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The Assessment of Task-Dependent Manual Laterality in Second Grade Students

İkinci Sınıf Öğrencilerinde Göreve Bağlı Manuel Lateralitenin Değerlendirilmesi

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ABSTRACT

Objective: This study was aimed to evaluate the task-dependent manual laterality during fine coordination and grapho-motor tests in school children.

Materials and Methods: We used two action tests (transitive and intransitive) to assess fine coordination skills and a tablet PC to assess number of strokes, pressure, speed and quality in a figure-tracing skill test, among 20 school children (12 girls and 8 boys) of second grade (7-8 years old).

Results: Two-way RM-ANOVA (side × gender) revealed better values in the transitive task on the dominant side (p<0.05), a lesser number of strokes in girls (p<0.001), especially on the dominant side, and higher pressure and better quality on the dominant side (p<0.001). We also found correlations between speed and strokes ratios (r=-0.684), speed and quality ratios (r=0.627), stroke and quality ratios (r=-0.440), and pressure and stroke ratios (rho=-0.395).

Conclusions: Findings showed that functional asymmetry was prominent in complex tasks and in tasks related to practice, such as tracing. Gender differences were also involved. Finally, children were shown to use specific motor strategies to accomplish coordination and grapho-motor tasks with the non-dominant hand.

Keywords: Handedness, tablet PC, asymmetry, fine coordination, grapho-motor skills, gender differences

ÖZ

Amaç: Bu çalışma ile okul çocuklarında ince koordinasyon ve grapho-motor testleri sırasında göreve bağlı manuel lateralitenin değerlendirilmesi amaçlandı.

Gereç ve Yöntem: 20 okul çocuğunun (12 kız, 8 erkek; ikinci sınıf, 7-8 yaş) ince koordinasyon becerilerini değerlendirmek için iki eylem testi (geçişli ve geçişsiz) ve tablet bilgisayar kullanılarak şekil izleme beceri testi ile vuruş sayısı, basıncı, hızı ve kalitesi değerlendirildi.

Bulgular: İki yönlü RM-ANOVA (yan × cinsiyet) baskın taraftaki geçiş görevinde daha iyi değerler ortaya koydu (p<0.05). Kızlarda daha az sayıda (p<0.001) ve baskın tarafta daha yüksek basınçta ve kaliteli vuruş saptandı (p<0.001). Ayrıca hız ve vuruş oranları (r=-0.684), hız ve kalite oranları

(r=0.627), vuruş ve kalite oranları (r=-0.440) ile basınç ve vuruş oranları (rho=-0.395) arasında korelasyon bulundu.

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Sonuçlar: Fonksiyonel asimetrinin karmaşık görevlerde ve izleme gibi uygulama ile ilgili görevlerde ön plana çıktığı görülmüştür. Cinsiyet farklılıkları da söz konusudur. Ayrıca, çocukların baskın olmayan el ile koordinasyon ve grafo motor görevlerini yerine getirmek için spesifik motor stratejileri kullandıkları gösterilmiştir.

Anahtar sözcükler: El seçimi, tablet bilgisayar, asimetri, ince koordinasyon, grafo-motor beceriler, cinsiyet farklılıkları

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INTRODUCTION

The handedness development, in the framework of dominance and laterality, is a complex process; some authors refer to a "multiple trajectories" model (1), with an early Role-Differentiated Bimanual Manipulation (RDBM) over the first two years (2) and a stabilization throughout the late toddlerhood and the pre-school period. However, the consistence of the motor dominance throughout the lifespan and the associated factors are still unclear (3).

The differences in the hands are early expressed with the orientation that each hand adopts during a task, rather than in the ability to accomplish the motor task (4). Thus, the nature of the task and the exposure to specific activities can provide a framework for understanding the coordinative differences between the two hands.

A complex interaction of early life factors may direct hand selection, but the predictive role of those factors (e.g; family status and educational context) on motor development is minimal and there remain to be clarified other hidden factors and the course of their interaction over the life-span (5). From this point of view, the understanding of fine coordination, in the relationship with the handedness, needs to be improved to better clarify the motor control of a contingent task.

Assessment of fine and gross motor skills is a big research field (6) and the wide spectrum of coordinative skills is a fundamental topic in the studies on motor development, with emerging attention on the use of modern technological devices. Axford et al. affirmed that the use of tablet devices could reduce the development of fine motor skills, but that we could use them to obtain improvements in learning with an adequate educational context (7).

The applications of modern technology can also be used in the assessment of writing and tracing skills (8), a field that has been widely studying the domain of fine coordination. Drawing, tracing and writing are grapho-motor skills, i.e. the result of an integrated input from visual and motor modalities during small scale and precise movements; the other clusters of fine motor skills are dexterity, related to the manipulation of small objects, and speed-dominated skills, related to the simple and likely repetitive movements (9).

The fine interplay between fine and grapho-motor skills, as well as fitness performance and athropometrics, is still a debated topic in motor behavior studies (10–13). Grapho-motor skills are acquired throughout the pre-school period and are consolidated during the early stage of scholastic experience, however, the links between specific motor skills and different grapho-motor performances, especially in terms of developmental trajectories, have not yet been sufficiently clarified (14).

Thus, in the present study we wanted to evaluate the differences between the dominant and non-dominant hand in different fine coordinative tasks, by the means of modern technological devices, taking into account the framework of task-dependent manual laterality, testing children in an early consolidation stage on the scholastic course. We included anthropometric and fitness data, by the means of common indexes and a running test, to provide a wide description of our children.

Finally, we aimed to provide a framework for further studies in this field.

MATERIALS AND METHODS

Participants

We recruited initially 22 children from a 2nd grade of a primary school in Italy (mean age=7.2 y, no student repeating the year). We decided to exclude a child with a certificate of disability and a child with a left manual dominance. The final sample was comprised of 12 girls and 8 boys. The study was approved by the Ethics Committee of the "G. d'Annunzio" University of Chieti – Pescara (n. 254/2017). The study ethics was approved by Italian Olympic Committee (CONI). Permission was obtained by the school administration and informed consent was signed by the parents of the children. The study conformed to the Declaration of Helsinki.

Setting

Children were assessed at their school in presence of their teachers. We first measured height, weight and waist circumference of participants, and calculated their Body Mass Index (BMI) and their Waist-to-Height Ratio (WHtR) (15). We assessed children on the 4 × 10 meters shuttle run, collecting their run time (SHUTTLE) (16) (Table 1). We finally conducted tablet PC and functional assessments. The order of execution among Dominant (D) and Non-Dominant (ND) side was randomly conducted for each participant in order to prevent transfer effects.

Materials and procedure

Tablet PC test consisted of a figure-tracing task to assess the grapho-motor skills (9), carried out following the model of Giammarco et al. (17), taking into account the number of strokes (STROKES), mean pressure (PRESSURE), mean speed (SPEED) and mean oscillation from the graphic line (QUALITY). In particular, children were required to redraw with a digital pen 8 segments showed on the screen of a tablet PC (Samsung Galaxy Note 10.1, 1280×800, S. Korea), on a square and on a diamond, both represented both by four segments not connected at the top, and both large enough to cover the screen.

There was an initial repetition as a familiarization phase, followed by two repetitions with the two hands, focusing on the quality of the task. Functional assessment consisted of a tool-related action test (i.e. FLOPPY: transitive) and a non-tool related action test (i.e. THUMB: intransitive) to assess fine coordination. The transitive test required to insert twelve floppy disks one at a time in the proper case, as fast as possible, controlling the case while inserting the disks (to provide different role for each hand). Next, the child performed the same test with the hands in opposite roles. The rationale of the test was based on manual dexterity (9) and, with respect to similar tests – like the coins task of M-ABC 2 battery– this test is not affected by motor experience of common tasks (18). We provided also a link with the technological experience of the tablet, explaining briefly the ancient use of floppy disks. Furthermore, this test requires a strategy to better accomplish the task with increased difficulty during execution (the more disks are in the case, the narrower becomes the empty space). The intransitive test was based on the upper limb coordination and the visual-motor control rationale of BOT-2 battery (19), and on speed-dominated skills (9), with a common task in clinical assessment (finger-thumb test) and motor rehabilitation, and the same outcome of the previous test (time of completing). Participants were required to touch each finger of one hand with the thumb of the same hand in an alternating pattern (5th, 4th, 3rd, and then 2nd finger, and reverse), as fast as possible. The test is repeated with the opposite hand.

Data analysis

We calculated asymmetry indexes (RATIOs) of the tablet PC and functional parameters, as percentage increment or decrement of the non-dominant side performance. The statistical analyses were carried out using GraphPad Prism Software, version 7 (GraphPad Software, La Jolla, USA), and R-based open-source software

Jamovi (https://www.jamovi.org). Identification of outliers was performed with Iterative Grubbs method (Alpha=0.01). Normality of the distributions was assessed with Shapiro-Wilk test. Equality of variances was assessed with Levene's test. Data are reported as Mean (M) ± Standard Deviation (SD). Independent samples T-test was used to examine gender differences on BMI, WtHR and SHUTTLE. Two-way RM-ANOVA was conducted to examine side × gender differences. Tukey correction was used for multiple analyses. Multivariate ANCOVA with Wilk's Lambda method was performed to test the influence of factors (gender) and covariates (WtHR and SHUTTLE) on all the RATIOs. We used correlation analyses with Pearson or Spearman method to test the correlations between the parameters; we used correlation matrixes also for tablet pc parameters on D and ND side.

RESULTS

Anthropometrics and fitness

Independent samples T-test revealed no significant differences between girls and boys on BMI, WtHR and SHUTTLE. One girl was over the metabolic risk threshold of 0.5 in WtHR anthropometric index (20). We matched our data with the existing World Health Organization (WHO) cut-off for the age (21); in particular, we characterized the children according to the over-weight cut-off of 85th percentile and the obesity cut-off of 97th percentile (22): we found 5 overweight and 2 obese girls, and 1 overweight boy. Thus, in our sample, the percentages of at-least-overweight children was 58.3% on girls and 12.5% on boys. Median of SHUTTLE test, in our sample, was close to the 25th percentile for boys and close to the 40th percentile for girls, considering the present European references for children of the same age (23).

Dominant (D) vs. Non-Dominant (ND) comparison

Two-way RM-ANOVA revealed the following: FLOPPY time was lower on D side ($p=0.028$); boys used more STROKES ($p<0.001$), especially on D side (girls vs. boys on D side, $p=0.005$); QUALITY was better on D side ($p<0.001$) on both girls ($p<0.001$) and boys ($p<0.001$); PRESSURE was higher on D side ($p<0.001$) on both girls ($p<0.001$) and boys ($p=0.017$). Regarding RATIOs, among the four tablet parameters and the two functional tests, the greatest percentage spread was on QUALITY (64.7%) while the lowest one was on THUMB (3.21%). MANCOVA revealed no significant differences on RATIOs, related to gender, WtHR and SHUTTLE.

Correlation matrixes revealed good or low correlation between SPEED and QUALITY RATIOS ($r=0.627$), SPEED and STROKES RATIOS ($r=-0.684$), STROKE and QUALITY RATIOs ($r=-0.440$), and PRESSURE and STROKE RATIOs (rho=-0.395). No correlation was found for FLOPPY or FINGERS RATIOs and the other parameters; on D side, we found correlation between SPEED and QUALITY ($r=0.801$), SPEED and STROKES ($r=-0.694$), STROKES and QUALITY ($r=-0.492$); on ND side, we found correlation between SPEED and QUALITY ($r=0.785$), SPEED and STROKES ($r=-0.511$).

Table 1. Anthropometric, fitness and functional parameters of the participants

				Dominant side		Non-dominant side	
	BMI	**WtHR**	**SHUTTLE**	**FLOPPY**	**THUMB**	**FLOPPY**	**THUMB**
Girls	18.20 ± 2.65	0.47 ± 0.03	15.51 ± 1.26	20.10 ± 3.34	4.12 ± 0.89	23.49 ± 3.39	3.95 ± 0.85
Boys	16.42 ± 0.89	0.44 ± 0.02	15.30 ± 2.17	22.41 ± 4.27	4.55 ± 0.37	23.50 ± 2.95	4.42 ± 0.44

BMI: Body Mass Index; WtHR: Waist-to-Height Ratio; data are expressed as Mean ± SD

Table 2. Tablet PC parameters of the participants

	Dominant side				Non-dominant side			
	STROKES	**PRESSURE**	**SPEED**	**QUALITY***	**STROKES**	**PRESSURE**	**SPEED**	**QUALITY***
Girls	10.72±2.27	66.68±7.09	23.79±8.74	0.84±0.24	13.40±3.37	47.51±14.10	23.50±6.55	1.28±0.23
Boys	15.09±1.96	59.71±14.04	17.31±4.88	0.77±0.13	15.60±2.77	43.92±8.44	21.12±4.53	1.35±0.21

*Data expressed as Mean ± SD; *Smaller values denote better results*

DISCUSSION

We aimed to explore the topic of Dominant (D) vs. Non-Dominant (ND) in different fine motor tasks. Depending on our results, we strongly support the concept of laterality as a complex and multifaced profile in motor performances (24).

Tracing quality was better with the dominant hand, considering that tracing is an experience-related task, we can assume that better performance derives by practice. The strategy to accomplish the grapho-motor task on D side seemed to be related to lesser speed and lesser number of strokes. Furthermore, we can assume a greater confidence on D side, expressed by higher pressure and lesser number of strokes. Thus, better outcome on D side can be plausibly related to a lesser "neuromotor noise" during the execution (25).

The higher pressure on D side, but the absence of correlation with the quality, lead us to interpret hand pressure during writing as a result of a more automated execution, with a little implication on fine coordinative expression. This interpretation is coherent with the results of Giammarco and colleagues, who reported the association between pressure on tablet task and handgrip strength (17). The strategy seemed to be different between girls and boys, with the latter showing no significant difference in the number of strokes between D and ND side. However, correlation results, together with the high variability of our results, let us to assume that the strategy of accomplishing this fine coordinative grapho-motor task cannot be generalized because of the involvement of individual strategies. Considering the difference in the sensorimotor network when performing dominant vs. non-dominant simple motor task (26), we can speculate that complex tasks may be related to different sensorimotor dynamic networks, leading to different motor control experiences.

We did not find differences in THUMB test. This was a simple fine coordinative task, thus we can assume that in motor tasks with a low-level of complexity, children do not perform better with the dominant hand. FLOPPY test performance was better on D side; this test required a more complex strategy and motor outcomes, with a RDBM structure. Thus, we assume that in dexterity tasks requiring hand action differentiation and interaction with a tool, performance is better with the dominant hand. However, these two tests are time-related, so that we cannot exclude different results in process-related tests. Indeed, considering that fine coordinative training lead to different brain functional changes depending on whether hand (dominant or non-dominant) is trained (27), we should consider such difference in motor learning experiences.

The anthropometric and the fitness domains follow different developmental trajectories with respect to fine coordinative abilities and grapho-motor skills. Our observations and the articulate interaction with the health and the social domains (28), lead us to suggest further studies considering fine coordination and grapho-motor skills in the associations with social incomes, social habits and healthy fitness status.

Limitations

The number of participants was relatively low in our sample, as well as the inclusion of right-handed children only; thus, further studies with

a larger number of participants and the evaluation of right-handed vs. left-handed children are required to reveal more comprehensive results related with this topic.

Perspectives

We suggest using multi-domain and multi-tool batteries in the assessment of physical traits in Primary School, and to contextualize functional and digital tests in a physical education setting. We suggest a continuous monitoring, by teachers and parents, to check the developmental trajectories of children by taking into account fine motor skills. A large recruitment organized by policy developers should be really useful for the establishment of specific references for a wide spectrum of motor tests.

CONCLUSIONS

The handedness is expressed as a task-dependent difference between dominant and non-dominant side. We can assume that practice-related tasks (like grapho-motor tasks in school) and complex dexterity actions are dominance-dependent, while simple and non-familiar tasks do not follow this rule. Considering also the blurry knowledge about the concordance of different domains in hemispheric lateralization (29), further studies are needed to extend the conceptual and practical framework of task-dependent manual laterality.

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