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Identifying the Level of Symmetrization of Reaction Time According to Manual Lateralization between Team Sports Athletes, Individual Sports Athletes, and Non-Athletes

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Abstract: The present study aimed to investigate the impact of practicing sports activities on manual skills, focused on reaction time depending on manual laterality. The objectives of the study were to identify the differences in improving simple, optional, and cognitive reaction times in the manual executions of student athletes who practice team sports involving the manual handling of the ball (volleyball, basketball, handball) in comparison with student athletes who practice individual sports and with non-athletic students; to identify the differences regarding the reaction time of the right- and left-handed executions depending on the manual lateralization of the subjects (right- and left-handedness) between the three experimental samples: team sports group (TSG), individual sports group (ISG), and the group of non-athletes (NAG) through the use of computer tests. The study included 335 subjects who were divided into three groups: TSG with 102 subjects, ISG with 112 subjects, and NAG with 121 subjects. The subjects of the study were given five computer tests to evaluate three types of reaction time: simple reaction time (Start/Stop Test), choice reaction time (Check Boxes Test, Hit-the-dot Test), and time of cognitive reaction (Trail making Test part A and B). The results were analyzed regarding right- and left-handedness, as well as the execution hand (right hand or left hand) in solving the tests. The results of the study highlighted significant statistical differences between the three groups: TSG, ISG, and NAG. The best results were recorded by TSG in all tests, and the lowest by NAG. Statistically significant differences were also recorded between the executions with the dominant hand compared to the executions with the non-dominant hand in relation to right- and left-handedness. The study highlighted that the smallest differences in all the study groups were recorded in the simple reaction time test, where the differences between the right-handed and left-handed executions were the lowest, reflecting the best level of symmetrization of the motor executions.

Keywords: left- and right-handedness; simple reaction time; choice reaction time; cognitive reaction time; computer tests; team sport; individual sports; non-sports

1. Introduction

The present study focuses on identifying the differences in simple, choice, and cognitive reaction time between right- and left-handed executions in relation to manual laterality through the use of computer tests. Cerebral lateralization has a direct effect on the mobility of the upper limbs, which is realized through manual laterality, according to which the subjects are divided into right-handed, left-handed, and ambidextrous [1–3]. The research has shown that the better the level of hemispheric lateralization is defined and the more extensive the motor experience of the individual, the better the efficiency of the manual executions is embodied in reaction time, correctness of the movement, execution technique, efficiency of the movement, etc. [4–7]. Through the process of sports training or through the expansion of digital skills, it is possible to optimize the executions at the level of the right or left hand, as well as improve the level of symmetry of the executions based on the motor transfer from the dominant to the non-dominant segment [8–10].

The motor reaction time is inextricably dependent on the perceptual speed in performing a motor task, the speed of the decision or execution being conditioned by the level of complex mental processes, especially thinking [11,12]. The reaction time is dependent on the following factors: sensory modality (visual, auditory), sensory quality, stimulus intensity, surface or significance of the surface or the stimulating organ, the interval between the inception of the preparatory signal and the stimulus; the appearance or the moment of cessation of the stimulation, the similarity of the stimuli; the number of stimuli and responses; motivation of the subject in performing the experimental task, experience in performing reaction time tests [13,14].

The interrelationship between cognitive and motor skills influences the way and speed with which athletes make decisions based on which they order and manage their motor skills in order to make them more efficient. The evolution of technology has led to the development of digital and motor skills and implicitly the reaction time of some cognitive abilities [15–17]. Studies have shown that the stimulation of cognitive skills in relation to reaction time can be achieved by practicing physical and sports activities [18,19]. The reaction time is dependent on the nature of the stimulus (visual or auditory), on the manual lateralization, on the level of symmetrization of motor abilities and skills, and on the complexity of the task, including simple, optional, and cognitive reaction time [20–22]. The simple motor reaction time manifests itself in response to different stimuli embodied by a simple movement [23,24], while the choice or cognitive reaction time involves the selection or combination of some tasks in the shortest possible time in relation to the nature, complexity, and intensity of the stimulus [25–27].

The complexity of the physical and technical skills specific to sports games requires the athletes to handle the ball with one or both hands; passing or diving on different trajectories with force, with adequate speed, and with great precision; catching the ball launched with different trajectories and force, etc. [28–30]. The specifics of team sports require from the athletes a special technical level and a great ability to adapt physical and technical skills in ever-changing conditions imposed by the specifics of the game, the level of sports training, the play of teammates, and especially the play of opponents [31,32]. The efficiency of training, evaluation, and performance of players in training and competition conditions is conditioned by the ability to analyze and make cognitive decisions, by the speed of motor reactions, and by the efficiency of technical executions [33,34]. In individual sports, the reaction time in performing motor skills which do not involve manual execution is manifested at the level of motor reactions, the ability to analyze and decide, changes in direction, and the transformation and combination of movements [35–38]. Studies have shown that between cognitive abilities, neuromuscular reaction, and physical and technical abilities, there is an interrelationship that aims at the modality, efficiency, and speed of decision making and execution of physical and technical skills in order to increase efficiency in training and competitions, these aspects being essential in optimizing the process of sports training [39–41].

Our study approaches the analysis of reaction time from a new perspective, that of the use of a computer test in relation to three groups of students, one of which includes athletes who practice team games which require handling the ball (volleyball, basketball, handball), another including individual sports practitioners without manual practice or manipulation of objects, and another group of non-athlete students. We consider the computer tests used for the evaluation of simple, optional, and cognitive reaction times to be part of the current trends of expanding motor and manual digital skills and the implementation of technologies in human activities. Identifying the differences between right-handed and left-handed executions depending on manual laterality will facilitate the identification of both the differences and the degree of symmetrization of the reaction time at the level of manual skills.

The present study on the impact of practicing sports activities on manual skills focused on reaction time depending on manual laterality had the following objectives:

— O1. Identifying the differences in terms of improving reaction times: simple, optional, and cognitive in the manual executions of students—athletes who practice team sports that involve manual handling of the ball (volleyball, basketball, and handball) compared to subjects who practice individual sports (which do not require handling an object) and compared to non-athlete subjects.

— O2. Identifying the differences regarding the reaction time of right- and left-handed executions depending on the manual laterality (right- and left-handedness) between the three experimental groups—team sports group (TSG), individual sports group (ISG), and non-athletes group (NAG)—through the use of computer tests.

2. Materials and Methods

2.1. Study Design

The research was carried out between April and November 2023. In order to establish the manual laterality (manual dominance), the dominant hands of the subjects, they were asked with which hand they catch and throw the ball, with which hand they brush their teeth, and with which hand they do most of manual actions. The study included 5 computer tests under ambidextrous execution conditions (with the dominant hand—right and with the non-dominant hand—left) for the evaluation of reaction time: simple, choice, and cognitive. All tests were applied under standardized conditions regarding the order in which they were performed, the number of trials, the equipment used, and the time interval of application (10–14 a.m.). The subjects of the study were trained on the experimental protocol. The order of application of the tests was Start/Stop Test [42], Check Boxes Test [43], Hit-the-dot Test [44], and Trail Making Test part A and B [45]. Before the start of the test sessions, the subjects of the study were instructed on the order of the tests and on the fact that they should focus on performing the tests as quickly as possible in order to evaluate the manual motor reaction time. Each test included 2 trials and the time or the best score achieved by each subject was taken into account. The trial sessions were preceded by a training session in which the subjects had the opportunity to adapt to the tests and the testing conditions. The tests were performed on the Samsung S9+ 12.4″ tablet with touch screen.

This research was approved under no. 72/08.11.2023 of the Review Board of the Faculty of Physical Education and Mountain Sports from Transylvania University of Brasov, Romania. The participation in the study was voluntary, based on the informed consent of each participant; the study followed the principles of the Declaration of Helsinki. All authors of this article contributed equally and all of them made an equal contribution to the first author.

2.2. Participants

The present cross-sectional study was attended by 335 subjects; students were divided into three groups as follows:

— (TSG) the group of active athletes who practice a team game at performance level, totaling 102 subjects, structured according to sports as follows: 22 athletes—volleyball, 38 athletes—basketball, 42 athletes—handball; right-handed 88, left-handed 14.
— (ISG) the group of athletes practicing individual sports, totaling 112 subjects, of which 42 athletes—athletic sports, 11 athletes—winter sports, 59 athletes—other individual sports; right-handed 100, left-handed 12.
— (NAG) the group of non-athletes, made up of 121 students in the programs of economic sciences, physiotherapy, and other university study programs; right-handed 110, left-handed 11.

The characteristics of the entire group were as follows: mean age ± SD 22.31 ± 2.59, female 153 (45.6%), male 182 (44.4%); TSG: 45 female (44.1%), 57 male (55.9%); ISG: 47 female (41.9%), 659 male (48.1%); NAG: 43 female (35.5%), 78 male (64.5%). The criteria for the inclusion of these subjects in the study were as follows: active athletes practicing the sports selected for research with at least 6 years of experience, good health condition, between 20 and 24 years of age, students and full-time students. Exclusion criteria included interruption of sports activity for more than a month due to injuries or not completing the tests fully.

2.3. Measures

In the study, three variants of the reaction time were targeted, according to which the computerized tests were selected, as follows:

— simple motor reaction time was tested with the Start/Stop Test;
— choice reaction time was tested with the Check Boxes Test and Hit-the-dot Test;
— cognitive reaction time was tested with the Trail Making test part A and B.

Start/Stop Test [42]. The test includes 5 attempts and their arithmetic mean is quantified. The test starts by pressing the “Start” button, after which the word “wait” appears, and when the word “push” appears, the subject must touch the “Stop” button as quickly as possible. The lowest average time achieved by the subject from the 2 trials is recorded for the study. The test is performed first with the right hand and then with the left hand.

Check Boxes Test [43]. It consists in touching with one finger as many circles as possible in 20 s. The test includes 100 circles arranged in 10 columns and 10 rows. The largest number of circles selected in 20 s between the 2 trials is quantified. The test is performed first with the right hand, then with the left hand.

Hit-the-dot Test [44]. The computerized test is performed by touching with your finger as many black dots as possible that appear in the empty circles; the dots appear randomly. The test includes a total of 60 circles arranged in 6 lines with 10 circles each; the test takes 30 s. The Hit-the-dot Test includes 2 trials and the highest number of points achieved is considered for the study. The test is performed first with the right hand and then with the left hand.

Trail Making Test—part A and B [45]. The Trail making Test—part A [46,47] includes 25 randomly arranged circles, and the subject must draw with his/her finger on the touch screen lines between numbers in ascending order (1-2-3 . . .25). The Trail making Test—part B consists in the random arrangement on the tablet screen of 25 circles that contain numbers from 1 to 13 and letters from A to L; the subject must draw lines with his/her finger so as to associate the numbers with the letters in ascending order (according to the model 1-A, ... 12-L, 13). The shortest time from the two trials is taken into account. The test is performed first with the right hand and then with the left hand.

2.4. Statistical Analysis

The data were processed using IBM-SPSS 24. Statistical parameters calculated were as follows: arithmetic mean (mean), standard deviation (SD), mean difference (ΔX), Student *t*-test and confidence coefficient (95% CI) with the two levels lower and upper, coefficient of variance (CV), and Skewness parameter. The verification of the normal distribution was carried out by means of the Skewness asymmetry statistical parameter; interpretation of the values was performed as follows: between −1 and +1 are considered excellent indicators of normality. The coefficient of variation (CV) reflects the dispersion of the data, respectively, the degree of homogeneity of the group. The interpretation was performed as follows: 0–10% high homogeneity, 10–20% relatively high homogeneity, 20–30% medium homogeneity, over 30% relatively heterogeneous population. Analysis of variance (ANOVA) was used to evaluate if there were differences between the average values of the three study groups (TSG, ISG, NSG), in relation to the type of reaction time analyzed. The ANOVA analysis focused on the calculation of the following statistical parameters: sum of squares, mean squares, degrees of freedom (df), F—Fisher parameters, p—the level of statistical significance. The reference statistical significance value for this study was p-value < 0.05.

3. Results

In Tables 1–3, we present the statistical analysis of the results of the three groups of the study, and in Tables 4 and 5 are presented the analysis of variance (ANOVA) between the three groups for each test according to manual laterality (right- and left-handedness).

Table 1. Statistical analyses of the results of the tests of reaction time for the team sports group (TSG).

Test	Manual Lateralization	Hand of Execution	Mean	SD	Ske	CV (%)	ΔX	*t*	*p*	95%CI Lower	95%CI Upper
Start/Stop Test	right-handedness	RH	0.26	0.02	−0.65	7.69	−0.02	−2.70	0.012	−0.06	−0.01
		LH	0.28	0.01	0.99	3.57					
	left-handedness	RH	0.29	0.04	−0.86	13.79	0.03	3.36	0.003	0.01	0.04
		LH	0.26	0.02	0.40	7.69					
Check Boxes Test	right-handedness	RH	32.34	6.24	0.13	19.30	6.65	7.98	0.000	4.99	8.30
		LH	25.69	1.43	0.38	5.57					
	left-handedness	RH	26.10	5.12	0.04	19.61	−4.43	−7.73	0.000	−13.23	−7.62
		LH	30.53	4.21	0.35	13.79					
Hit-the-dot Test	right-handedness	RH	34.20	4.40	−0.57	12.87	6.97	1.44	0.000	3.92	7.87
		LH	27.23	4.56	0.53	16.75					
	left-handedness	RH	19.34	3.57	−0.01	18.46	−10.35	−5.66	0.000	−14.28	−6.41
		LH	29.69	5.90	−0.84	19.87					
Trail Making Test—part A	right-handedness	RH	27.44	7.00	0.96	25.51	−5.42	−0.77	0.012	−11.29	2.44
		LH	32.86	5.96	0.82	18.14					
	left-handedness	RH	32.93	7.32	−0.07	22.23	1.68	3.46	0.002	0.27	4.08
		LH	33.25	5.05	−0.11	15.19					
Trail Making Test—part B	right-handedness	RH	36.86	8.90	0.48	24.15	−6.04	0.44	0.031	−8.57	1.49
		LH	42.90	6.87	0.62	16.01					
	left-handedness	RH	46.17	8.78	0.67	19.02	8.37	4.02	0.001	4.03	12.69
		LH	37.80	6.52	−0.01	17.25					

SD—standard deviation, t—value of Student test, p—lever of statically probability, CI—interval of confidence, RH—right hand, LH—left hand, CV—coefficient of variance, Ske—Skewness parameter, ΔX—mean difference.

In all the tests, the subjects of the TSG group recorded better results when performing with the hand corresponding to the (dominant) manual side compared to the other performing hand. Analyzing the results in Table 1, it can be seen that the results recorded with the dominant hand were better than with the non-dominant one, in all tests. The arithmetic means of all tests fell between the lower and upper limits of the 95% CI for all tests depending on manual dominance. The differences between the executions with the right and the left hand were statistically significant, for the selected reference p-value < 0.05.

Depending on the manual dominance, between the executions with the two hands, we can see that bigger differences were recorded for left-handedness in the tests: Check Boxes Test 6.65 points, Trail Making Test—part A—5.42 s. And in the other tests, the left-handedness executions recorded greater differences compared to right-handedness.

Table 2. Statistical analyses of the results of the tests of reaction time for the individual group (ISG).

Test	Manual Lateralization	Hand of Execution	Mean	SD	Ske	CV (%)	ΔX	*t*	*p*	95%CI Lower	95%CI Upper
Start/Stop Test	right-handedness	RH	0.32	0.01	−0.05	3.13	−0.02	−3.26	0.005	−0.02	−0.01
		LH	0.34	0.02	0.50	5.88					
	left-handedness	RH	0.33	0.03	−0.81	9.09	0.03	4.93	0.000	0.017	0.04
		LH	0.30	0.06	−0.17	20.00					
Check Boxes Test	right-handedness	RH	30.63	5.82	0.27	19.00	8.63	6.07	0.000	5.63	11.64
		LH	22.00	4.43	−0.22	20.14					
	left-handedness	RH	22.32	4.47	0.36	20.03	−4.84	−5.16	0.000	−9.67	−4.02
		LH	27.16	4.28	0.86	15.76					
Hit-the-dot Test	right-handedness	RH	31.82	3.18	0.39	9.99	8.07	6.81	0.000	5.51	10.63
		LH	23.75	3.93	0.24	16.55					
	left-handedness	RH	20.80	3.90	0.03	18.75	−7.78	−17.87	0.000	−9.75	−7.79
		LH	28.58	0.900	−0.53	3.15					
Trail Making Test—part A	right-handedness	RH	29.47	4.80	0.28	16.29	−5.78	−2.59	0.023	−10.60	−0.946
		LH	35.25	6.48	0.49	18.38					
	left-handedness	RH	39.20	7.759	−0.58	19.79	5.15	2.31	0.033	3.36	9.93
		LH	34.35	5.52	−0.97	16.07					
Trail Making Test—part B	right-handedness	RH	39.87	6.83	0.91	17.13	−6.82	−4.38	0.000	−10.07	−3.54
		LH	46.69	4.75	0.69	10.17					
	left-handedness	RH	49.40	7.91	−0.08	16.01	9.85	7.05	0.000	7.61	11.08
		LH	39.55	2.51	0.89	6.35					

SD—standard deviation, *t*—value of Student test, *p*—lever of statically probability, CO—interval of confidence, RH—right hand, LH—left hand, CV—coefficient of variance, Ske—Skewness parameter, ΔX—mean difference.

For the Start/Stop Test, the best time achieved was with the hand corresponding to the manual dominance, at 0.26 s. For the Check Boxes Test, the best score was achieved by the right-handed subjects when performing with the right hand, at 32.34 points. In the Check Boxes Test, the best score was achieved by the right-handed subjects when performing with the right hand, at 34.20 points. In the Hit-the-dot Test choice reaction time evaluation test, the best score was recorded for the right-handed subjects when performing with the right hand, at 34.20. In the Trail Making Test—part A, the best cognitive reaction time was achieved by the right-handed subjects when executing with the right hand, at 27.44 s. Finally, for the Trail Making Test—part A, the best score was also for the right hand, at 36.86 s. The values of the Skewness parameter reflect a normal distribution for all tests depending on the execution hand and manual lateralization, the values being between −1 and 1. Similarly, the coefficient of variation (CV) reflects a good and relatively good homogeneity in the majority of tests with the following exceptions for the Trail Making Test—part A and B for right-handed executions, where the homogeneity of the groups was average, the values falling between 20 and 30%.

Analyzing the results recorded by the ISG group, we found that for the Start/Stop Test, the best time achieved was with the left hand corresponding to left-handedness, at 0.30 s. For the Check Boxes Test, the best score was achieved by the right-handed subjects when performing with the right hand, at 30.63 points. In the Check Boxes Test, the best score was achieved by the right-handed subjects when performing with the right hand, at 34.20 points. For the Hit-the-dot Test, the best score was recorded by the right-handed subjects when performing with the right hand, at 31.82. For the Trail Making Test—part A, the best time was achieved by the right-handed subjects for execution with the right hand, at 29.47 s. Finally, for the Trail Making Test—part A, the best score was achieved by left-handed subjects for the executions with the left hand, at 39.55 s.

Table 3. Statistical analyses of the results of the tests of reaction time for the non-sports group (NAG).

Test	Manual Lateralization	Hand of Execution	Mean	SD	Ske	CV (%)	ΔX	*t*	*p*	95%CI Lower	95%CI Upper
Start/Stop Test	right-handedness	RH	0.34	0.03	−0.23	8.82	−0.03	−4.18	0.000	−0.03	−0.01
		LH	0.37	0.02	−0.30	5.41					
	left-handedness	RH	0.34	0.04	0.40	11.76	0.03	3.27	0.002	0.01	0.04
		LH	0.31	0.03	−0.14	9.68					
Check Boxes Test	right-handedness	RH	29.67	5.78	0.77	19.48	6.86	5.76	0.000	4.44	9.25
		LH	22.81	4.76	0.95	20.87					
	left-handedness	RH	19.64	3.75	0.92	19.09	−9.63	−7.22	0.000	−12.36	−6.88
		LH	29.27	5.96	0.77	20.36					
Hit-the-dot Test	right-handedness	RH	29.31	3.83	−0.80	13.07	6.72	8.23	0.000	5.07	8.38
		LH	22.59	3.31	0.72	14.65					
	left-handedness	RH	20.64	4.21	0.32	20.40	−5.72	−6.02	0.000	−7.64	−3.78
		LH	26.36	3.92	−0.74	14.87					
Trail Making Test—part A	right-handedness	RH	32.77	6.28	−0.05	19.16	−2.31	−3.97	0.000	−6.48	−1.13
		LH	35.08	3.98	0.840	11.35					
	left-handedness	RH	35.90	6.87	−0.08	19.14	2.05	6.39	0.000	0.52	4.59
		LH	37.85	4.80	−0.08	12.68					
Trail Making Test—part B	right-handedness	RH	44.38	6.75	−0.59	15.21	−3.41	−2.60	0.013	−6.06	−0.76
		LH	47.79	5.13	0.71	10.73					
	left-handedness	RH	50.29	11.71	0.42	23.28	9.93	6.35	0.000	8.17	15.68
		LH	40.36	6.57	0.70	16.28					

SD—standard deviation, *t*—value of Student test, *p*—lever of statically probability, CI—interval of confidence, RH—right hand, LH—left hand, CV—coefficient of variance, Ske—Skewness parameter, ΔX—mean difference.

The differences between the arithmetic averages of the right-handed and left-handed executions, in all tests for right-handedness and left-handedness, were statistically significant. The differences in the arithmetic means for all tests, for both right- and left-handedness, fell between the two limits of the 95% CI. In all the tests, the subjects of the ISG group recorded better results in the executions with the hand corresponding to the manual dominance compared to the other execution hand (for example, for right-handedness with left hand execution, respectively, for left-handedness with right hand executions) (Table 2). The values of the Skewness parameter reflect a normal distribution for all the tests depending on the execution hand and the manual lateralization, the values being between −1 and 1. Similarly, the coefficient of variation (CV) reflects a good and relatively good homogeneity of all the tests depending on manual lateralization and hand of execution.

Table 4. ANOVA between right-handedness of TSG, ISG, and NAG.

Test	Hand of Execution	Groups	Mean Difference	Sum of Squares	df	Mean Square	F	*p*
Start/Stop Test	RH	ISG-TSG	0.06	0.25	2	0.12	214.30	0.000
		NAG-TSG	0.08					
		NAG-ISG	0.02					
	LH	ISG-TSG	0.04	0.13	2	0.06	43.75	0.000
		NAG-TSG	0.05					
		NAG-ISG	0.01					
Check Boxes Test	RH	ISG-TSG	−1.71	288.30	2	144.15	4.08	0.018
		NAG-TSG	−2.67					
		NAG-ISG	−0.96					
	LH	ISG-TSG	−3.78	21.20	2	10.60	0.48	0.014
		NAG-TSG	−6.46					
		NAG-ISG	−2.68					
Hit-the-dot Test	RH	ISG-TSG	−2.38	374.12	2	187.06	12.92	0.000
		NAG-TSG	−4.89					
		NAG-ISG	2.51					
	LH	ISG-TSG	1.46	100.06	2	50.03	3.24	0.041
		NAG-TSG	1.30					
		NAG-ISG	−0.16					
Trail Making Test—part A	RH	ISG-TSG	2.03	485.07	2	242.53	6.64	0.002
		NAG-TSG	5.33					
		NAG-ISG	3.30					
	LH	ISG-TSG	6.27	505.85	2	252.92	4.70	0.010
		NAG-TSG	2.97					
		NAG-ISG	−3.30					
Trail Making Test—part B	RH	ISG-TSG	3.01	1046.74	2	523.37	9.36	0.000
		NAG-TSG	7.52					
		NAG-ISG	4.51					
	LH	ISG-TSG	3.23	2456.91	2	1228.45	13.16	0.000
		NAG-TSG	4.12					
		NAG-ISG	0.89					

TSG—group of team sports, ISG—group of individual sports, NAG—group of non-sports, RH—right hand, LH—left hand, df—degree of freedom, F—value of Fisher test, *p*—level of statistical probability.

Analyzing the results recorded by the ISG group, we find that for the Start/Stop Test, the best time achieved was with the left hand corresponding to the left-handed subjects, at 0.31 s. For the Check Boxes Test, the best score was achieved by the right-handed subjects when performing with the right hand, at 29.67 points. In the Check Boxes Test, the best score was achieved by the right-handed subjects when performing with the right hand, at 34.20 points. For the Hit-the-dot Test, the best score was recorded by the right-handed subjects when performing with the right hand, at 29.31. For the Trail Making Test—part A, the best time was achieved by the right-handed subjects when executing with the right hand, at 32.77 s. Finally, for the Trail Making Test—part A, the best score was achieved by left-handed subjects for left-handed executions, at 40.36 s.

Table 5. ANOVA between left-handedness of TSG, ISG, and NAG.

Tests	Hand of Execution	Groups	Mean Difference	Sum of Squares	df	Mean Square	F	*p*
Start/Stop Test	RH	ISG-TSG	0.06	0.04	2	0.03	80.95	0.000
		NAG-TSG	0.09					
		NAG-ISG	0.03					
	LH	ISG-TSG	0.04	0.02	2	0.01	17.98	0.000
		NAG-TSG	0.05					
		NAG-ISG	0.01					
Check Boxes Test	RH	ISG-TSG	−3.69	99.27	2	49.63	3.04	0.048
		NAG-TSG	−2.88					
		NAG-ISG	0.81					
	LH	ISG-TSG	−3.37	72.39	2	36.19	1.37	0.026
		NAG-TSG	−1.26					
		NAG-ISG	2.11					
Hit-the-dot Test	RH	ISG-TSG	−3.48	178.76	2	89.38	6.03	0.005
		NAG-TSG	−4.64					
		NAG-ISG	−1.16					
	LH	ISG-TSG	−1.11	125.69	2	62.84	3.35	0.044
		NAG-TSG	−3.33					
		NAG-ISG	−3.22					
Trail Making Test—part A	RH	ISG-TSG	2.39	145.97	2	72.98	2.33	0.019
		NAG-TSG	2.22					
		NAG-ISG	0.17					
	LH	ISG-TSG	1.1	177.86	2	88.93	3.47	0.040
		NAG-TSG	4.6					
		NAG-ISG	3.5					
Trail Making Test—part B	RH	ISG-TSG	3.79	199.74	2	99.87	3.20	0.050
		NAG-TSG	4.89					
		NAG-ISG	1.1					
	LH	ISG-TSG	1.75	84.41	2	42.22	1.25	0.029
		NAG-TSG	2.56					
		NAG-ISG	0.81					

TSG—group of team sports, ISG—group of individual sports, NAG—group of non-sports, RH—right hand, LH—left hand, df—degree of freedom, F—value of Fisher test, *p*—lever of statistical probability.

The tests regarding the simple, choice, and cognitive reaction time for the group of non-athletes highlighted the fact that the results with the hand corresponding to manual dominance were better than with the other hand. The differences between the arithmetic means for right-handed and left-handed executions were statistically significant for p-value < 0.05 for all tests related to manual dominance (right-handedness and left-handedness). The differences between the arithmetic means of the right-handed and the left-handed executions for all tests fell within the 95% of the CI limits (Table 3). The values of the Skewness parameter reflect a normal distribution for all the tests depending on the execution hand and the manual lateralization, the values being between −1 and 1. Similarly, the coefficient of variation (CV) reflects a good and relatively good homogeneity of all the tests depending on manual lateralization and execution hand, with a single exception in the Trail Making Test—part B in subjects with left manual lateralization in executions with the left hand, where values of 23.28% homogeneity were recorded, being medium.

The analysis of variance for all tests indicates statistically significant differences between the three study groups in all tests for the right-handed subjects. In all tests, the differences between the arithmetic averages between TSG and ISG, respectively, and NAG were in favor of TSG, which recorded better reaction times for both right-handed and left-handed executions. Analyzing the differences between the arithmetic averages recorded between ISG and NAG, it is found that ISG had better reaction times than NAG.

For the Start/Stop Test, the biggest difference between the groups was recorded for right-handed executions between NAG and TSG, at 0.08 s., and for left-handed executions, at 0.05, also in favor of TSG compared to NAG. For the Check Boxes Test, the biggest difference was between TSG and NAG, in favor of TSG for executions with both hands. For the Hit-the-dot Test, the biggest difference was −4.89 for right-handed execution between TSG and NAG, respectively, with the left hand, at 1.46 points, between ISG and TSG. For the Trail making Test part A and B, the biggest differences were recorded for the right hand between TSG and NAG, with a single exception for part A in the executions with the right hand, where a difference in arithmetic averages of 6.27 s was recorded between ISG and TSG (Table 4).

In all tests, the differences between the arithmetic averages between TSG and ISG, respectively, and NAG were in favor of TSG, which recorded better reaction times for right-handed executions, as well as for left-handed executions. Analyzing the differences between the arithmetic averages recorded between ISG and NAG, it is found that ISG had better reaction times than NAG. Analyzing the ANOVA results, we observe statistically significant differences between the three groups of the study in all tests for the left-handed subjects. In most of the tests, the biggest differences between the arithmetic averages for right- or left-handed executions were recorded between TSG and NAG, in favor of TSG, the exceptions being the Hit-the-dot Test for right-handed executions, where the biggest difference was between TSG and ISG, at 3.48, respectively, for the Trail Making Test—part A, as well as for right-handed executions, at −2.39 s, between TSG and ISG (Table 5).

4. Discussion

Our study sought to identify the differences regarding the manual reaction time depending on the manual laterality through computer tests between three categories of students: a group of sports students from team games with a ball, a second group of athletes from individual sports, and a third group of non-athletes. The second aim of the present study aimed to identify differences regarding the reaction time of right- and left-handed executions depending on manual dominance (right- and left-handedness) between the three experimental groups: team sports group (TSG), individual sports group (ISG), and non-athletes group (NAG). The results of the study highlighted the fact that the athletes who practice team games with a ball (volleyball, handball, and basketball) have a simple, optional, and cognitive reaction time better than the group of athletes who practice individual sports and also than the group of non-athletes. Maneuvering an object determines the expansion of the manual handling skills and implicitly the reaction time of the athletes compared to athletes who do not handle objects manually or compared to non-athletes. Also, in the study, we identified statistically significant differences between the executions with the corresponding dominant hand compared to the other hand.

The results are in line with the evidence identified in previous studies in which the superiority in the manual execution of various motor actions of athletes compared to non-athletes was highlighted [48–51]. The results of the study contribute to expanding the level of knowledge regarding how the hemispheric lateralization manifested in manual laterality and motor experience influence the manual motor skills evaluated through computer tests, between different athletes and non-athletes [52–55]. Numerous studies have focused on identifying the reaction time in performing different motor tasks in relation to manual laterality [56–58]. A series of studies aimed at identifying the differences between athletes and non-athletes; thus, in a study carried out on a group of football players compared to non-athletes, significant differences were identified regarding the reaction time of moving and hitting the ball [54,55,59].

Studies carried out on different categories of subjects have highlighted differences in the performance of digital or manual skills [60–62]. The evaluation of different types of reaction times was carried out by means of tests or computer games and highlighted differences between the executions with the dominant and non-dominant hand [63–65]; between women and men [66,67]; between different categories of athletes depending on the sport they practice [68–74]; the type of visual or auditory stimulus in relation to the manual or foot reaction time [71,73].

We believe that the approach to such a complex topic as the one regarding the identification of the differences regarding the reaction time in different categories of athletes and non-athletes will have to be approached from an interdisciplinary perspective [75–77]. Numerous sports activities involve symmetrical and asymmetrical manual executions, with the left or right hand, and optimizing the symmetrization process of executions can contribute to improving motor performance. Numerous studies have demonstrated that the improvement and diversification of training methods aimed at digital or manual skills of reaction times contribute to the expansion of human motor and cognitive potentialities [21,78,79]. The studies highlighted the link between the lateralization of the brain manifested by the structural and functional differences between the right and left hemispheres and the lateralization of executions at the manual level between right-handed and left-handed executions [4,5,8,24]. The impact of manual lateralization in the performance of motor skills is influenced by motor control, which aims at the activity of the brain regulating movements of voluntary muscle activities. [13,14,21]. Manual lateralization was also approached from the perspective of neuroscience, which studies the connection between the functionality of the brain and the biological aspects of human performance and behavior [80–82]. Recent studies have demonstrated that there are close links between motor and sensory functions, which generate predictions for the formation of new motor experiences with different stimuli and in different training conditions [83,84]. The connection between the complexity of the brain activity, the reliability of the motor control of the movements, and the variety of conditions and training methodologies specific to sports training lead to the increase in performance and the modeling of behaviors in relation to the sports objectives [85,86]. We believe that the interdisciplinary approach to the effectiveness of manual lateralization in the performance of motor skills focused on reaction time will facilitate the complex understanding of the interaction of neuroscience, motor control, and sports science in making sports behaviors more efficient.

The strong points of the study consist in the large number of subjects involved in the study; dividing the subjects into three groups depending on the activity and the type of sport practiced (team sports, individual sports) and the comparison with a group of non-athletes; comparative analysis of the results related to the typology of groups; the analysis of the results depending on the manual laterality and execution hand; computer test use. Limitations of the study include the the relatively small number of subjects with left manual laterality and the fact that the gender differences regarding the manifestation level of simple, choice, or cognitive reaction time were not analyzed; the inclusion in the study only of the subjects who were between 20 and 24 years old due to the age of the students; the fact that the present study only considered the manual reaction time and not the reaction time at the foot level, and the fact that the subjects included in the TSG practiced only three team sports (handball, basketball, and volleyball), and other team sports were not taken into account due to the small number of active student athletes; the fact that a comparative analysis of the results was not carried out according to the type of sports practiced, both between the three sports games and between the three categories of individual sports.

5. Conclusions

Among the three types of reaction times targeted in the study, we found that the smallest differences were recorded in the simple reaction time test, where the differences between right-handed and left-handed executions were the lowest, reflecting the best level of symmetrization of motor executions. Also, regarding the types of reactions, simple, choice, and cognitive, the biggest differences were recorded between the group of athletes practicing ball games (TSG) and the group of non-athletes (NAG). The results of the computerized tests of the reaction time of the subjects practicing team sports in which a ball is handled were better than those of the subjects practicing individual sports without manual handling of an object. The results for the dominant hand were better compared to the results from the non-dominant hand in all tests. The theoretical and practical implications of this study will facilitate the expansion of the level of interdisciplinary knowledge and optimization of the training process aimed at reaction time in performing motor or technical skills depending on the typology and the characteristics of the practiced sport, and training and competition conditions in order to improve athletes' performances in relation to the specifics of the sport.

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