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Application of the Neurofunctional Psychomotor Test for Groups of Children ages 3-14 in Cuenca, Ecuador: A Statistical Analysis of Group Correlations

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Abstract

This study was designed to determine if the Neurofunctional Psychomotor Test developed by Elena Simonetta for children and young people from 3 to 14 years old is applicable to the local and regional context of the city of Cuenca, Ecuador. A sample of 793 children and young people was obtained from a universe of 70,838 students through cluster sampling. Fifteen parishes were sampled and the optimal Neyman proportional stratified sampling was applied. The Neurofunctional Psychomotor Test was administered to all 793 students. The results obtained using the uniform rectangular distribution method showed that 75% of the children passed the test. A statistical correlation method was used to determine the linear association between continuous variables. Significant correlations were determined within 95% confidence limits in: correct laterality and temporal perceptions; general dynamic coordination with the postural adjustment variable and tonic control. These significant correlations allowed us to confirm that the Neurofunctional Psychomotor Test was valid when applied to children ages 3-14 in Cuenca, Ecuador. In addition, correlations between pairs of variables were studied for each age group, and cluster analysis methods were applied to investigate global similarities among the variables under study for each age group.

Keywords: *Neurofunctional Psychomotor Test; Neurofunctional development assessment; Psychomotor skills; Children aged 3-14 years; Multivariate analysis.*

Introduction

The architecture of the developing human brain is built through a process that begins before birth, continues into adulthood, and is established as a basis for health, learning, and later behavior (Shonkoff & Karakowsky, 2014). During the prenatal, perinatal, and postnatal periods, a series of intrinsic (individual) and extrinsic (environment) factors can generate mild to severe alterations and/or deviations from what is considered normal that affect neurotypical psychomotor development (García & Martínez, 2016; Medina et al., 2015). Motor, cognitive, perceptual and sensory capacities are structured, differentiated and organized during childhood through experiences. The maturation and myelination processes of the nervous system enable a balanced interaction with the social environment. It is essential to evaluate psychomotor

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development at each stage to identify possible abnormal development during these processes (Ismail Fatemi & Johnston, 2017; Pérez et al., 2017). Many studies have focused on child psychomotor development along with the factors that influence it. Evaluation tests and timely intervention strategies have been proposed that predict and protect the motor and mental development of preschool-aged children, school-aged children, and adolescents (Bedoya-Salazar et al., 2022; Lipkin, 2020; Más, 2019).

Psychomotor assessment through the application of contextualized instruments constitutes a fundamental resource that allows the determination of levels of development achieved. These instruments can also help identify the possible causes of delay or neurofunctional deficits with or without organic lesions. Those deficits without lesions can be of the affective/relational type, which in turn, produce problems that will affect the acquisition of preschool and school learning. It is important to note that the evaluation of movement is a neurobiobehavioral process, which interacts with emotions and determines the manifestation of human behavior (Simonetta, 2024). From this perspective, Aguilar Salguero and López (2015) along with Arias et al. (2020) showed that high scores in psychomotor tests are related to good academic performance.

In Latin America, the percentage of children under 6 years of age at risk of presenting developmental problems varies significantly depending on the socioeconomic environment and the age at which the assessments are carried out. Recent studies carried out by UNESCO/UNICEF/ECLAC (United Nations Educational, Scientific and Cultural Organization/United Nations Children's Fund/Economic Commission for Latin America and the Caribbean, 2022) indicated that, in densely populated urban areas, the risk of problems in child development tended to be higher due to factors such as lack of access to adequate health services, precarious living conditions and environmental stress. In contrast, in rural settings or communities with better access to basic resources and services, this risk may be lower. Hence, it is necessary to have contextualized, validated, standardized, sensitive, reliable evaluation instruments designed for effective and timely evaluation (Lejarraga, 2014; Rizzoli and Delgado, 2015).

The research reported here aimed to determine if the ***"Neurofunctional Psychomotor Test"*** developed by Elena Simonetta for children and young people from 3 to 14 years old is applicable to the local and regional context of Cuenca, Ecuador.

Method

Design

The quantitative study reported here used the **"Neurofunctional Psychomotor Test for children and young people from 3 to 14 years old"** developed by Simonetta (2024). The uniqueness of this tool lies in its ability to detect difficulties and different psychomotor typologies without generating stigmatization in the individuals undergoing evaluation.

Sampling

In this work, the population universe consisted of 70,788 male and female students from 200 urban parish schools divided into 4 levels according to age. The total sample (793) was obtained with a simple random sampling with a variance of 0.25 error of 10%, since the variables are dichotomous. The number of subjects selected from each parish was obtained by assigning a sample calculated from the percentage of the population universe. The distribution of the universe of students from schools in urban parishes is presented in Table 1:

Table 1. Distribution of students in schools in urban parishes of Cuenca

PARISH	NUMBER OF STUDENTS	Proportion (%)
Bellavista	8739	12.35
Cañaribamba	2699	3.81
The Batan	3111	4.39
The Tabernacle	3450	4.87
The Neighbor	5507	7.78
Gil Ramirez Davalos	2992	4.23
Brother Michael	3448	4.87
Huaynacapac	6024	8.51
Machangara	2737	3.87
Monay	3128	4.42
Saint Blaise	3421	4.83
San Sebastian	7541	10.65
Sucre	4240	5.99
Totoracocha	4240	5.99
Yanuncay	9511	13.44

Considering the large number of students in each parish, a random cluster sampling was chosen (Madow, 1953). Using this technique, the total population was divided into groups and a subsample was extracted for each group proportional to their number. Since each cluster is made up of schools from a particular urban parish in Cuenca and each school has different levels depending on the age of the students, the Neyman's "optimal" proportional sampling method was applied (Mathew et al., 2013). Forty-four professionals from the areas of education and psychology were trained in the use and handling of the test, then each of them applied the tool to about 18 individuals randomly designated with prior informed consent of the parents. The areas evaluated were: Genetic Motor Predominance, Perception of the Body Scheme, Perception of Spatial-Temporal Information. The database of children and young people from 3 to 14 years of age from the participating educational institutions was accessed. Table 2 presents the number of students drawn per school from each parish:The alternative hypothesis (H_1) stated that if all children in an age range failed to answer correctly with a result less than 75% of the cases (3rd quartile) with a confidence level of 95%, H_0 is rejected. In this case, the stratum would fail to pass the test instructions.

Table 2. Number of students selected by each school and by parish

Parroquia		Yanuncay	Totoracocha	Sucre	S. Sebastián	S. Blas	Machángara	Monay	Gil Ramírez	Herm. Miguel	Huayna Cápac	El Batán	El Sagrario	El Vecino	Bellavista	Cañaribamba	Veloz-Riobamba	Total por grupo
Primer grupo	Total 1	10	10	9	9	7	9	10	12	11	8	8	6	6	9	7	8	144
Segundo grupo	Total 2	14	14	15	13	14	15	14	13	13	12	12	13	13	14	14	14	216
Tercer grupo	Total 3	11	12	13	13	13	13	12	12	13	12	14	13	13	13	16	13	205
Cuarto grupo	Total 4	15	13	14	14	15	13	12	15	13	17	15	18	18	14	13	14	224
Total por parroquia		**50**	**49**	**51**	**49**	**49**	**49**	**48**	**50**	**50**	**49**	**49**	**50**	**50**	**50**	**50**	**50**	**793**

The analysis of the motor dominance of use and the neurofunctional psychomotor domain was developed using correlations between variables in the different age groups. These variables were formed by the sum of all the results of all the students relative to each item of the test. In this context, a Pearson correlation value was calculated using the INFOSTAT program (Di Rienzo et al., 2012). This correlation calculation only showed the associations between pairs of variables. In addition, multivariate statistic analysis were applied to the data. Cluster analysis is a technique useful to identify groups (clusters, clouds) of similar objects (or similar variables). The groups thus identified may suggest "categories" for further studies, such as classification analysis, or may confirm the existence of already defined categories. Clustering techniques are based on the distances between objects and the similarity, which is inversely proportional to the distance. The standardization of the variables and the distance metric are of enormous importance in these techniques, in fact, the formation of the clusters depends on the type of standardization and the type of distance calculation, these techniques are not suitable for quantitative studies, but they allow obtaining a lot of information about the global structure of the problem under study. In this study, the Z transformation was used as the data standardization method, the squared Euclidean distance as the distance and the Ward's method as the agglomeration approach (Ward, 1963). The result of a clustering technique is generally expressed as graph called dendrogram in which the ordinate is the distance or similarity between the clusters, while the abscissa is the various objects that the algorithm groups at increasingly greater distances or in increasingly smaller similarities. Evolving Factor Analysis (EFAA) was also used to identify variables common to all age groups.

Results and Discussion

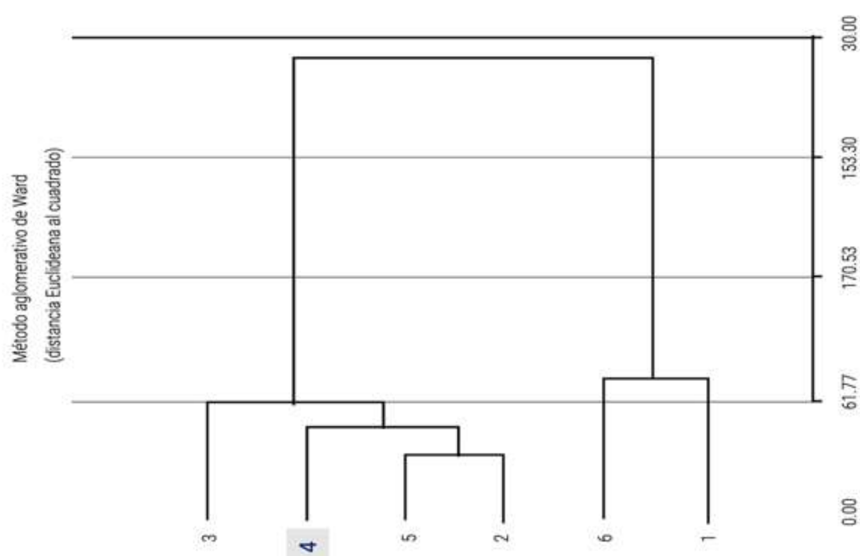
The age group study was conducted using observed and theoretical (when all answers are affirmative), data in two main areas.

1. Data relating to the motor domain of use: for each child in each school, it was determined whether he or she was right-handed, left-handed or ambidextrous. In the case of right-handed and left-handed children, a score of (1) was given, and in the case of ambidextrous children, a score of (0).
2. Neurofunctional psychomotor domain tests with yes (1) and no (0)

To analyze possible statistically significance differences among the data obtained through hypothesis testing, the null hypothesis (H0) postulated that there was no correlation between the variables (R coefficient = 0), while the alternative hypothesis (H_1) maintained that there was a correlation. A significance level (alpha) of $p \leq 0.05$ was used to make decisions. If the associated p-value was less than 0.05, H_0 is rejected and H_1 is accepted. Additionally, the correlation matrix between variables common to all age groups was calculated. Finally, multivariate statistical techniques were applied to the data obtained because correlation analysis allows identifying associations only between pairs of variables, and does not allow highlighting the influence of other variables on the pair under examination.

The variables under study are common to all age groups, and the observation values were weighted to compensate for the differences in composition of each group. The common variables are: 1. Correct Laterality, 2. General Dynamic Coordination, 3. Hand-Eye Coordination, 4. Postural Adjustment, 5. Tonic Control, and 6. Spatial-Temporal Perceptions. These were grouped into two large blocks: (3,4,5,2) and (6, 1). These results show a logical evolution of the individuals, which allows us to affirm that the variables are united, they support each other, one is the basis of the other and if one is altered the others are also altered, these findings confirm the duality between laterality and spatial-temporal perception, especially in instrumental learning (Figure 1).

Figure 1. Dendrogram of the groups of variables studied in the analysis of the results of all bands.



In addition to clustering, Evolving Factor Analysis (EFAA) was applied to the variables common to all age groups. The study reported here focused on analyzing the observations in a comprehensive manner, considering their temporal evolution, specifically in its Evolutionary Principal Component Analysis modality proposed by Keller & Massart (1991), whose main objective is to explore the underlying structure of the data and discover possible latent factors that will explain the relationships between the variables observed over time.

From this point of view, it is parallel to cluster analysis with some additional advantages, for example, it allows to observe which original variables are associated in some way with the components of a cluster, it allows to reduce the dimensions of the problem for the elimination of experimental noise. This technique, proposed for the first time by Pearson (1900) and later developed by Hotelling (1933), can be considered as part of factor analysis that involves transforming related variables into new uncorrelated variables.

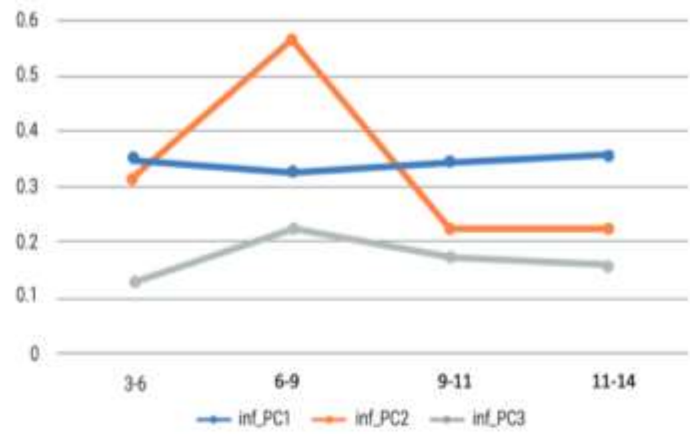
These new variables are called principal components or principal axes. It allows for the reduction of the number of variables and makes the information less redundant. The principal components are orthonormal linear combinations of the original variables, the coefficients or weights (better the squares of the weights) of each original variable in the linear combination depend directly on its importance in the combination. The principal component analysis algorithm builds them so that the first component explains most of the original total information, the second is built perpendicular to the first and explains most of the remaining information, the third is built in the same way.

Using Evolving Factor Analysis, it is possible to follow the evolution of a phenomenon characterized by many components over time. Using information from the first three principal components (90% of the total information), the fraction of information from each component on the accumulated age ranges is summarized in Table 3.

Table 3. Information contained in the first three components by accumulated age ranges.

AGE	INF_ PC1	INF_PC2	INF_PC3
3-6	0.35	0.32	0.13
6-9	0.327	0.567	0.219
9-11	0.341	0.255	0.173
11-14	0.354	0.227	0.159

Figure 2. Evolution of the first three components in the accumulated age range data



It can be observed that component 1 varies very little as age progresses, this means that the weights of the variables are substantially stable. Component 2 increases from the range of 3 to 6 years to that of 6 to 9 years and then decreases to include the range of 9 to 11 years, then remains stable (11 to 14 years). The weights of the variables in this component are: Weight of correct laterality = 0.58, weight of general dynamic coordination = -0.216, weight of eye-hand coordination = 0.267, weight of postural adjustment = 0.011, weight of tonic control = -0.172, weight of temporal perceptions = 0.718. The most important variables are: correct laterality and temporal perceptions since they have higher weights, so the temporal evolution of component 2 substantially represents the behavior of these variables. The maximum value was obtained in the accumulated range up to 9 years. It is possible that this behavior is related to age. Individuals should achieve this mastery as the sum of all other aspects, such as a sense of complete maturity.

A similar behavior, but with lower values, can be seen for component 3. The weights of the variables in this component are: Correct laterality weight = -0.42, general dynamic coordination weight = -0.229, eye-hand coordination weight = 0.865, postural adjustment weight = -0.236, tonic control weight = 0.163, temporal perceptions weight = -0.025. In this component, the most important variables are correct laterality and eye-hand coordination. The maximum value is obtained in the accumulated range up to 9 years of age. These responses are related to the developmental level of the individuals in the sample group. The results suggest that at an early age, these skills are consolidated, and little by little the maximum development is reached, then stop in the highest age group since the domain should exist by then.

This study determined the applicability of the neurofunctional psychomotor test (2024) for children and young people from 3 to 14 years old, for which two fundamental components were used: 1) the data related to the motor domain of use, 2) the neurofunctional psychomotor domain tests. The first component related to the motor use domain generated significant results by age group. Laterality in children aged 3 to 6 years revealed that only 22% of children acquired the correct laterality, suggesting that there is a significant proportion of children who have not yet fully developed this ability. Laterality has been defined in the literature as the predominance exerted by one side of the body over another to perform motor tasks that depend on the organization of brain functions and inter-hemispheric communication (Aguayo et al., 2018). The lack of full development of laterality may have implications for the early motor and cognitive development of children (Prado et al., 2017). In the study reported here, variability was found in the acquisition of laterality. The proportion of children with defined laterality varied depending on the age group. The acquisition of laterality was lower in the younger groups (3 to 6 years old) and gradually increased in older age groups. Corballis (2014) and Márquez and Celis (2017) suggest that the development of laterality may be a gradual process that continues into adolescence. The results obtained regarding the neurofunctional psychomotor domain, in all groups reached 75%, a result that would be closely related to the lack of effectiveness in achieving the internalization of laterality. The studies by Corballis (2014), Hepper (2013), and Márquez and Celis (2017), maintain that children and young people should experience their own body more and better, especially in the first years of life to lay the foundations for segmental, global and integral development.

The evolution of the psychomotor neurofunctional domain was also analyzed by means of Factor Analysis over time. The results obtained with this method determined significant correlations at 95% as explained in each of the following ages.

The results showed that in children aged 3 to 6 years, significant correlations stood out between general dynamic coordination and controlled postural adjustment, which suggests a close relationship with motor development. To achieve global coordination of the body, the activation of all the subject's motor automatisms is necessary, such as: perception of space, topological organization, precise motor control, recognition of body parts and regulation of time. These findings agree with the studies of Lafe & Newell (2022) who have shown that movement patterns emerge and are strengthened from stimulation between biomechanical and neuromuscular systems. Many studies have explored the relationship between spatial perception and postural stability, as well as the influence of proprioception on motor coordination during the execution and planning of controlled movements in specific tasks in response to changes in the environment and in situations of imbalance or instability (Hodges, BPhty et al., 2019; Peterka, 2018; Sutapa et al., 2021). The most relevant correlations found between the variables: motor and perceptual development in children aged 6 to 9 years, were those related to respiratory control with egocentric orientation, with the regulation of one's own body and with the mental representation of the static posture. Studies of school-aged children developed by Ivanenko & Gurfinkel (2018); Simbaña-Haro et al. (2022), emphasize the importance of intervening in respiratory control as part of timely stimulation and intervention programs. At this age, a significant positive correlation was also revealed, indicating that as temporal perception improves, so does the child's egocentric orientation. This suggests that the ability to understand and process time is related to the ability to orient oneself and synchronize movements with respect to one's own body, which is crucial for daily activities and learning new motor skills (Roselli, 2015; Rubio and Rubio, 2015). **Temporal structures and time perception, which has been shown to have** a strong and significant correlation by Sánchez López and Restrepo de Mejía (2018). These results suggest that children who have a better perception of time are able to reproduce rhythmic sequences, perceive temporal structures, have the ability to follow and dictate rhythms and timing, not only in musical and artistic development, but also in linguistic and motor coordination skills.

Within this same age range (6 to 9 years) a positive correlation was found between **egocentric orientation and laterality. This** finding indicates that a better definition of laterality (preference for one side of the body) is related to a better egocentric orientation, which is essential for self-regulation and safety in the child's movements, helping him or her to perform daily tasks more efficiently (Cañizares and Carbonero, 2016). In addition, the correlation between **postural control and dissociation** are related to the ability to perform these movements in which the different parts of the body move independently, and are the basis for the development of fine and gross motor skills. Therefore, working on postural control can have positive effects on the child's ability to perform complex and precise actions (Ivanenko & Gurfinkel, 2018; Simbaña-Haro et al., 2022).

Finally, in the range between 6 – 9 years of age, an inverse correlation was found between a greater ability to regulate time and the recognition of body parts. Studies suggest that children who focus on regulating time may have fewer cognitive resources available for body recognition, and vice versa, (Martínez, 2014; Palacio-Duran et al., 2017). This is an area that requires more research to better understand the interactions between these two skills.

In the age range of 9 to 11 years, the results of the study presented showed a significant correlation in all except correct laterality, postural adjustment/time. These findings are contradictory to what other studies have shown in which it was suggested that children who develop a lateral preference (right- or left-handed) had better control of their posture. Likewise, laterality influenced the ability to temporarily adjust to different situations (Mendoza Morán, 2017; Sánchez and Samada, 2020). This contradiction could be explained by the age of the participants and by incorrect school management regarding the lack of stimulation of these skills. Many educators consider these skills as acquired and not necessary within the teaching-learning process at these ages.

Other negative correlations found in this age range were general dynamic coordination, and perception and control of the body in movement, which are related to a deficit and/or difficulties in activities that require precise movement. Also, the **perception and control of body movement showed an opposite association to the perception and decentralized organization of space**. These results were also shown by Williams et al. (2010) who state that this could be due to factors related to the age and development of children.

As for **general dynamic coordination, decentralized primary orientation, time perception, tonic and gait control**, significant positive correlations were evident, which suggested that movement control could facilitate spatial orientation, the ability of children to perform tasks that require temporal synchronization, better eye-hand control associated with adequate tonic control of the body. Therefore, according to the contributions of Adolph (2008) these factors significantly influenced postural reproduction for mental representation.

In the results from 11 to 14 years, the correlations suggest that improving one skill can have positive effects on other areas. Thus, it was found that adequate general dynamic coordination and good tonic control had positive effects on postural adjustment, mental representation, laterality and dissociation.

These motor skills improved the ability to imagine, plan movements, maintain an effective posture and the ability to make complex mental representations of actions.

All of these skills allowed the individual to improve their academic and comprehensive performance (Ansuini et al., 2016; Orban et al., 2021).

Multivariate analysis considers all the variables. The results may agree or contradict the results of the bivariate study since all the variables influence each other and the consideration of only pairs may limit or restrict the outcome of the analysis. The results of the Evolving Factor Analysis clearly indicated that up to the age of 9, there is a positive evolution in all responses, while at later ages, probably due to school situations, the responses decrease, returning almost to initial levels. Once again, the importance of the educational system and the family in the processes of acquiring the potentials under study is confirmed.

These correlations found in each age range provide a global view of how different motor and cognitive skills relate and influence each other, which is crucial to understanding development as a multifaceted process and designing appropriate educational and therapeutic interventions (Simonetta, 2024).

Conclusions

The study presented here showed that the problem of lateral dominance presents substantial deficiencies at the level of all the schools analysed. This problem seems to be repeated in other contexts as well. The causes and analogies could be identified by the lack of bodily experiences of children, either due to family habits or lack of knowledge about the management and internalisation of this skill by the educational system, an acquisition that has been considered as a curricular content. Many evolutionary aspects are noted at the time of the correlations between the variables and in the various multivariate studies by age and later of the group. These responses allow us to confirm the success of their applicability. The study represents a significant contribution to the preschool and school education system, to psychology, and to health in general. It is recommended to complete the instrument between the ages of 0 and 3 years.

The coincidence of the data observed for all age groups according to the reference distribution suggests that the assessment method used in the study can be effectively used to assess neurofunctional psychomotor development in children and young people within different contexts.

Conflict of Interest

The authors take responsibility for ensuring:

That they are not subject to any conflicts of interest, regarding both the topic and the area of research.

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References

Adolph, K. E. (2008). Learning to move. Current directions in psychological science, 17 (3), 213-218. https://doi.org/: 10.1111/j.1467-8721. 2008.00577.x

Aguayo, B. B., Román, P. Á. L., Sánchez, J. S., & Vallejo, A. P. (2018). Acute Effect on the Attention of Children Aged 12 to 14 Years of a Physical Education Class. Ibero-American Journal of Diagnosis and Evaluation-e Psychological Assessment, 4 (49), 121-129.

Aguilar, A., Salguero, F., & Lòpez, B. (2015). Contributions to psychomotor education, reading and writing learning and the assimilation of the body schema in 5-year-old children. ReiDoCreo, 4, 219-227. https://digibug.ugr.es/bitstream/handle/10481/37248/

Ansuini, C., Cavallo, A., Campus, C., Quarona, D., Koul, A., & Becchio, C. (2016). Are we real when we fake? Attunement to object weight in natural and pantomimed grasping movements. Frontiers in Human Neuroscience, 10, 471. https://doi.org/:10.3389/fnhum.2016.00471

Arias, J., Mendivel , R. & Uriol , A. (2020). Psychomotor skills in pre-writing of 5-year-old children from early childhood educational institutions in the Huancavelica area. Conrado Magazine, 16 (76), 43-50.

Bedoya-Salazar, DM, Hoyos-Arenas, Álvarez-Sossa, ME, (2022). The effects of curricular pedagogical programs that apply motor games in the development of executive functions in preschool: A systematic review. Journal Bulletin Redipe, 11 (2), 205-223.

Cañizares, J., & Carbonero. C. (2016). Perceptual-motor abilities, body schema and laterality in childhood. Wanceulen SL.

Corballis, MC (2014). Left brain, right brain: Facts and fantasies. PLoS Biology, 12 (1), e1001767. https://doi.org/10.1371/journal.pbio.1001767

Di Rienzo, JA, Casanoves, F., Balzarini, MG, González, L., Tablada, M., & Robledo, CW (2012). InfoStat version 2010. InfoStat Group, Faculty of Agricultural Sciences. National University of Córdoba, Argentina

García, M., Martínez, M. (2016). Psychomotor development and alarm signs. In: Aepap. Pediatrics Update Course. Lúa Editions. 81-93. https://www.aepap.org/sites/default/files/2em.1_desarrollo_psicomotor_y_signos_de_alarma. pdf.

Hepper, P. G. (2013). The developmental origins of laterality: Fetal handedness. Developmental psychobiology, 55 (6), 588-595. https://doi.org/10.1002/dev.21119

Hodges, PT., BPhty , PW, Van Dieën , JH, & Cholewicki , J. (2019). Time to reflect on the role of motor control in low back pain. Journal of orthopedic & sports physical therapy, 49 (6), 367-369. https://www.jospt.org/doi/10.2519/jospt.2019.0104

Hotelling , H. (1933). Analysis of a complex of statistical variables into principal components. Journal of educational psychology, 24 (6), 417. https://doi.org/10.1037/h0071325

Ismail, F.Y., Fatemi, A., & Johnston, M.V. (2017). Cerebral plasticity: Windows of opportunity in the developing brain. European journal of pediatric neurology, 21 (1), 23-48. https://doi.org/ 10.1016/j.ejpn.2016.07.007

Ivanenko , Y. & Gurfinkel , V.S. (2018). Human postural control. Frontiers in neuroscience, 12, 301583. https://doi.org/10.3389/fnins.2018.00171

Keller, H.R., & Massart , D.L. (1991). Evolving factor analysis. Chemometrics and intelligent laboratory systems, 12 (3), 209-224. https://doi.org/10.1016/0169-7439(92)80002-L

Lafe, C.W., & Newell, K.M. (2022). Instructions on Task Constraints Mediate Perceptual-Motor Search and How Movement Variability Relates to Performance Outcome, Journal of Motor Behavior, 54 (6), 669-685. https://doi.org/10.1080/00222895.2022.2063787

Lejarraga, H., Pascucci, M. C., Masautis, A., Kelmansky, D., Lejarraga, C., Charrúa, G., ... & Nunes, F. (2014). Child psychomotor development in the Matanza-Riachuelo basin: research on inapparent developmental problems. Argentine Journal of Public Health, 5 (19), 17-24.https://www.rasp.msal.gov.ar/index.php/rasp/article/view/266

Lipkin, PH, Macias, MM, Norwood, KW, Brei, TJ, Davidson, LF, Davis, BE, ... & Voigt, RG (2020). Promoting optimal development: identifying infants and young children with developmental disorders through developmental surveillance and screening. Pediatrics, 145 (1). https://doi.org/10.1542/peds.2019-3449 .

Madow , W. (1953). On The theory of systematic sampling, III. Comparison of centered and random start systematic sampling. The annals of Mathematical Statistics, 101-106.Mahler, M. (2000) La nascita psychology of the baby. Bollati Boringhieri

Márquez, JMC, & Celis, CC (2017). How to improve perceptual-motor skills, laterality... in your child (Vol. 10). Wanceulen Editorial. Márquez, JMC, & Celis, CC (2017). How to improve perceptual-motor skills, laterality... in your child (Vol. 10). Wanceulen Editorial.

Martín Casas, P., Meneses Monroy, A., Beneit Montesinos, JV and Atín Arratibel, MA (2014). Children Gait Development as a Learning Process. Psychological Action, 11 (1), 45-54. http://dx.doi.org/10.5944/ap.1.1.13866.

Martínez, EJ (2014). Psychomotor development in early childhood education. Bases for intervention in psychomotor skills (Vol. 36). University of Almería.

More, M. (2019). Detection of neurodevelopmental disorders in the Primary Care consultation. In Aepapp. Pediatric Update Congress (pp. 143-147).

Mathew, O., Sola, A., Oladiran, B. & Amos, A. (2013). Efficiency of Neyman allocation pro- cedure over other allocation procedures in stratified random sampling. American Journal of Theoretical and Applied Statistics, 2(5), 122-127

Mendoza Morán, AM (2017). Development of fine and gross motor skills in childhood. Electronic Journal of Educational Synergies, 2 (2), 4. https://doi.org/10.37954/se.v2i2.25

Medina Alva, MDP, Kahn, IC, Muñoz Huerta, P., Leyva Sánchez, J., Moreno Calixto, J., & Vega Sánchez, SM (2015). Childhood neurodevelopment: normal characteristics and warning signs in children under five years of age. Peruvian Journal of Experimental Medicine and Public Health, 32 (565-573). chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.scielosp.org/pdf/rpmesp/2015.v32n3/565-573/es

Orban, G.A., Sepe, A., & Bonini, L. (2021). Parietal maps of visual signals for bodily action planning. Brain Structure and Function, 226 (9), 2967-2988. https://doi.org/10.1007/s00429-021-02378-6

Palacio-Duran, E., Pinillos-Patiño, Y., Herazo-Beltrán, Y., Galeano-Muñoz, L., & Prieto-Suarez, E. (2017). Determinants of psychomotor performance in schoolchildren in Barranquilla, Colombia. Journal of Public Health, 19, 297-303. https://doi.org/10.15446/rsap.v19n3.65597

Pearson, K. (1900): "Philosophical transactions" University College, London

Pérez R, Rizzoli R, Alonso A, Reyes H. (2017). Advances in early childhood development: from neurons to large-scale programs. Bol Méd Hospital Infantil de México. 74 (2):86-97.

Peterka RJ (2018). Sensory integration for human balance control. Handbook of clinical neurology, 159, 27–42. https://doi.org/10.1016/B978-0-444-63916-5.00002-1

Prado, J.J., Gonzalez, Y., & Prado, E. (2017). Review of a Contemporary Theoretical and Practical Approach to Laterality in Early and School Ages. Journal of the Faculty of Physical Education of the University of Granma 14(45), 113-127. https://dialnet.unirioja.es/servlet/articulo?codigo=6210525

Rizzoli-Córdoba, A., & Delgado-Ginebra, I. (2015). Steps to transform a need into a valid and useful tool for the early detection of problems in child development in Mexico. Medical Bulletin of the Children's Hospital of Mexico, 72 (6), 420-428. https://doi.org/10.1016/j.bmhimx.2015.11.003

Rosselli, M. (2015). Neuropsychological development of visuospatial and visuostructional skills. Journal of neuropsychology, neuropsychiatry and neurosciences, 15 (1), 175-200. http://revistaneurociencias.com/index.php/RNNN/article/view/87

Rubio, P., & Rubio, E. (2015). Children's perception of the immediate environment. Spatial Analysis and Geographic Representation: Innovation and Application; In de la Riva, J., Ibarra, P., Montorio, R., Rodrigues, M., Eds, 1485-1494.

Sánchez López, J. V., & Restrepo de Mejía, F. (2018). Preconceptions of temporality in children. Diversitas: Perspectives in Psychology, 14 (2), 363-376. https://doi.org/10.15332/s1794-9998.2018.0002.12

Sánchez, A., and Samada, Y. (2020). Psychomotricity in the comprehensive development of the child. Mikarimin. Multidisciplinary Scientific Journal, 6 (1), 121-138.

https://revista.uniandes.edu.ec/ojs/index.php/mikarimin/article/view/1838

Shonkoff, J.P., & Karakowsky , Y. (2014). Neurobiology of development in early childhood. Foundation for a sustainable society. Bravo, M. & Ruíz, F. The invisibles. Girls and boys from 0 to, 6, 23-47. https://www.mexicanosprimero.org/wp-content/uploads/2022/07/los_invisibles_2014.pdf .

Simbaña-Haro, MP, Gonzalez-Romero, MG, Merino-Toapanta, CE, & Sanmartin-Lazo, DE (2022). Body expression and motor development in 3-year-old children. Scientific Journal Challenges of Science, 6 (12), 25-40. https://retosdelacienciaec.com/Revistas/index.php/retos/article/view/385

Simonetta, E. (2024) The Movement Examination. The Neurofunctional Psychomotor Approach. Publishing House of the University of Azuay. https://doi.org/10.33324/ceuazuay.313

Sutapa , P., Pratama , KW, Rosly , MM, Ali, SKS, & Karakauki , M. (2021). Improving motor skills in early childhood through goal-oriented play activity. Children, 8(11), 994. https://doi.org/10.3390/children8110994

UNESCO/UNICEF/ECLAC (United Nations Educational, Scientific and Cultural Organization/United Nations Children's Fund/Economic Commission for Latin America and the Caribbean) (2022), The crossroads of education in Latin America Latin America and the Caribbean. Regional monitoring report SDG4-Education 2030, Paris.

Ward Jr, J. H. (1963). Hierarchical grouping to optimize an objective function. Journal of the American statistical association, 58 (301), 236-244. http://www.jstor.org/stable/2282967?origin=JSTOR-pdf

Williams, C. M., Tinley, P., & Curtin, M. (2010). Idiopathic toe walking and sensory processing dysfunction. Journal of FootandAnkle Research, 3 (16-20). http://www.jfootankleres.com/content/3/1/16