,128]. Gender differences in terms of motor quotient (motor coordination), where boys perform better than girls, could be related to both daily physical activities and sports practice, aspects that favor boys [128,129]. In a study with 2815 subjects (children and adolescents) aged between 3 and 15 years, in which

 doi:10.20944/preprints202307.0823.v1

approx. 90% of participants had a good body weight, Ishii et al. [130] reported that boys were more physically active than girls.

The results of the study, similar to other studies [128], suggest that, also in the case of coordination, its level increases with age, for both genders. The general motor behavior of children and adolescents, consisting of everyday daily activities and the practice of physical activities in an organized setting, is determined by the level of motor coordination ability [131]. Furthermore, higher levels of coordination during childhood and adolescence influence children's ability to successfully participate in movement situations and engage in physical activity throughout life [132,133].

The hypothesis of the study presupposes the verification of the existence of a positive relationship between psychomotor behaviors (manual dexterity, body scheme, general coordination, static balance and body balance on the water) and the process of learning the execution technique of the two styles of swimming, front crawl and backstroke. The results show positive correlations of strong intensity (r or rs between 0.77 and 0.85), which makes us say that the association of these variables is very important. Only manual dexterity registered a positive correlation of moderate intensity ($rs = 0.63$ for the crawl procedure; $rs = 0.57$ for the back procedure).

There are studies in the literature that show that it is possible to improve sports performance by manipulating anthropometric, biomechanical and/or energetic variables (Barbosa et al., 2010b). Also, anthropometric, hydrostatic and hydrodynamic variables are described as related to swimming performance [26–29]. Anthropometric, hydrodynamic and biomechanical testing procedures are often reported in the literature attempting to predict swimming performance, as in other sports disciplines [30]. The literature is no longer as "rich" regarding psychomotor behaviors and their association with sport swimming (learning or improvement).

The novelty in this research comes from the fact that it proposes the association of these variables with swimming and also approaches as the dependent variable the learning process of swimming styles and not the sports performance in swimming. The process of learning the technique of execution of swimming styles is missing from the literature, although it is the basis on which future sports performance is built.

In carrying out this study, a series of aspects were identified that can be considered as limitations of the research. Limitation of the research sample was due to either parents opting out of their children's participation in the study or dropping out of swimming lessons along the way. Also, some results could be negatively influenced by certain environmental barriers (noises, etc.) by decreasing the subjects' ability to focus.

Future research directions can be oriented towards the identification of causal relationships, through quantitative, linear regression analyses, between the variables invoked.

5. Conclusions

All psychomotor behaviors analyzed in the study (manual dexterity, body schema, static balance, body balance on the water and general coordination) had positive relationships with learning the execution technique of swimming, front crawl and backstroke styles. Manual dexterity had positive associations of moderate intensity (both neck and back), and the other variables had positive associations of strong intensity with both procedures. Thus, we can conclude that they are very important in the process of learning sports swimming styles. Therefore, the main hypothesis formulated was confirmed.

The study gave us the opportunity to analyze the balance of the body on the water (buoyancy) and from a psychomotor perspective, not just from a hydrostatic and dynamic perspective in learning some swimming styles.

Author Contributions: Conceptualization: P.R.G., M.C.E., R.O., P.I.M., Ș.I.C. and C.M.; methodology, P.R.G., M.C.E., R.O., R.L.E. and R.C.M.; software, P.R.G., P.I.M., R.L.E. and R.O.; validation, P.R.G., M.C.E, O.A., R.L.E., P.I.M. and R.C.M.; formal analysis, P.R.G., O.A., C.M. and Ș.I.C.; investigation, P.R.G., C.M., O.A:, Ș.I.C. and R.C.M.; writing—original draft preparation, P.R.G., M.C.E., R.O., P.I.M., C.M., Ș.I.C., O.A., R.C.M. and R.L.E.; writing—review and editing, P.R.G., M.C.E., R.O., P.I.M., Ș.I.C., C.M., R.L.E., R.C.M. and O.A. All authors have equal contributions. All authors have read and agreed to the published version of the manuscript.

Funding: This research was co-funded by the European Social Fund, through Operational Programme Human Capital 2014-2020, project no POCU/993/6/13/153322, project title "Educational and training support for PhD students and young researchers in preparation for insertion in the labor market".

 doi:10.20944/preprints202307.0823.v1

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Faculty of Physical Education and Sport, "Alexandru Ioan Cuza " University of Iasi (protocol code 13bis form March 30ty 2021).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study through their legal representatives.

Data Availability Statement: The data are available upon request from the corresponding author.

Acknowledgments: In this section, you can acknowledge any support given which is not covered by the author contribution or funding sections. This may include administrative and technical support, or donations in kind (e.g., materials used for experiments).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

1. Tests for measuring and evaluating independent variables

To measure manual dexterity, we used the "Tapping" test, created to measure manual dexterity and speed [34,105–107], for both hands. The subjects received a stopwatch, a pencil and two sheets of 20/20 cm size, on each sheet a square with a side of 10 cm was printed, divided into 100 squares with a side of l cm. The subject had to make, with the pencil, one point in each of the 100 squares, first with the dominant hand, then with the other. The timer was started when the child made the first point and stopped after the child made the last point. The total score summarized the time, in seconds converted to centiles, that the child obtained on the two tests (right-handed and left-handed). It is considered poor dexterity (0-30 centiles), average dexterity (31-70 centiles), good dexterity (71-100 centiles).

The Goodenough test was used to measure the body schema [110,112]. The test can be applied to children between 3 and 13 years old with a double role: detecting mental deficiencies and identifying the IQ level that a child can have at different ages [111]. The subject was asked to draw a man on the sheet of paper, being encouraged but not helped or influenced. The presence/absence of 27 elements were scored, the maximum score being 30 points (26 from the body elements and 4 from the presented clothing items).

For normally developed children the scores (± 1 point) regarding the cortical representation of the body schema are: at 3 years = 6 points; at 4 years = 8 points; at 5 years = 10 points; at 6 years = 14 points; at 7 years = 18 points; at 8 years = 20 points; at 9 years = 22 points; at 10 years = 24 points; at 11 years = 26 points; at 12-13 years = 28 points [110,112].

Hand laterality was assessed by means of the Tapping Test, which was also used for the manual dexterity variable. The dominant hand was identified both qualitatively (by observation) and quantitatively (by the number of seconds obtained). In order to convince us that the detection of the dominant hand was correct, two more tests were used, each performed twice: throwing to the target and erasing with the eraser [134]. Two tests were used to detect the dominant leg: four successive jumps on one leg and kicking a ball [134]. The tests were performed twice.

The Flamingo test was used to measure static balance [135–138]. The test requires participants to maintain a standing position on one leg with hands on hips, the other lower limb should be flexed at the knee and with the sole pressed against the medial aspect of the knee of the base leg. The test can be taken both with the eyes closed and with the eyes open. It was performed on both the right and left legs as described above, with the eyes closed. The test was performed twice for each leg and the best time (expressed in seconds) was taken into account. The arithmetic mean (of the best time from the right leg with the best time from the left leg) was used in the statistical analysis. Through this test, the laterality of the lower limbs was also monitored.

Body balance on water testing (buoyancy) was performed using the horizontal buoyancy test [139–143] by adapting the vertical buoyancy test [29]. The test was applied to the children after they had participated in a minimum of five swimming sessions and were adapted to the water. Subjects were asked to lie horizontally in the water with the lower and upper limbs extended in body extension and slightly apart, hands no more than hand-width apart, and feet no more than basin-width apart. At the level of the internal malleolus (between the legs) a plastic bar graduated in centimeters and positioned vertically (perpendicular to the bottom of the pelvis) was placed. The zero point was considered to be at the water level marked by a white band, and ten centimeters below (in

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

the water) another white band was mounted. Also, the children's ankles were marked. Testing was performed both from the face lying position (on the chest) and from the dorsal lying position (on the back). The children were placed on the water by a trainer, an assistant positioned the bar at the level of the inner ankles and timed. The time (in seconds) maintained in the horizontal position was measured. The timer was stopped when the feet (inner malleolus) reached the level of the second white band. The test was performed twice both for the face lying position (on the chest) and for the dorsal lying position (on the back). An assistant recorded the best time (for the facial position and for the dorsal position). In the statistical analysis, the arithmetic mean of the times (in seconds) obtained at the two positions was used.

The following tests were used for coordination:

➢ coordinating the movements of the upper limbs from the initial position standing slightly apart:

1) rotating the arms from the shoulder joint, simultaneously forward;
2) rotating the arms from the shoulder joint, simultaneously backwards;
3) rotation of the arms from the shoulder joint, simultaneously, the right forward and the left backward;
4) rotation of the arms from the shoulder joint, simultaneously, the left forward and the right backward;
5) arm shears in the transverse plane with the hands from thigh level above the head and vice versa, the lower limbs are perfectly stretched;

For tests 1-5, the minimum execution time in the context of the age-appropriate assessment was followed (at 6 years = 10 seconds; at 7 years = 15 seconds; at 8 years = 20 seconds; at 9 years = 25 seconds).

➢ coordination of the lower limbs - jumping on the coordination scale

6) successive jumps on both legs;
7) successive jumps with the right leg, followed by jumps with the left leg;
8) successive alternating jumps (right/left);
9) successive jumps on both legs (from near to far; inside and outside the steps of the coordination ladder);
10) lateral jumps, successive, from one foot to another.

Specification for the number of repetitions according to age: at 6 years = 8; at 7 years = 10; at 8 years = 12; at 9 years = 14 jumps.

➢ general coordination and spatial orientation

11) The Matorin test [144] which consisted of a jump on both feet with an attempt to turn 3600 around the longitudinal axis of the body.

The measurement of coordination was carried out by two trainers, for tests 1-10, the value "1" was assigned for successful execution and the value "0" for unsuccessful execution. For the Matorin test, values between 1 and 8 were assigned as follows: jumping between 0-450= 1 point; jump between 46-900 = 2 points; jump between 91-1350 = 3 points; jump between 136-1800 = 4 points; jump between 181-2250 = 5 points; - jump between 226-2700 = 6 points; - jump between 271-3150 = 7 points; - jump between 316-3600 = 8 points. Each subject performed the 11 coordination tests twice and the best performance was taken into account. The score obtained was calculated by summing all the points obtained in all 11 coordination tests. This can be between 0 and 18.

2. Tests for Measuring the Dependent Variables

The test for measuring and evaluating the technical execution of the front crawl style tracked the execution of the following technical details:

- Assessment of the movement of the upper limbs in the active phase - action of the hand through the water***:***

1) the hand enters the water with the thumb;
2) the hand enters the water in the extension of the head between the shoulder and the sagittal plane;
3) the hand grabs the water (flexion of the hand on the forearm);
4) drawing water, the upper limb flexed at the elbow;
5) pushing the water, the palm reaches the thigh;
6) the hand leaves the water with the little finger;

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

- Assessment of the movement of the upper limbs in the preparatory phase - the action of the hand through the air:
7) rotation of the arm from the shoulder joint, the forearm flexed on the arm, in the aerial way the elbow is higher than the hand;
- Assessment of the movement of the lower limbs in the descending and ascending phase:
8) the whipping movement of the lower limbs;
9) plantar flexion of the foot, the heel leaves the water;
10) the range of motion between the two lower limbs is correct (35 - 45 cm)
- Assessment of coordination between upper and lower limbs:
11) when executing a cycle of movements of the upper limbs, the presence of two cycles of movements of the lower limbs.
- Assessment of lateral breathing (breathing with two arms) and its coordination with the execution technique:
12) the lateral twisting of the head (cervical area) is doubled by the twisting of the trunk only from the thoracic area (the hips are not involved in this movement), and the upper limb that is in the water must be stretched in the extension of the body;
13) the head does not lose contact with the water during lateral breathing (without head extension);
14) the distance between the chin and the chest is the same (both in the face lying position and during the lateral twisting movement);
15) inhalation is done through the mouth, deep, short, in the active phase (through the water) of an upper limb (right or left - at your choice), followed by a short apnea when the hand leaves the water;
16) exhalation through the mouth and nose, slow, long, in the active phase (through water) of the other upper limb (opposite to the one we referred to for inspiration);
17) the direction of movement on the water is linear, without left-right oscillations.

The technical details presented in points 1 - 9 have been evaluated for both the right and left limbs. The correct execution of each technical aspect in the global execution of the crawl procedure was scored with "1", and the lack or wrong execution was scored with "0". Each subject performed the front crawl over a distance of 50 m (two pool lengths), the measurement and evaluation test of the crawl procedure being performed twice, the best result being used for statistical analysis. The final score was made by adding up all the points obtained in all technical aspects, which could be between 0 and 26.

The test for measuring and evaluating the technical execution of the backstroke style tracked the execution of the following technical details:
- Assessment of the movement of the upper limbs in the active phase - the action of the hand through the water:
1) the hand enters the water with the little finger;
2) the hand enters the water in the extension of the head next to the shoulder;
3) the hand grabs the water (flexion of the hand on the forearm);
4) pulling the water, the upper limb flexed at the elbow (side rowing);
5) water push, the palm reaches the thigh;
6) the hand leaves the water with the thumb;
- Assessment of the movement of the upper limbs in the preparatory phase - the action of the hand through the air:
7) rotation of the upper limb from the shoulder joint, perfectly stretched from the elbow and hand joints; this movement is doubled by the internal rotation (in the longitudinal axis) of the upper limb near the shoulder so that the hand enters the water with the little finger;
- Assessment of the movement of the lower limbs in the descending and ascending phase:
8) whipping movement of lower limbs;
9) plantar flexion of the foot, the phalanges of the toes leave the water;
10) the amplitude of the movement between the two lower limbs is correct (35 - 45 cm);
11) the head (cervical area) does not lose contact with the water;
12) the head is in a slight flexion with respect to the trunk, the distance between the chin and the chest is the same (over the entire travel distance);
- Assessment of coordination between upper and lower limbs:

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

13) when performing a cycle of upper limb movements, the presence of two lower limb movement cycles;
- Assessment of breathing and its coordination with the execution technique:
14) inhalation is done through the mouth, deep, short, in the first third of the airway of an upper limb (right or left - at your choice), followed by a short apnea until the limb enters the water;
15) exhalation through the mouth and nose, slow, long, in the active phase (through water) of the same upper limb (to which we referred for inspiration);
16) the direction of movement on the water is linear, without left-right oscillations.

The technical details presented in points 1 - 9 have been evaluated for both the right and left limbs. The correct execution of each technical aspect in the global execution of the back procedure was scored with "1", and the lack or wrong execution was scored with "0". Each subject performed the backstroke over a distance of 50 m (two pool lengths), the measurement and evaluation test of the backstroke being performed twice, the best result being used for statistical analysis. The final score was made by adding up all the points obtained for all technical aspects, which could be between 0 and 25.

Appendix B

Table 1. Descriptive statistical analysis - manual dexterity variable.

		Subjects	Male	Female
N	Valid	76	40	36
	Lack	0	0	0
Arithmetic mean (M)		74.08	73.38	74.86
Standard error of the mean (ES)		1.157	1.615	1.672
Median (Me)		75	75	75
Module (Mo)		70	70[a]	80
Standard Deviation (DS)		10.090	10.215	10.035
Amplitude (A)		40	40	40
The minimum value (Vmin)		50	50	50
Maximum value (Vmax)		90	90	90

Table 2. Descriptive statistical analysis – body schema variable.

		Subjects	Male	Female
N	Valid	76	40	36
	Lack	0	0	0
Arithmetic mean (M)		19.20	18.65	19.81
Standard error of the mean (ES)		.410	.569	.581
Median (Me)		19	19	19.50
Module (Mo)		19	19	19
Standard Deviation (DS)		3.570	3.599	3.487
Amplitude (A)		16	14	14
The minimum value (Vmin)		12	12	14
Maximum value (Vmax)		28	26	28

Table 3. Right-dominant subjects by gender variable.

Laterality on the right side	Gender	Research subjects	
		Valid	Total

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

		N	Percentages	N	Percentages
Right-hand dominant	Male	36	53,73%	67	100.0%
	Female	31	46,27%		
Right-leg dominant	Male	36	53,73%	67	100.0%
	Female	31	46,27%		

Table 4. Left-dominant subjects by gender variable.

Laterality on the left side	Gender	Research subjects			
		Valid		Total	
		N	Percentages	N	Percentages
Left-hand dominant	Male	4	44,44%	9	100.0%
	Female	5	55,56%		
Left-leg dominant	Male	4	44,44%	9	100.0%
	Female	5	55,56%		

Table 5. Right-dominant subjects by age variable.

Laterality on the right side	Age	Research subjects			
		Valid		Total	
		N	Percentages	N	Percentages
Right-hand dominant Right-leg dominant	6,0 - 6,11 years	16	23,88%	67	100.0%
	7,0 - 7,11 years	19	28,36%		
	8,0 - 8,11 years	17	25,37%		
	9,0 - 9,11 years	15	22,39%		
Laterality on the right side	6,0 - 6,11 years	16	23,88%	67	100.0%
	7,0 - 7,11 years	19	28,36%		
	8,0 - 8,11 years	17	25,37%		
	9,0 - 9,11 years	15	22,39%		

Table 6. Descriptive statistical analysis – static balance variable.

		Subjects	Male	Female
N	Valid	76	40	36
	Lack	0	0	0
Arithmetic mean (M)		11.8405	11.2088	12.5425
Standard error of the mean (ES)		.23960	.33649	.30460
Median (Me)		12.0900	11.2400	12.9150
Module (Mo)		12.24[a]	13.61[a]	12.24
Standard Deviation (DS)		2.08882	2.12814	1.82758
Amplitude (A)		8.29	7.71	6.92
The minimum value (Vmin)		7.35	7.35	8.72
Maximum value (Vmax)		15.64	15.06	15.64

Table 7. Descriptive statistical analysis - body balance on water(buoyancy) variable.

		Subjects	Male	Female
N	Valid	76	40	36
	Lack	0	0	0
Arithmetic mean (M)		18.4809	17.7955	19.2425
Standard error of the mean (ES)		.24170	.27532	.37276
Median (Me)		18.3600	17.4500	19.0500
Module (Mo)		15.98[a]	16.04[a]	15.74[a]
Standard Deviation (DS)		2.10711	1.74126	2.23654
Amplitude (A)		8.62	6.70	7.70
The minimum value (Vmin)		14.82	14.82	15.74
Maximum value (Vmax)		23.44	21.52	23.44

Table 8. Descriptive statistical analysis – coordination variable.

		Subjects	Male	Female
N	Valid	76	40	36
	Lack	0	0	0
Arithmetic mean (M)		12.09	11.58	12.67
Standard error of the mean (ES)		.243	.377	.270
Median (Me)		12.00	12.00	13.00
Module (Mo)		14	12	14
Standard Deviation (DS)		2.118	2.385	1.621
Amplitude (A)		9	9	6
The minimum value (Vmin)		7	7	10
Maximum value (Vmax)		16	16	16

References

1. Gordon, W.A. Structura şi dezvoltarea personalităţii. Didactică şi Pedagogică: București, Romania, 1991
2. Oliveira, G. Psicomotricidade: Educação e Reeducação num enfoque Psicopedagógico. 5th ed., Vozes: Sao Paolo, Brazil, 2001.
3. Borges, M.F.; Rubio, J.A.S. A Educacao Psicomotora como instrumento no Processo de Aprendizagem, Rev. Eletronica Saberes Educ. 2013, 4(1), 1-12.
4. Rabelo, K.I.L.; Aquino, G.B. Relacao entre psicomotricidade e desenvolvimento infantil: um relato de experiencia. Rev. Cient. Faminas 2014, 10, 109-123.
5. Viscione, I.; D'elia, F.; Vastola, R.; Sibilio M. Psychomotor assisment in Teaching and Educational research, Athens J. Educ. 2017, 4(2),169-178.
6. Wallon, H. Evoluţia psihologică a copilului. Pro Humanitate: București, Romania, 1975.
7. Piaget, J.; Barber, I. Psihologia copilului. Cartier: București, Romania, 2005.
8. Sas, L.G.; Farina, E.F.; Ferreiro, M.C.; Fernandez, J.E.R.; Couto, J.M.P. Improvement of self-esteem and emotional intelligence through psychomotricity and social skills workshops. Sportis Sci J 2017, 3(1), 187-205.
9. Shingjergji, A. Psycho-motor education of the pre-school children - a possibility for qualitative training. Int. lett. Soc. Humanist. Sci. 2014, 6, 74-80.
10. Albu, A.; Albu, C. Psihomotricitate. Spiru Haret: Iași, Romania, 1999.
11. Popescu, O.; Popescu, V. Aspects on the motor and psychomotor learning at children with intellectual disabilities, Discobolul 2015, 11(2), 39-42.

12. Schmidt, R.A.; Lee, T.D.; Carolee, W.; Wulf, G.; Zelaznik, H. Motor Control and Learning, 6th ed., Human Kinetics: Champaign, IL, SUA, 2019.
13. Williams, S.J.; Kendall, L. Perceptions of elite coaches and sports scientists of the research needs for elite coaching practice. J Sports Sci. 2007, 25(14), 1577-1586. https://doi.org/10.1080/02640410701245550.
14. Martindale, R.; Nash, C. (2013). Sport science relevance and application: Perceptions of UK coaches. J Sports Sci. 2013, 31(8), 807-819. https://doi.org/10.1080/02640414.2012.754924.
15. Waters, A.; Phillips, E.; Panchuk, D.; Dawson, A. The coach-scientist relationship in high-performance sport: Biomechanics and sprint coaches. Int J Sports Sci Coach 2019, 14(5), 617–628. https://doi.org/10.1177/1747954119859100.
16. Côté, J.; Young, B.W.; North, J.; Duffy, P. Towards a definition of excellence in sport coaching. Int. J. Coach. Sci. 2007, 1(1), 3-17.
17. Phillips, E.; Farrow, D.; Ball, K.; Helmer, R. Harnessing and understanding feedback technology in applied settings. Sports Med. 2013, 43(10), 919–925. https://link.springer.com/article/10.1007/s40279-013-0072-7.
18. Steel, K.A.; Harris, B.; Baxter, D.; King, M. Skill acquisition specialists, coaches and athletes: The current state of play? J. Sport Behav. 2013, 36(3), 291–305.
19. Davids, K.; Renshaw, I.; Pinder, R.; Barris, S.; Greenwood, D. Enhancing skill acquisition and expertise in high performance programmes. In Sport and exercise psychology: Practitioner case studies, Weston, N., Breslin, G., Cotterill S., Eds., 2017, Wiley-Blackwell, UK, pp. 329-353.
20. Dehghansai, N.; Headrick, J.; Renshaw, I.; Pinder, R.; Barris, S. Olympic and paralympic coach perspectives on effective skill acquisition support and coach development. Sport Educ. Soc. 2019, 25(6), 667–680. DOI: 10.1080/13573322.2019.1631784.
21. Brackley, V.; Barris, S.; Tor, E.; Farrow, D. Coaches' perspective towards skill acquisition in swimming: What practice approaches are typically applied in training? J Sports Sci 2020, 38(22), 2532-2542. doi: 10.1080/02640414.2020.1792703.
22. Ginting, A.; Asmawi, M.; Tangkudung, J.; Heri, Z.; Suprayitno, S. Implementation of I-S-L-A-M Learning Model in Improving Free Style Swimming Skill. Advances in Social Science, Education and Humanities Research, 5th International Conference on Physical Education, Sport, and Health 2019, 362, 170-173.
23. Barbosa, T.M.; Bragada, J.A.; Reis, V.M.; Marinho, D.A.; Carvalho, C.; Silva, A.J. Energetics and biomechanics as determining factors of swimming performance: updating the state of the art. J Sci Med Sport 2010a, 13(2), 262-269. doi: 10.1016/j.jsams.2009.01.003.
24. Saavedra, J.M.; Escalante, Y.; Rodríguez, F.A. A multivariate analysis of performance in young swimmers. Pediatr Exerc Sci 2010, 22(1), 135-151. doi: 10.1123/pes.22.1.135.
25. Barbosa, T.M.; Costa, M.; Marinho, D.A.; Coelho, J.; Moreira, M.; Silva, A.J. Modeling the links between young swimmers' performance: energetic and biomechanic profiles. Pediatr Exerc Sci 2010b, 22(3), 379-391. doi: 10.1123/pes.22.3.379.
26. Geladas, N.D.; Nassis, G.P.; Pavlicevic, S. Somatic and physical traits affecting sprint swimming performance in young swimmers. Int J Sports Med 2005, 26(2), 139-144. doi: 10.1055/s-2004-817862.
27. Lätt, E.; Jürimäe, J.; Haljaste, K.; Cicchella, A.; Purge, P.; Jürimäe, T. Longitudinal development of physical and performance parameters during biological maturation of young male swimmers. Percept Mot Skills 2009a, 108(1), 297-307. doi: 10.2466/PMS.108.1.297-307.
28. Lätt, E.; Jürimäe, J.; Haljaste, K.; Cicchella, A.; Purge, P.; Jürimäe, T. Physical development and swimming performance during biological maturation in young female swimmers. Coll Antropol 2009b, 33(1), 117-122. PMID: 19408614.
29. Silva, A.J.; Costa, A.M.; Oliveira, P.M.; Reis, V.M.; Saavedra, J.; Perl, J.; Rouboa, A.; Marinho, D.A. The use of neural network technology to model swimming performance. J Sports Sci Med 2007, 6(1), 117-125. PMID: 24149233.
30. Rogulj, N.; Papić, V.; Cavala, M. Evaluation models of some morphological characteristics for talent scouting in sport. Coll Antropol 2009, 33(1), 105-110. PMID: 19408612.
31. Hohmann, A.; Seidel, I. Talent prognosis in young swimmers. In: Biomechanics and Medicine in Swimming XI, Kjendlie, P.L., Stallman, R.K., Cabri J., Eds., Norwegian School of Sport Sciences: Oslo, 2010, pp. 262-264.
32. Lafon, R. Vocabulaire de psychopedagogie et de psychiatrie infantile. PUF: Paris, France, 1969.
33. Păunescu, C. Copilul deficient - cunoașterea și educarea lui. Științifică și Enciclopedică: București, Romania, 1983.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

34. Radu D.I.; Ulici, G. Evaluarea şi educarea psihomotricităţii. Fundația Humanitas: București, Romania, 2002.
35. Garcia, A.C. The play and the psychomotricity, Monograph. Postgraduate degree in Psychomotricity, Universidade Cândido Mendes: Rio de Janeiro, Brazil, 2007.
36. Mendoza, V. Dessarollo infantil. La teoria de Wallon. Mexico: Asociacion Oaxaquena de Psichologia A.C. 2007.
37. Cro, M.; Andreucci, L.; Pereira, A.; Pinho, A.; Chova, L.; Belenguer, D.; Martinez, A. Psychomotricty, health and well-being in childhood education. Edulearn11: 3rd International Conference on Education and New Learning Technologies 2011, 4716-4722.
38. Epuran, M. Motricitate şi psihism în activităţile corporale. Prolegomene la o metateorie a activităţilor corporale, ludice, gimnice, agonistice, recreative, compensatorii. Vol. 2, FEST: București, Romania, 2013.
39. Merida-Serrano, R.; Olivares-Garcia, M.D.; Gonzalez-Alfaya, M.E. Discovering the world through the body in the childhood. The importance of materials in the child psychomotricity, Retos 2018, 34, 329-336.
40. McGrew, K.S. The Cattell-Horn-Carroll Theory of Cognitive Abilities: Past, Present, and Future. In Contemporary Intellectual Assessment: Theories, Tests, and Issues, 2nd ed., Flanagan, D.P., Harrison, P.L., Eds., The Guilford Press: New York, USA, 2005, pp. 136-181.
41. McGrew, K.S. CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research, Intelligence 2009, 37(1), 1-10. doi:10.1016/j.intell.2008.08.004.
42. Newton J.H.; McGrew K.S. Introduction to the special issue: Current research in Cattell–Horn–Carroll–based assessment, Psychol Sch. 2010, 47(7), 621-634. doi:10.1002/pits.20495.
43. Schneider, W.J.; McGrew, K.S. The Cattell–Horn–Carroll theory of cognitive abilities. In Contemporary intellectual assessment: Theories, tests, and issues, Flanagan, D.P., Harrison P.L., Eds., The Guilford Press: New York, USA, 2018, pp. 73–163.
44. de Vignemont, F. Body schema and body imagePros and cons, Neuropsychologia 2010, 48(3), 669-680. https://doi.org/10.1016/j.neuropsychologia.2009.09.022.
45. Teixeira, H.J.; Abelairas-Gomez, C.; Arufe-Giráldez, V.; Pazos-Couto, J.M.; Barcala-Furelos, R. Influence of a physical education plan on psychomotor development profiles of preschool children. J. Hum. Sport Exer. 2015, 10(1), 126-140. doi:10.14198/jhse.2015.101.11.
46. De Meur, A.; Staes, L. Psyhomotricité. Ėducation et rééducation, niveaux maternel et primaire. Ed. De Boeck: Bruxelles, Belgium, 1988.
47. Matsumiya, K. Multiple representations of the body schema for the same body part. Proc Natl Acad Sci 2022, 119(4), 1-9. doi: 10.1073/pnas.2112318119.
48. Haggard, P.; Wolpert, D. Disorders of body scheme. In Higher-Order Motor Disorders, Freund, H.J., Jeannerod, M., Hallett, M., Leiguarda, R., Eds., Oxford Unviersity Press: Oxford, UK, 2004, 1-7.
49. Annett, M. Handedness in the children of two left-handed parents. BrJ Psychol 1974, 65, 129-131.
50. Carter, S.L.; Scarr, S.S.; Barker, W.B.; Katz, S. Left-handedness in twins: incidence and patterns of performance in an adolescent sample. Behav Genet 1976, 6, 189-203.
51. Longstreth, L.E. Human handedness: more evidence for genetic involvement. J Genet Psychol 1980, 137, 275-283.
52. Hicks, R.E.; Hinsborne, M. Human handedness: a partial cross-fostering study. Science 1976, 192, 908-910.
53. Bondi, D.; Prete, G.; Malatesta, G.; Robazza, C. Laterality in Children: Evidence for Task-Dependent Lateralization of Motor Functions. Int J Environ Res Public Health 2020, 17(18), 6705. doi: 10.3390/ijerph17186705.
54. Scharoun, S.M.; Bryden, P.J. Hand preference, performance abilities, and hand selection in children. Front. Psychol. 2014, 5:82. doi:10.3389/fpsyg.2014.00082.
55. Stancher, G.; Sovrano, V.A.; Vallortigara, G. Motor asymmetries in fishes, amphibians, and reptiles. Prog Brain Res 2018, 238, 33-56. doi: 10.1016/bs.pbr.2018.06.002.
56. Corballis, M.C. Evolution of cerebral asymmetry. Prog Brain Res 2019, 250, 153-178. doi: 10.1016/bs.pbr.2019.04.041.
57. Bizouard, P. Développement psychomoteur du nourrisson et de l´enfant. La revue du Practicien: Paris, France, 1995.
58. Risch, N.; Pringle, G. Segregation analysis of human hand preference. Behav Genet 1985, 15, 385-400.
59. McManus, I.C. The inheritance of left-handedness. Ciba Found Symp 1991, 162, 251-281.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 12 July 2023 doi:10.20944/preprints202307.0823.v1

60. Geschwind, D.H.; Miller, B.L. Molecular Approaches to Cerebral Laterality: Development and Neurodegeneration. Am. J. Med. Genet. 2001, 101, 370-381. https://doi.org/10.1002/1096-8628(20010715)101:4<370::AID-AJMG1223>3.0.CO;2-G.
61. Brancucci, A.; Lucci, G.; Mazzatenta, A.; Tommasi, L. Asymmetries of the human social brain in the visual, auditory and chemical modalities. Philos. Trans. R. Soc. Lond. B Biol. Sci. 2009, 364, 895-914. doi: 10.1098/rstb.2008.0279.
62. Carling, C.; Williams, M.; Reilly, T. Handbook of Soccer Match Analysis: A Systematic Approach to Improving Performance. Routledge: London, UK, 2005.
63. Hodges, N. J.; Starkes, J. L.; MacMahon, C. Expert performance in sport: a cognitive perspective. In The Cambridge Handbook of Expertise and Expert Performance, Ericsson, K.A., Charness, N., Feltovich, P.J., Hoffman, R.R., Eds., Cambridge University Press: London, UK, 2006, pp. 471-488.
64. Hagemann, N.; Strauß, B.; Cañal-Bruland, R. Training perceptual skill by orienting visual attention. J. Sport Exerc. Psychol 2009, 28, 143-158. doi: 10.1123/jsep.28.2.143.
65. Teixeira, L. A.; Oliveira, D. L.; Romano, R. G.; Correa, S.C. Leg preference and interlateral asymmetry of balance stability in soccer players. Res. Q. Exerc. Sport 2013, 82, 21–27. https://doi.org/10.1080/02701367.2011.10599718.
66. Bishop, D.T.; Wright, M.J., Jackson, R. C., Abernethy, B. Neural bases for anticipation skill in soccer: an fMRI study. J. Sport Exerc. Psychol. 2013, 35, 98-109. doi: 10.1123/jsep.35.1.98.
67. Loffing, F.; Solter, F.; Hagemann, N.; Strauss, B. Accuracy of outcome anticipation, but not gaze behavior, differs against left and right-handed penalties in team-handball goalkeeping. Front. Psychol. 2015, 6:1820. doi: 10.3389/fpsyg.2015.01820.
68. Bell, F. Principles of mechanics and biomechanics. Stanley Thornes: Cheltenham, UK, 1998.
69. Berg, K.; Wood-Dauphinee, S.; Williams, J.; Gayton, D. Measuring balance in the elderly: preliminary development of an instrument. Physiother Can 1989, 41, 304-311.
70. Winter, D.A. Human balance and posture control during standing and walking. Gait Posture 1995, 3, 193-214.
71. Braune, W.; Fischer, O. On the centre of gravity of the human body. Springer-Verlag: Berlin, Germany, 1985, 1(1), 59-60. doi:10.1016/0268-0033(86)90072-0.
72. Hall, S.J. Basic biomechanics. 8th ed., McGraw-Hill Education: New York, USA, 1991.
73. Pollock, A.S.; Durward, B.R.; Rowe, P.J.; Paul J.P. What is balance? Clin. Rehab. 2000, 14, 402-406. DOI: 10.1191/0269215500cr342oa.
74. Zatsiorsky V.M.; Duarte, M. Instant equilibrium point and its migration in standing tasks: rambling and trembling components of the stabilogram. Motor Control 1999, 3(1), 28-38. doi: 10.1123/mcj.3.1.28. PMID: 9924099.
75. Daneshjoo, A.; Mokhtar, A.H.; Rahnama, N., Yusof, A. The Effects of Comprehensive Warm-Up Programs on Proprioception, Static and Dynamic Balance on Male Soccer Players. PLoS ONE 2012, 7(12):e51568. doi:10.1371/journal.pone.0051568.
76. King, M.B.; Judge, J.O.; Wolfson, L. Functional base of support decreases with age. J Gerontol 1994, 49(6):M, 258–263.
77. McGuine, T.A.; Greene, J.J.; Best, T.; Leverson, G. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med 2000, 10(4), 239-44. PMID: 11086748.
78. Hrysomallis, C. Relationship between balance ability, training and sports injury risk. Sports Med 2007, 37(6), 547-56. doi: 10.2165/00007256-200737060-00007.
79. Hrysomallis, C.; McLaughlin, P.; Goodman, C. Relationship between static and dynamic balance tests among elite Australian Footballers. J Sci Med Sport 2006, 9(4), 288-91. doi: 10.1016/j.jsams.2006.05.021.
80. Maurer, C.; Mergner, T.; Peterka, R.J. Multisensory control of human upright stance. Exp Brain Res 2006, 171(2), 231-50. doi: 10.1007/s00221-005-0256-y.
81. Paillard, T. Plasticity of the postural function to sport and/or motor experience. Neurosci Biobehav Rev 2017, 72, 129-152. doi: 10.1016/j.neubiorev.2016.11.015.
82. Adlerton, A.K.; Moritz, U.; Moe-Nilssen, R. Forceplate and accelerometer measures for evaluating the effect of muscle fatigue on pos doi: 10.1002/pri.289.tural control during one-legged stance. Physiother Res Int. 2003, 8(4), 187-99.
83. Hrysomallis, C. Balance ability and athletic performance. Sports Med 2011, 41(3), 221-232. doi: 10.2165/11538560-000000000-00000.

84. Emery, C.A.; Meeuwisse, W.H. The effectiveness of a neuromuscular prevention strategy to reduce injuries in youth soccer: a cluster-randomised controlled trial. Br J Sports Med 2010, 44(8), 555-562. doi: 10.1136/bjsm.2010.074377.
85. Eils, E.; Schröter, R.; Schröder, M.; Gerss, J.; Rosenbaum, D. Multistation proprioceptive exercise program prevents ankle injuries in basketball. Med Sci Sports Exerc 2010, 42(11), 2098-2105. doi: 10.1249/MSS.0b013e3181e03667.
86. Yanai, T.; Wilson, B.D. How does buoyancy influence front-crawl performance? Exploring the assumptions. Sports Technol 2008, 1, 89-99. https://doi.org/10.1002/jst.23.
87. Barbosa, T.M.; Costa, M.J.; Morais, J.E.; Moreira, M.M.; Silva, A.J.; Marinho, D.A. How Informative are the Vertical Buoyancy and the Prone Gliding Tests to Assess Young Swimmers' Hydrostatic and Hydrodynamic Profiles? J Hum Kinet 2012, 32, 21-32. doi: 10.2478/v10078-012-0020-x.
88. McLean, S.P.; Hinrichs, R.N. Buoyancy, Gender, and Swimming Performance. Journal of Applied Biomechanics 2000, 16(3), 248–263. doi:10.1123/jab.16.3.248.
89. Corbin, C.B.; Pangrazi, R.P.; Franks, B.D. Definitions: health, fitness, and physical activity. Pres. Counc. Phys. Fit. Sports Res. Dig 2000, 3, 1-11.
90. Bruton, M.; O'Dwyer, N. Synergies in coordination: a comprehensive overview of neural, computational, and behavioral approaches. J. Neurophysiol 2018, 120, 2761-2774. doi: 10.1152/jn.00052.2018.
91. Kimura, A.; Yokozawa, T.; Ozaki, H. Clarifying the Biomechanical Concept of Coordination Through Comparison With Coordination in Motor Control. Front Sports Act Living 2021, 3:753062. doi: 10.3389/fspor.2021.753062.
92. Wannier, T.; Bastiaanse, C.; Colombo, G.; Dietz, V. Arm to leg coordination in humans during walking, creeping and swimming activities. Exp Brain Res 2001, 141(3), 375-379. doi: 10.1007/s002210100875.
93. Donker, S.F.; Beek, P.J.; Wagenaar, R.C.; Mulder, T. (2001). Coordination Between Arm and Leg Movements During Locomotion. J. Mot. Behav. 2001, 33(1), 86–102. doi:10.1080/00222890109601905.
94. Seifert, L.; Vantorre, J.; Lemaitre, F.; Chollet, D.; Toussaint, H.M.; Vilas-Boas; J.P. Different Profiles of the Aerial Start Phase in Front Crawl. J. Strength Cond. 2010, 24(2), 507-516. doi:10.1519/jsc.0b013e3181c06a0e.
95. Schneider, W.J.; McGrew, K.S. The Cattell-Horn-Carroll model of intelligence. In Contemporary intellectual assessment: Theories, tests, and issues, Flanagan, D.P., Harrison P.L., Eds., The Guilford Press: New York, USA, 2012, pp. 99–144.
96. Knobbe, T.J.; Kremer, D.; Eisenga, M.F.; Corpeleijn, E.; Annema, C.; Spikman, J.M.; Navis, G.; Berger, S.P.; Bakker, S.J.L. Hand dexterity, daily functioning and health-related quality of life in kidney transplant recipients. Sci Rep 2022, 12:16208. . https://doi.org/10.1038/s41598-022-19952-5.
97. Martin, J.A.; Ramsay, J.; Hughes, C.; Peters, D.M.; Edwards, M.G. Age and grip strength predict hand dexterity in adults. PLoS One 2015, 10(2):e0117598, 1-18. doi: 10.1371/journal.pone.0117598.
98. Kuloor, H. Assessment of Dexterity on sports persons and non-sports persons using MMDT. International Journal of Multidisciplinary Educational Research 2021, 10(7), 86-88. DOI: http://ijmer.in.doi./2021/10.07.252.
99. Deschodt, V.J.; Arsac, L.M.; Rouard, A.H. Relative contribution of arms and legs in humans to propulsion in 25-m sprint front-crawl swimming. Eur J Appl Physiol Occup Physiol 1999, 80(3), 192–199. doi:10.1007/s004210050581.
100. Chollet, D.; Chalies, S.; Chatard, J.C. A new index of coordination for the crawl: description and usefulness. Int J Sports Med 2000, 21(1), 54-59. doi: 10.1055/s-2000-8855.
101. Lerda, R.; Cardelli, C.; Chollet, D. (2001). Analysis of the interactions between breathing and armactions in the front crawl. J. Hum. Mov. Stud. 2001, 40, 129–144.
102. Yanai, T. Stroke frequency in front crawl: its mechanical link to the fluid forces required in non-propulsive directions. Jurnalul de Biomecanica 2003, 36(1), 53–62. doi:10.1016/s0021-9290(02)00299-3.
103. Mukaka, M.M. Statistics corner: A guide to appropriate use of correlation coefficient in medical research. Malawi Med J 2012, 24(3), 69-71. PMID: 23638278.
104. Schober, P.; Boer, C.; Schwarte, L.A. (2018). Correlation Coefficients: Appropriate Use and Interpretation. Anesth Analg 2018, 126(5), 1763-1768. DOI: 10.1213/ANE.0000000000002864.
105. Binet, A.; Vaschide, N. Expériences de force musculaire et de fond chez les jeunes garçons. L'année psychologique 1897, 4, 15-63. DOI: https://doi.org/10.3406/psy.1897.2887.
106. Capol, M.; Walther, L. Contribution à l'étude de l'habileté manuelle. L'année psychologique 1953, 53(1), 35-58. doi: https://doi.org/10.3406/psy.1953.8686.

107. Fauche, S. Les paradigmes de la psychomotricité. In: Revue française de pédagogie 1994. 107, 97-107. doi: https://doi.org/10.3406/rfp.1994.1266.
108. Junaid, K.A.; Fellowes, S. Gender Differences in the Attainment of Motor Skills on the Movement Assessment Battery for Children. Physical & Occupational Therapy in Pediatrics 2006, 26(1-2), 5-11. doi:10.1080/j006v26n01_02.
109. Jaime, M.; Longard, J.; Moore, C. Developmental changes in the visual-proprioceptive integration threshold of children. J. Exp. Child Psychol 2014, 125, 1-12. doi: 10.1016/j.jecp.2013.11.004.
110. Rosa, H.R. Teste Goodenough-Harris e indicadores maturacionais de Koppitz para o desenho da figura humana: estudo normativo para crianças de São Paulo. Doctoral Thesis, Instituto de Psicologia, University of São Paulo, São Paulo, 2006. doi:10.11606/T.47.2006.tde-01102006-162329.
111. Gherghuț, A. Sinteze de psihopedagogie specială. Ghid pentru concursuri și examene de obținere a gradelor didactice. Polirom: Iași, Romania, 2013.
112. Rosa, H.R.; Boccato Alves, I.C. Estudo normativo do Teste Goodenough-Harris em crianças na cidade de São Paulo. Bol. – Acad. Paul. Psicol. 2014, 34(87), 336-351.
113. Șunei, M.C.; Petracovschi, S.; Bota, E.; Almajan-Guță, B.; Nagel, A. Relationship between Body Schema and Scholar Maturity: A Study from the National College of Banat in Timisoara, Romania. Children 2022, 9(9), 1369. doi: 10.3390/children9091369.
114. León, M.P.; González-Martí, I.; Contreras-Jordán, O.R. What Do Children Think of Their Perceived and Ideal Bodies? Understandings of Body Image at Early Ages: A Mixed Study. Int J Environ Res Public Health 2021, 18(9), 4871. doi: 10.3390/ijerph18094871.
115. Vallortigara, G.; Rogers, L.J. Survival with an asymmetrical brain: advantages and disadvantages of cerebral lateralization. Behav Brain Sci 2005, 28(4), 575-633. doi: 10.1017/S0140525X05000105.
116. Michel, G.F.; Nelson, E.L.; Babik, I.; Campbell, J.M.; Marcinowski, E.C. Multiple trajectories in the developmental psychobiology of human handedness. Adv Child Dev Behav 2013, 45, 227-260. doi: 10.1016/b978-0-12-397946-9.00009-9.
117. Parma, V.; Brasselet, R.; Zoia, S.; Bulgheroni, M.; Castiello, U. The origin of human handedness and its role in pre-birth motor control. Sci. Rep.2017, 7, 16804.
118. Gooderham, S.E.; Bryden, P.J. Does your dominant hand become less dominant with time? The effects of aging and task complexity on hand selection. Developmental Psychobiology 2014, 56(3), 537-546. doi:10.1002/dev.21123.
119. Schedler, S.; Kiss, R.; Muehlbauer, T. Age and sex differences in human balance performance from 6-18 years of age: A systematic review and meta-analysis. PLoS One 2019, 14(4):e0214434. doi: 10.1371/journal.pone.0214434.
120. Schedler, S.; Tenelsen, F.; Wich, L.; Muehlbauer, T. Effects of balance training on balance performance in youth: role of training difficulty. BMC Sports Sci. Med. Rehabilitation 2020, 12(1):71. doi:10.1186/s13102-020-00218-4.
121. Lenroot, R.K.; Giedd, J.N. Brain development in children and adolescents: insights from anatomical magnetic resonance imaging. Neurosci Biobehav Rev 2006, 30(6), 718-729. doi: 10.1016/j.neubiorev.2006.06.001.
122. Koolschijn, P.C.; Crone, E.A. Sex differences and structural brain maturation from childhood to early adulthood. Dev Cogn Neurosci 2013, 5, 106-118. doi: 10.1016/j.dcn.2013.02.003.
123. Barela, J.A.; Jeka, J.J.; Clark, J.E. Postural control in children. Coupling to dynamic somatosensory information. Exp Brain Res 2003, 150(4), 434–442. https://doi.org/10.1007/s00221-003-1441-5.
124. Bair, W.N.; Kiemel, T.; Jeka, J.J.; Clark, J.E. Development of multisensory reweighting for posture control in children. Exp Brain Res 2007, 183(4), 435–446. https://doi.org/10.1007/s00221-007-1057-2.
125. McLean, S.P.; Hinrichs, R.N. Sex differences in the centre of buoyancy location of competitive swimmers, Journal of Sports Sciences 2008, 16(4), 373-383. DOI: 10.1080/02640419808559365.
126. Battaglia, G.; Giustino, V.; Tabacchi, G.; Lanza, M.; Schena, F.; Biino, V.; Giuriato, M.; Gallotta, M.C.; Guidetti, L.; Baldari, C.; Gennaro, A.; Palma, A.; Bellafiore, M. Interrelationship Between Age, Gender, and Weight Status on Motor Coordination in Italian Children and Early Adolescents Aged 6-13 Years Old. Front Pediatr 2021, 9:738294. doi: 10.3389/fped.2021.738294.
127. Davies, P.L.; Rose, J.D. Motor skills of typically developing adolescents: awkwardness or improvement? Phys Occup Ther Pediatr 2000, 20, 19-42. doi: 10.1080/J006v20n01_03.

128. D'Hondt, E.; Deforche, B.; Vaeyens, R.; Vandorpe, B.; Vandendriessche, J.; Pion, J.; Philippaerts, R.; de Bourdeaudhuij, I.; Lenoir, M. Gross motor coordination in relation to weight status and age in 5- to 12-year-old boys and girls: a cross-sectional study. Int J Pediatr Obes 2011, 6(2-2), e556-64. doi: 10.3109/17477166.2010.500388.
129. Vandorpe, B.; Vandendriessche, J.; Lefevre, J.; Pion, J.; Vaeyens, R.; Matthys, S.; Philippaerts, R.; Lenoir, M. The KörperkoordinationsTest für Kinder: reference values and suitability for 6-12-year-old children in Flanders. Scand J Med Sci Sports 2011, 21(3), 378-88. doi: 10.1111/j.1600-0838.2009.01067.x.
130. Ishii, K.; Shibata, A.; Adachi, M.; Nonoue, K.; Oka, K. Gender and grade differences in objectively measured physical activity and sedentary behavior patterns among Japanese children and adolescents: a cross-sectional study. BMC Public Health 2015, 15, 1254. doi: 10.1186/s12889-015-2607-3.
131. Stodden, D.F.; Goodway, J.D.; Langendorfer, S.J.; Roberton, M.A.; Rudisill, M.E.; Garcia, C.; Garcia, L.E. A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity: An Emergent Relație, Quest 2008, 60(2), 290-306. DOI: 10.1080/00336297.2008.10483582.
132. Lopes, V.P.; Stodden, D.F.; Bianchi, M.M.; Maia, J.A.R.; Rodrigues, L.P. Correlation between BMI and motor coordination in children. J. Sci. Med. Sport 2012, 15, 38-43. doi: 10.1016/j.jsams.2011.07.005.
133. Veldman, S.L.C.; Santos, R.; Jones, R.A.; Sousa-Sa, E.; Okely, A.D. Associations between gross motor skills and cognitive development in toddlers. Early Hum Dev 2019, 132, 39–44. doi: 10.1016/j.earlhumdev.2019.04.005.
134. Musalek, M. Skilled performance tests and their use in diagnosing handedness and footedness at children of lower school age 8-10. Front. Psychol. 2015, 5, 1-8. doi:10.3389/fpsyg.2014.01513.
135. Hammami, R.; Granacher, U.; Makhlouf, I.; Behm, D.G.; Chaouachi, A. Sequencing effects of balance and plyometric training on physical performance in youth soccer athletes. J Strength Cond Res 2016, 12, 3278-3289.
136. Kang, S.H.; Kim, C.W.; Kim, Y.I.L.; Kim, K.B.; Lee, S.S.; Shin, K.O. Alterations of muscular strength and left and right limb balance in weightlifters after an 8-week balance training program. J Phys Ther Sci 2013, 25(7), 895-900.
137. Karami, B.; Ali, M.; Farzaneh, Y.; Homayoun, G.; Parmoon, A. Neuromuscular training as the basis for developing the level of the static and dynamic balance in selected students of physical. Int J Sport Sci Fit 2014, 4(1), 20-38.
138. Dobrijević, S.; Moskovljević, L.; Dabović, M. The influence of proprioceptive training on young rhythmic gymnasts balance. Facta Univ 2016, 14(2), 247-255.
139. Yanai, T. Buoyancy is the primary source of generating bodyroll in front-crawl swimming. J Biomech 2004, 37(5), 605-612. doi: 10.1016/j.jbiomech.2003.10.004.
140. Marinho, D.A.; Barbosa, T.M.; Klendlie, P.L.; Vilas-Boas, J.P.; Alves, F.B.; Rouboa, A.I.; Silva, A.J. Swimming Simulation. In: Computational Fluid Dynamics for sport simulation. Ed: Peter M., 2009, Heidelberg: Springer-Verlag, 33-61.
141. Marinho, D.A.; Barbosa, T.M.; Costa, M.J.; Figueiredo, C.; Reis, V.M.; Silva, A.J.; Marques, M.C. Can 8-weeks of Training Affect Active Drag in Young Swimmers? J Sports Sci Med 2010, 9(1), 71-78. PMID: 24149388.
142. Pendergast, D.R.; Capelli, C.; Craig, A.B.; di Prampero, P.E.; Minetti, A.E.; Mollendorf, J.; Termin, I.I.; Zamparo, P. Biophysics in swimming, Rev Port Cien Desp 2006, 6(Supl.2), 185–189.
143. Costa, A.M.; Silva, A.J.; Louro, H.; Reis, V.M.; Garrido, N.D.; Marques, M.C.; Marinho, D.A. Can the curriculum be used to estimate critical velocity in young competitive swimmers? J Sports Sci Med 2009, 8(1), 17-23. PMID: 24150551.
144. Popescu, G. Performance, Reference Systems and Strategies for Balance Training in Syndrome Down Subjects Beginning Gymnastics. Procedia - Social and Behavioral Sciences 2014, 117, 553-558. doi:10.1016/j.sbspro.2014.02.261.