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**INFLUENCE OF SPORT ON LATERALITY IN CHILDREN AGED**  
**9-11 YEARS**

Irina Băițel (a)\*, Luminița Maria Pătru  
\*Corresponding author

(a) “Dante Alighieri” Theoretical High School, 9 Fuiorului Street, Bucharest, Romania

(b) National University of Physical Education and Sports, 140 Constantin Noica Street, Bucharest, Romania

*Abstract*

In this study, we try to highlight the influence of practicing a sport on laterality in 3rd and 4th graders from the “Dante Alighieri” Theoretical High School in Bucharest. The two groups of children (one made up of subjects practicing sport and free-time motor activities, and the other not involved in extracurricular sports activities) were subjected to the following tests: Ruler Test, Touch the Plates, measurement of the response rate to visual and auditory stimuli. The sports practiced by children outside the physical education classes are: basketball, football, handball, athletics, water sports, gymnastics, karate, field tennis, climbing, sports dance and ballet. For each test, each subject had five attempts for both the right hand and the left hand; the mean of the five attempts on each side was recorded, and the differences between the left and right hand results were analysed and compared between children belonging to the two groups. We also tried to establish a correlation between the results of children in the group practicing sports and the sport practiced. Thus, our hypotheses are the following: in sports practicing children, we expect to find lower differences between the right and left hand test values (functional differences in the smaller cerebral hemispheres), and in the “Touch the Plates”, the left-right differences are expected to be smaller for martial arts, basketball and handball.

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**Keywords:** Laterality, sport practice, coordination.



## 1. Introduction

According to Schmidt (1991), the remarkable human capability to perform skills is a critical feature of our very existence. People are born with this capability of producing many skills that develop with maturation, for instance walking, running and balance; other abilities are developed, educated and improved over the course of their lives, being useful in ordinary everyday actions, in practicing various activities or professions and, where appropriate, in practicing sports, regardless of their level. But to get there, coordination in general and bilateral coordination in particular is an essential part of adapting and integrating the child into the environment. Good bilateral coordination is an indication that both brain hemispheres effectively communicate and exchange information. Children with ambilateral coordination disorders may have difficulties in accomplishing daily tasks such as dressing and tying shoelaces or in performing activities that involve fine motor skills (joining Lego blocks, cutting – paper stabilisation with one hand and holding the scissors with the other one) or activities such as walking, crawling, climbing stairs, roller skating or cycling. Thus, given that day-to-day activities are mostly bimanual movements, the understanding of bilateral coordination is important at all ages, moreover, functional problems are correlated in some cases to other various disorders (Vasconcelos, Rodrigues, Barreiros, & Jacobsohn, 2014; Woytowicz, Whittall, & Westlake, 2016; Ostwald, Snowdon, Rysavy, Keenan, & Kane, 1989). By the age of 3-4 years, children can use both hands equally, working with the hand closest to the subject of interest. After this age, children should develop their ability to cross the midline (Child's Play Therapy Center, 2014), namely to cross over the midline of the body with a segment while fulfilling a motor task (e.g. crossing the legs, touching the opposite elbow etc.). Establishing the dominant hand after this age is an indicator of maturation of the brain and is correlated with the emergence of the ability to cross the midline. A well-defined body pattern occurs only in well-coordinated children (Stănescu, 2002), and in its absence, in the cognitive plane, writing and reading deficiencies may occur. The delay in specifying laterality causes children problems with spatial orientation, materialised by the inability to distinguish left and right, difficulties in organizing text writing on the page, confusing letters and figures, such as d and b, p and q, n and u, 6 and 9 etc. (Stănescu, 2002, p. 87). To answer why lateralisation occurs, given that in other creatures it has not been identified, there have been many assumptions about our hominid ancestors (Goldman, 2014) who mostly used right-hand tools (*Homo habilis*, *Homo erectus*, now 1.5 million years). The anthropologists' argument is that the right-handedness rule for humans is due to language, which is controlled by the left hemisphere of the brain.

Although the left hemisphere is specialised in language, the preference for the right hand has simply intensified as an effect of intensifying the activity of this hemisphere. Thus, it was hypothesised that lateralisation was induced by the bipedal stance, and the preference for the right hand appeared later, as a result of the evolution of language. However, this hypothesis is hard to prove, as it would involve neurological tests on the ancestors of humans (Goldman, 2014). At least 75% of the human population in all cultures prefers to use the right hand to perform most of the motor tasks at different levels of dexterity.

## 2. Problem Statement

After specifying that laterality is a sign of balanced brain development in 3-4 years old children and especially a sign of an effective brain hemisphere communication, for younger pupils, particularly those

who have already chosen to practice a sport, there is a need to drive this communication between brain hemispheres, in the sense of transferring dexterity to the non-dominant part in order to obtain the best performance. Thus, in physical education and sports classes, mainly at primary school level, the proposed activities are based on the development of psychomotor skills (Sopa & Pomohaci, 2015a; Sopa & Pomohaci, 2015c). In addition, sport practicing has a positive influence on the dexterity of the non-dominant limb, all the more so as the training is conducted in this respect and, on the other hand, if the sport involves the use of both limbs equally.

### **3. Research Questions**

There are two aspects that we expect to capture and illustrate through this research, namely that the response time to visual and auditory stimuli is different for the right hand and left hand and that the speed of execution/repetition of a simple movement is also different, but differences are smaller in the case of the group of children practicing sports. Also, differences between the left and right hand executions are expected to be lower for children practicing ball sports than those practicing swimming or athletics.

### **4. Purpose of the Study**

Testing and evaluating the physical fitness of young generations has become important, scientists stating that the monitoring of physical activity can reduce sedentariness, health problems, social exclusion and stress (Sopa & Pomohaci, 2015b). Starting from the premise that laterality is a component of the coordination abilities, whose manifestation can be measured, evaluated and educated, we have tried to highlight functional differences in the brain hemispheres, in terms of differences in the response time to visual and hearing stimuli measured for the right and left hands, as well as by measuring the speed of execution (repetition) of a simple movement performed with both the right hand and the left hand. In this regard, we applied reaction time tests and a speed test for a simple movement to two groups of children aged 9-11 years, one practicing sport outside the physical education classes, and the other not involved in extracurricular sports activities. Our goal was to highlight the differences between the left and right hands, both for the reaction and execution time, as well as the way in which the practice of a certain sport influences laterality.

### **5. Research Methods**

#### **5.1. The research subjects**

The subjects of the research were students of the “Dante Alighieri” Theoretical High School, grades 3 and 4, aged 9-11 years. The tests were carried out during the school year 2017-2018, as follows:

- Touch the Plates - 179 non-athlete children and 86 athletes;
- Ruler Test - 143 non-athlete children and 73 athletes;
- The online test “Can You Beat Usain Bolt Out of the Blocks?” (Aisch, Buchanan, & Watkins, 2016) issued in the *New York Times* - 44 non-athlete children and 29 athletes.

## 5.2. Test description

**Touch the Plates.** A 20 x 10 cm rectangle is drawn on a plate at a 15 cm distance from the long sides of the rectangle; in the middle of the sides, there are the centres of two circles with a radius of 5 cm marked on the right and left of the rectangle. The subject sits in front of this figure and places one hand in the centre of the rectangle, while the other is crossed over the fixed hand and performs a going back-and-forth movement between the two circles that must be touched as fast as possible; the time (in seconds, tenths and hundredths) in which the subject makes 25 going back-and-forth cycles is recorded.

**Ruler Test.** The subject is seated, with the elbow supported by the edge of a table so that the fist is beyond the edge of the table. The examiner holds a 40 cm ruler over the subject's hand, the lower end of the ruler (zero division) being placed between the subject's index and thumb. Unexpectedly, the examiner releases the ruler, and the subject has to catch it as fast as possible. Reading the length is done on the ruler at the index level, in centimetres, and the calculation of the simple reaction time (the time elapsed between the release of the ruler/the beginning of the fall and its grasping is done starting from the space law for the evenly accelerated movement,  $x = x_0 + v_0*t + a*t^2/2$ ,  $x - x_0 = v_0*t + a*t^2/2$ ; for  $v_0 = 0$ ,  $d = a*t^2/2$ ; because  $a = g$  in free fall, we get  $t = \sqrt{2*d/g}$ ). Given the fact that  $\sqrt{2/g} = 0.4515$  ( $g = 9.81 \text{ m/s}^2$ ), to obtain the time expressed in milliseconds, starting from the distance  $d_r$  measured in centimeters, we used the calculation formula:

$$t_r = 45.15 * \sqrt{d_r} \text{ [ms]} \quad (1)$$

where:  $x_0$  and  $x$  = distance to time moments  $t_0$  and  $t$ ;  $d$  = distance =  $x - x_0$ ;  $t$  = time;  $a$  = acceleration;  $g$  = gravitational acceleration;  $d_r$  = distance travelled by the ruler in free fall, until the moment of grabbing;  $t_r$  = reaction time

To determine the response time for visual and auditory stimuli, we used the "Can You Beat Usain Bolt Out of the Blocks?" test (Figure 01) using a Toshiba laptop P50-C-17K, Intel® Core™ i7-6500U up to 3.1GHz, 15.6" Full HD, 8GB, SSD 256GB, NVIDIA GeForce GT 930M 2GB, Windows 10, a Microsoft mouse and Google Chrome browser. We make this statement knowing that there are many factors that may alter the results of response time measuring when we are interested in precision at millisecond level. CPU speed, response time display, onscreen signal delay on the graphics card, refresh rate display, mouse-browsing response speed, touch pad or even touch screen response time, all of them can influence a millisecond precision result, and that is why it is good to take this into account. Thus, for a display with a 60 Hz refresh rate, the on-screen image can be updated 60 times per second, which means that the screen will display a new image every 16.7 milliseconds, and in the case of a 144 Hz display, it will be updated about every 6.9 milliseconds. Response time refers to how long a frame lasts to update to the next or, in other words, the speed at which individual pixels can move from one colour to another. Input delay is the time the image is processed before being displayed on the screen, and sometimes it may be significant; it is dependent on both the operating system and the computer's graphics card characteristics (Tom's Hardware, 2017). We gave these explanations to justify the results obtained using the "Can You Beat Usain Bolt Out of the Blocks?" test for measuring the reaction time to both visual (by deactivating the sound) and hearing (by covering the three red figures) stimuli. On the other hand, given that we used the same laptop, the same mouse, the same browser and the same Internet provider for all measurements, all these delays can be neglected when calculating the differences between the executions of right-handed and left-handed subjects.



**Figure 01.** The “Can You Beat Usain Bolt Out of the Blocks?” test interface

## 6. Findings

The Ruler Test was applied to 145 non-athlete children and 70 athletes practicing the following sports: karate (4 athletes), handball/basketball/volleyball/soccer (27), swimming/athletics (17), dance/gymnastics/ballet (20) and tennis (2). For both athletes and non-athletes, the homogeneity of the groups is high both for the right hand test and the left hand test, the value of the coefficient of variation being less than 10% (Table 01).

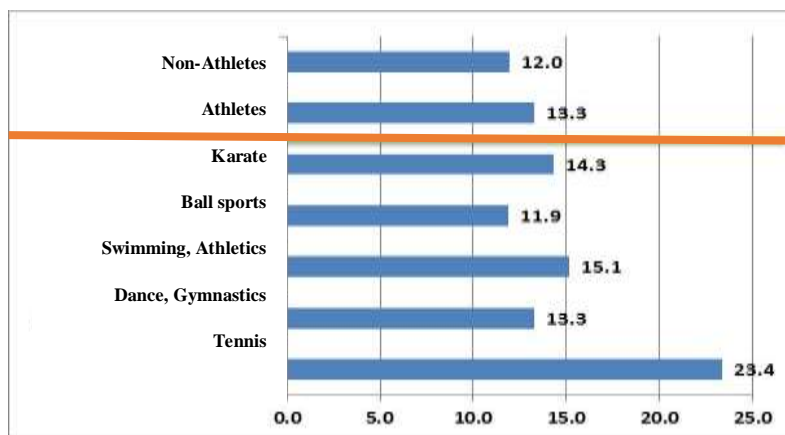
When applying the right hand test, athletes achieved a significantly better average time (214.6 milliseconds) than non-athlete children (226.0). The significant difference, given by the value of  $t$  calculated by applying the independent  $t$ -test, is 4.030, and the  $p$ -value is less than 0.05.

In the case of the left hand test, athletes achieved a significantly better average time (210.6 milliseconds) than the non-athlete children (225.0). The significant difference, given by the value of  $t$  calculated by applying the independent  $t$ -test, is 4.948, and the  $p$ -value is less than 0.05.

Analysing the difference between the results obtained for the right hand and the left hand, in absolute value, for athletes practicing handball, basketball, volleyball or football, the average difference (median value) has the smallest value (11.9), according to Figure 02. Smaller differences are also noted for those who practice dance, gymnastics or ballet (13.3). Larger mean differences are recorded for swimming or athletics (15.1) and tennis (23.4).

**Table 01.** Ruler Test

	Right		Left		Left-Right Difference		
	Non-Athletes	Athletes	Non-Athletes	Athletes	Non-Athletes	Athletes	
Number of cases (N)	145	70	145	70	145	70	
Arithmetic mean	226.0	214.6	225.0	210.6	14.1	16.6	
Median	225.8	213.7	224.9	209.8	12.0	13.3	
Standard deviation	19.5	18.9	20.3	19.6	10.6	14.3	
Coefficient of variation	8.6%	8.8%	9.0%	9.3%	75.2%	86.3%	
Minimum	177.2	165.3	173.7	173.7	1	2	
Maximum	274.7	266.4	270.9	258.6	50.7	79.4	
Independent t-test	t	4.030		4.948		-1.263	
	p	0.000		0.000		0.209	



**Figure 02.** Difference between the right and left hands measured by the Ruler Test (ms) – Sports analysis

The Visual Response Time Test was applied to 43 non-athlete children and 29 athletes practicing the following sports: karate (1 athlete), handball/basketball/volleyball/soccer (8), swimming/athletics (13) and dance/gymnastics/ballet (7). The two groups are homogeneous with regard to the results obtained in both the right hand test and the left hand test, the value of the coefficient of variation being less than 35% (Table 02).

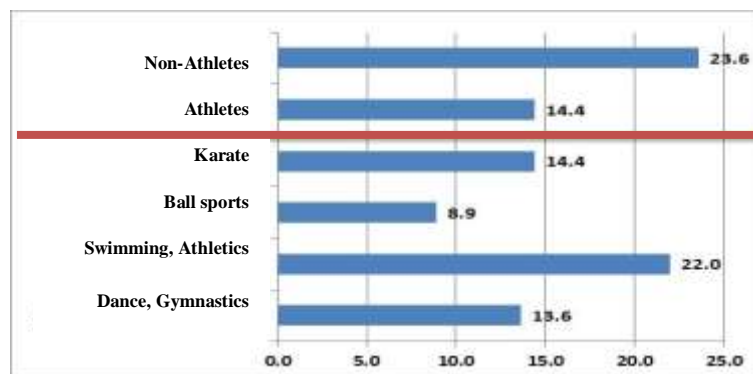
**Table 02.** The Visual Response Time Test

	Right		Left		Left-Right Difference		
	Non-Athletes	Athletes	Non-Athletes	Athletes	Non-Athletes	Athletes	
Number of cases (N)	43	29	43	29	43	29	
Arithmetic mean	285.4	273.4	282.4	281.2	26.6	24.7	
Median	292.0	271.7	287.8	274.4	23.6	14.4	
Standard deviation	35.4	35.4	40.6	45.6	21.2	28.5	
Coefficient of variation	12.4%	13.0%	14.4%	16.2%	79.8%	115.2%	
Minimum	208.0	205.7	192.6	210.6	1	1	
Maximum	352.2	334.0	383.8	372.0	100.0	137.6	
Independent t-test	t	1.414		0.118		0.326	
	p	0.162		0.906		0.746	

When applying the right hand test, athletes have a better average response time (273.4 milliseconds) than non-athlete children (285.4). The difference is not statistically significant, the value of t calculated by applying the independent t-test is 1.414, and the p-value is higher than 0.05.

In the case of the left hand test, athletes have a better average reaction time (281.2 milliseconds) than non-athlete children (282.4). The difference is not statistically significant, the value of t calculated by applying the independent t-test is 0.118, and the p-value is higher than 0.05.

Analysing the difference between the left and right hand results in absolute value, athletes obtained smaller time differences for the right hand test and the left hand test (median value was 14.4 milliseconds) compared to non-athlete children (23.6). In the case of athletes who practice handball, basketball, volleyball or football, the average difference has the smallest value (8.9), as shown in Table 02 and Figure 03. Smaller differences are also recorded for those who practice dance, gymnastics or ballet (13.6) or karate (14.4). Larger mean differences are recorded for swimming or athletics (22.0) (Figure 03).



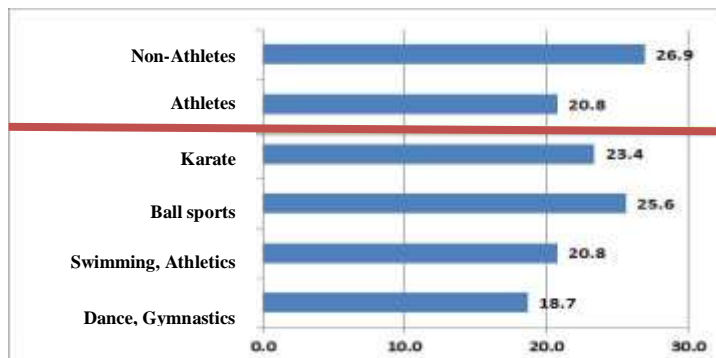
**Figure 03.** Difference between the right and left hands in the Visual Response Time Test (ms) – Sports analysis

The Auditory Response Time Test was applied to 44 non-athlete children and 29 athletes practicing the following sports: karate (1 athlete), handball/basketball/volleyball/soccer (8), swimming/ athletics (13), dance/gymnastics/ballet (7). The two groups are homogeneous with regard to the results obtained in both the right hand test and the left hand test, the value of the coefficient of variation being less than 35% (Table 03).

**Table 03.** The Auditory Response Time Test

	Right		Left		Left-Right Difference		
	Non-Athletes	Athletes	Non-Athletes	Athletes	Non-Athletes	Athletes	
Number of cases (N)	44	29	44	29	44	29	
Arithmetic mean	215.7	197.1	219.3	205.6	35.0	30.7	
Median	203.9	199.0	207.0	189.0	26.9	20.8	
Standard deviation	46.4	40.0	52.3	41.0	33.8	27.9	
Coefficient of variation	21.5%	20.3%	23.8%	20.0%	96.4%	90.7%	
Minimum	147.0	130.3	130.8	124.0	3.0	1.0	
Maximum	376.7	291.0	396.7	305.7	194.3	111.6	
Independent t-test	t	1.764		1.182		0.565	
	p	0.082		0.241		0.574	

When applying the test to the right hand, athletes scored a better average response time (197.1 milliseconds) than non-athlete children (215.7). The difference is not statistically significant, the value of t calculated by applying the independent t-test is 1.764, and the p-value is higher than 0.05.



**Figure 04.** The difference between right and left at Hearing Stimulus Response Time (ms) – Sports analysis

In the case of the left hand test, athletes have a better average response time (205.6 milliseconds) than non-sports children (219.3). The difference is not statistically significant, the value of t calculated by applying the independent t-test is 1.182, and the value of p is higher than 0.05.

Analysing the difference between the left and right hand results in absolute value, athletes obtained smaller time differences for the right hand test and the left hand test (median value was 20.8 milliseconds) compared to non-athlete children (26.9). In the case of athletes who practice dance, gymnastics or ballet, the difference has the smallest value (18.7), as shown in Table 03 and Figure 04. Smaller differences are also recorded for those who practice swimming or athletics (20.8). The largest average difference is recorded for those practicing one of the ball sports (25.6) (Figure 04).

The Touch the Plates Test was applied to 179 non-athlete children and 86 athletes practicing the following sports: karate (7), handball/basketball/volleyball/soccer (36), swimming/athletics/dance/gymnastics/ballet (23) and tennis (2). The two groups are homogeneous with regard to the results obtained in both the right hand test and the left hand test, the value of the coefficient of variation being less than 35% (Table 04).

**Table 04.** The Touch the Plates Test

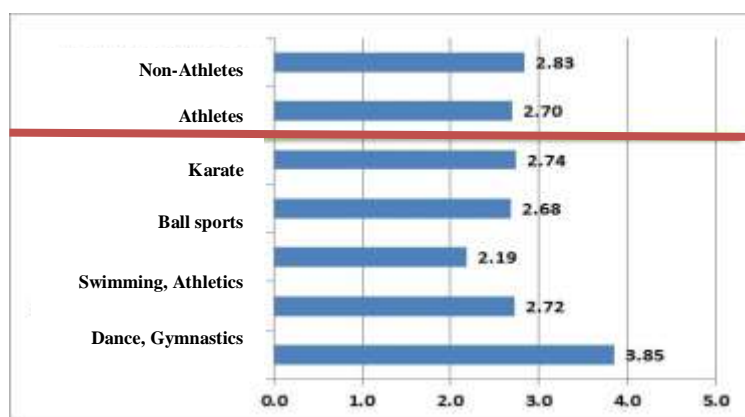
	Right		Left		Left-Right Difference		
	Non-Athletes	Athletes	Non-Athletes	Athletes	Non-Athletes	Athletes	
Number of cases (N)	179	86	179	86	179	86	
Arithmetic mean	11.81	10.41	14.40	12.84	2.87	2.98	
Median	11.85	10.08	14.45	12.85	2.83	2.70	
Standard deviation	2.53	2.36	2.74	2.56	1.80	1.86	
Coefficient of variation	21.4%	22.7%	19.0%	19.9%	62.5%	62.5%	
Minimum	6.11	6.10	6.69	5.65	0.02	0.10	
Maximum	18.58	16.93	23.19	19.79	10.37	7.51	
Independent t-test	t	4.320		4.409		-0.435	
	p	0.000		0.000		0.664	



In the case of the right hand test, athletes achieved a significantly better average time (10.41 seconds in 25 executions) than non-athlete children (11.81 s). The significant difference, given by the value of  $t$  calculated by applying the independent  $t$ -test, is 4.320, and the value of  $p$  is less than 0.05.

In the case of the left hand test, athletes achieved a significantly better average time (12.84 seconds in 25 runs) than non-athlete children (14.40 s). The significant difference, given by the value of  $t$  calculated by applying the independent  $t$ -test, is 4.409, and the value of  $p$  is less than 0.05.

Analysing the difference between the results obtained for the right hand and the left hand, in absolute value, for athletes practicing swimming or athletics, the average difference has the lowest value (median value is 2.19 s), according to Table 04 and Figure 05. Smaller differences are recorded for those who practice ball sports (2.68 s) or dance/gymnastics/ballet (2.72 s). The largest average difference is recorded for tennis players (3.85 s) (Figure 05).



**Figure 05.** Difference between the right and left hands in the Touch the Plates Test (time/25 executions [s]) – Sports analysis

## 7. Conclusion

The results show that differences in median and average reaction times recorded (or calculated, in the case of the Ruler Test) are very low between athlete and non-athlete groups, both in terms of comparison of times recorded in the right hand test (11, 12, 9 ms) and the left hand test (14, 1, 7 ms).

In the Touch the Plates Test, although the groups were homogeneous ( $CV < 35\%$ ), the differences were significant ( $p < 0.05$ ,  $T = 4.320/4.404$ ), both statistically and regarding the “quality” of execution, namely there were differences greater than 1 second between the two groups in the right and left hand executions. The left-right differences between the two groups are lower if medians are compared, and even higher, if averages are compared. The smallest difference has been achieved for swimming and athletics (cyclic sports in which the limbs are used approximately equally). The biggest difference has been in the case of tennis players, who obviously mostly use their favorite hand in the training.

In the case of the Ruler Test and the Visual Response Time Test, the smallest differences were recorded in children practicing ball sports (football, handball, basketball) and those practicing dance, gymnastics and ballet. In the case of the Auditory Response Time Test, the smallest differences were

obtained for dance, gymnastics, ballet and swimming and athletics, their performance being dependent on the response to the auditory stimulus (music, start).

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