International Journal of Applied Psychology 2014, 4(4): 127-133
DOI: 10.5923/j.ijap.20140404.01

Canonical Relations between Speed Movement of Bilateral Parts of the Body

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Abstract Since sensorimotor reactions of bilateral (parallel, transversal, diagonal) body parts represent the source, of a part of joint variability. This research study was conducted to affirm the relations of within these fields. In this research the velocity of bilateral (parallel, transversal, diagonal) body parts has been used as a dependent variable. The research was initiated by using lateralization functions, as well as interhemispheric interactions, and transmission speed of afferent and efferent impulses. The basic goal of the research is directed to affirm the relation of velocity between bilateral (parallel, transversal, diagonal) body parts. Considering that the morphological-functional structure establishes the dependency of the velocity of body parts or the whole body, a research was developed with the aim of verifying a part of the entire variable separated by the velocity of the bilateral (parallel, transversal, diagonal) body parts. The research was carried out on a sample of 20 subjects, of male gender, from 20 to 22 years of age. An analysis was carried out in the space of velocity of bilateral (parallel, transversal, diagonal) body parts. The evaluation of the velocity realized in bilateral structures was obtained through an especially constructed instrumentarium (Kinesiometer, M. Dodig, 1987) and calculating the pace obtained from basic kinetic elements (resistance, amplitude, time). Obtained results have been processed by application of canonical correlational analysis (Cooley and Lohnes, 1971). Based on maximum cohesion between the pair of linear functions of the group variables (parallel, transversal and diagonal body parts), two canonical characteristic roots have been isolated in every bilateral area have been extracted. Obtained pairs of canonical characteristic roots outline and define the bilateral (parallel, transversal, diagonal) velocity determinant of body parts. We are talking about a sequential regulation which consists of alternate activation and deactivation of certain groups of muscles, and which is important for fast execution of alternative motion where the velocity of the transversal and parallel body parts is prevalent. The basic reason of the obtained functional dependency between the velocity of bilateral body parts lies within the structure for regulation of excitation and partly the excitation intensity (activation of motor units) of various levels, synergic regulation and tonus regulation which are also determined according to bilateral structures.

Keywords Canonical Relations, Velocity, Bilateral (Transversal, Parallel, Diagonal) Body Parts

1. Problem

Motion of the human body is a fascinating, distinctive and vitally important phenomenon. The diversity of the motion program is endless where various tasks of bilateral (parallel, transversal, diagonal) body parts or the whole body are dealt with, and even if it seems simple in terms of kinetic structure, the inner workings and their structures are complex [7, 11, 14]. The motion of the human body and solving motor tasks is an endlessly diverse program which is solved by various velocities of certain body parts or the body as a whole. Velocity represents the ability for any given motion or a series of continuous motions to be carried out in the shortest possible time frame, velocity is equal to derivation multiplied by time expressed through kinetic features, the transit being in the function of time [13, 15]. The human body displays a tendency, upon doing any given motor task directed at right or left-sided motion, to use a certain cohesion, this phenomenon is a result of the impact of hemispheric asymmetry [1, 2, 6, 16]. The brain constantly receives huge amounts of diverse information that need to be processed, where the requirements of the processing itself differ greatly. Good cohesion of the two brain hemispheres enables a constant exchange of information between the hemispheres and is the basis of continuous communication and interaction between themselves [3, 4, 17, 18]. Considering that an individual's somatosensory passages are basically intertwined, it is to be expected that their impact will be significant in solving fast motions of bilateral body parts. While in regard to a unilateral application, only one hemisphere is stimulated, while in bilateral application, both hemispheres are stimulated simultaneously, what can in and of itself have an effect the result [8, 9, 10, 19, 20]. The

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Published online at http://journal.sapub.org/ijap

aforementioned indicates that in data conveyance, even at certain complex levels, subcortical structures are participants, despite cortical connections being key in this process.

In this research the velocity of bilateral (parallel, transversal, diagonal) body parts has been used as a dependent variable. The research was initiated by using lateralization functions, as well as interhemispheric interactions, and transmission speed of afferent and efferent impulses. The basic goal of the research is directed to affirm the relation of velocity between bilateral (parallel, transversal, diagonal) body parts. Considering that the morphological-functional structure establishes the dependency of the velocity of body parts or the whole body, a research was developed with the aim of verifying a part of the entire variable separated by the velocity of the bilateral (parallel, transversal, diagonal) body parts.

2. Methods

The sample subjects for this research list 20 subjects, male, ranging from 20 to 22 years of age. The planned sample ensures a reliability factor of 0.95, that every correlational coefficient is equal to or larger than 0.42, considers different from zero. The process of collecting data and setting parameters was conducted using an instrument called the KINESIOMETER (M. Dodig, 1987), hooked up to an electronic computer, with an adequate periphery, with application of program support for analogue – digital conversion in the programming language SIMON'S BASIC. The instrumentarium uses 8 important analogue – digital converters (ADC) to which the kinesiometer and signal system were directly plugged into and synchronized with the measuring system. The kinesiometer latched to body joints ensured transference of analogue sizes of body part reactions, which transform from electrical signals to digital impulses via an analogue-digital converter. The signal light system is directly connected to the converter which is synchronized with the measurement system that has a maximum precision measurement of 2^{-8}, i.e. 256 parts of basic value. Measuring was conducted according to a specific program. The subject was situated in an adequate position with the attached instrumentarium and carried out certain reactions with motion.

In this way obtaining significant data about the velocity of bilateral body parts is enabled. Measuring is conducted by way of an applied system for measuring in certain positions alongside solving various problems: (1) the subject is set on a background in a lying position on his back, with spread legs and arms next to his body to which kinesiometers are attached, (2) on a certain signal the subject exerts motion of arms and/or legs via bilateral body parts (picture 1).

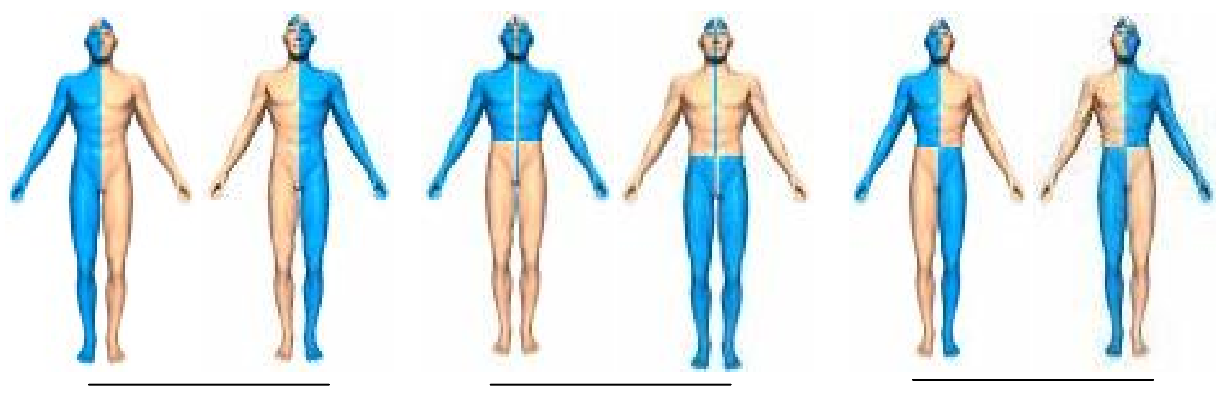
In this way, groups of variables that were data carriers in regard to the velocity of bilateral body parts were isolated. Tests were marked with distinctive codes where the first two letters mark the space of velocity (BG), the third letter marks the type of bilateral structure – parallel (P), transversal (T) and diagonal (D), the fourth and fifth letters the body part where the motion is realized, left leg (NL), left arm (RL), right leg (ND), right arm (RD)

(1) The variables for velocity evaluation of parallel body parts (left leg – left arm, right leg – right arm); 1. (BGPNL), 2. (BGPRL), 3.(BGPND), 4.(BGPRD)

(2) The variables for velocity evaluation of transversal body parts (left leg – right leg, left arm - right arm); 1. (BGTNL), 2. (BGTND), 3.(BGTRL), 4. (BGTRD)

(3) The variables for velocity evaluation of diagonal body parts (left leg– right arm, right leg – left arm); 1. (BGDNL), 2. (BGDRD), 3. (BGDND), 4. (BGDRL)

The relations between the velocity of bilateral body parts are analysed through the technique of canonical correlational analysis (Coolly and Lohnes, 1971). For identification of significant canonical dimensions in addition to the transformational coefficient vectors, vectors of correlational variables and canonical dimensions were also used. The standards pertaining to these vectors were treated as a measure of canonical dimensions. The number of significant dimensions was determined with the Bartlett method (Bartlett, 1974), where all those linked canonical correlations varying from zero with an inference reliability of 0.95 were considered significant.



A **B** **C**

Picture 1. Schematic overview of determinateness of bilateral body parts (**A** - parallel, **B** - transversal, **C** - diagonal)

3. Results

The results are presented as per the data analysis requirements. The interpretation was realized pursuant to the alleged areas shown in the tables. The variable characteristics were determined with routine descriptive procedures. The group of velocity variables of the bilateral body parts (table 1), indicates that all magnitudes of the central and dispersive parameters do not deviate significantly from normal distribution.

Table 1. The central and dispersive parameters of the velocity of the bilateral – parallel, transversal and diagonal body parts

	XA	SIG	MIN	MAX
1. BGPNL	4208.50	801.193	2810	5920
2. BGPRL	4132.55	1283.37	2386	6631
3. BGPND	4685.05	958.834	3503	7779
4. BGPRD	3977.75	1032.43	2327	5964
5. BGTNL	5108.15	954.039	3312	7289
6. BGTRL	3478.25	789.666	2446	5521
7. BGTND	5341.55	1007.43	3128	7981
8. BGTRD	3675.25	1082.28	2549	6408
9. BGDNL	4223.30	706.559	3114	5792
10.BGDRL	4408.60	1399.55	2833	7561
11.BGDND	5059.55	1183.21	3416	7941
12.BGDRD	4067.95	1144.29	2690	7436

Key: BGPNL – velocity parallel left leg, BGPRL – velocity parallel left arm, BGPND - velocity parallel right leg, BGPRD - velocity parallel right arm, BGTNL – velocity transversal left leg, BGTRL - velocity transversal left arm, BGTND - velocity transversal right leg, BGTRD - velocity transversal right arm, BGDNL – velocity diagonal left leg, BGDRL - velocity diagonal left arm, BGDND - velocity diagonal right leg, BGDRD - velocity diagonal right arm
XA – arithmetic mean
SIG – standard deviation
MIN – minimum
MAX - maximum

The dispersion of results in terms of arithmetic means indicates that derogation is larger in all those variables that tracked velocity in diagonal body parts. The lowest average magnitudes can be found in the velocity area of parallel and transversal body parts where arms lead with 0.3478, 0.3675 and 0.3981 seconds. A topological determinant of velocity is also noticed towards the hypothetically determined bilateralization.

The joint matrix of correlational coefficients for all variable groups shows a relatively solid homogeneity (table 2). The correlational coeffiecents display a tendency of forming three logical groups. These correlational coefficient groups match the topological conclusiveness, incurring as a result of the linear transformation of the bilateral variables.

The connection is satisfactory in the group that contains velocity variables' vectors of parallel body parts. The correlation coefficient between the right and somewhat weaker left body parts is significant, indicating that the velocity of parallel body parts is determined laterally. However, the cohesion with the variables of other groupations are considerably better, especially with variables that measured reactions of transversal and partly diagonal body parts. Upon inspection of the matrix part where variables that carry data about velocity of transversal body parts are located, it is indicated that cohesion was expressed within that circuit. The cohesion of upper limbs (0.74) and lower limbs (0.70) is especially emphasized. It should be pointed out that all coefficients are significant, and that this area is the most homogenous. In relation to other areas, the connection with the parallel (especially the lower limbs), and somewhat weaker with the diagonal body parts.

A significantly weaker cohesion is in the context of the variables that measured the velocity of diagonal body parts. Only one coefficient of correlation was significant (.70) between the variables that measured the reaction of diagonal body parts (right leg – left arm). The cohesion with other areas is expressed with the variables of parallel body parts and transversal body parts to a certain extent. However, there is a much better connection with the parallel and transversal body parts, what possibly infers to a larger direct, automatic use of the canal capacity and high organization of the activities of the effector of parallel and transversal structures. On an overall basis, the structure of the matrix in terms of the intercorrelation of variables indicates that the variables of the parallel and transversal body parts assemble within their own groupations, what is not the case with diagonal body parts. In the area of bilateral reactions, a momentary discrimination is determined with two cerebral processes which unfold simultaneously. Thus, two answers that stem simultaneously from the same stimulus represent the fundamental reason of incurred connections within these areas with an emphasis on the right side (right-handedness).

Table 2. The matrix of correlational coefficients of the velocity of bilateral – parallel, transversal and diagonal body parts

		1	2	3	4	5	6	7	8	9	10	11	12
1.	BGPNL	1.00											
2.	BGPRL	.40	1.00										
3.	BGPND	.47	.46	1.00									
4.	BGPRD	.28	.12	.65	1.00								
5.	BGTNL	.56	.03	.51	.31	1.00							
6.	BGTRL	.61	.68	.61	.56	.43	1.00						
7.	BGTND	.58	.22	.73	.33	.70	.42	1.00					
8.	BGTRD	.44	.27	.66	.85	.34	.74	.44	1.00				
9.	BGDNL	.14	-.21	.16	.38	.21	.10	-.04	.30	1.00			
10.	BGDRL	.60	.80	.45	.01	.24	.66	.34	.19	.09	1.00		
11.	BGDND	.59	.43	.38	-.05	.19	.34	.43	.13	.02	.70	1.00	
12.	BGDRD	.44	.49	.77	.75	.51	.76	.57	.82	.18	.38	.22	1.00

Key (see Table 1)

3.1. Canonical Relations of the Velocity of Parallel and Transversal Body Parts

The canonical correlational analysis of the variable group of velocity of parallel and transversal body parts indicates that out of four canonical roots, two are sufficient to explain the relations between the stated groupations (table 3).

Table 3. The canonical correlations, the roots of the canonical equation and tests of significance of canonical roots in areas of parallel and transversal body parts

	C2	C	L	X2	DF	P
1	.8062	.8979	.0244	53.868	16	.0000
2	.7160	.8462	.1256	30.078	9	.0004
3	.5005	.7075	.4424	11.824	4	.1187
4	.1142	.3379	.8858	1.758	1	.2849

Key: C2 – eigenvalue; C – canonical correlation; L – Wilks lambda; X2 – Chi – square; DF – D. F.; P – sing. level

The canonical correlation of the first pair of canonical dimensions isolated from the variable groupation amounts to (0.90) with 81% extracted joint variants. The second canonical correlation that belongs to the second canonical factor has a somewhat lesser cohesion (0.85) with 72% of joint variance. The obtained results indicate a significance level of P = 0.00. In the space of velocity with parallel body parts the canonical dimension is defined by the velocity of the right hand and left leg. In the space of velocity of the transversal body parts the first canonical dimension is defined by the right arm and right leg (table 4).

Table 4. The vectors of transformation into canonical variables (W) and canonical factors (F) are isolated in the area of velocity of parallel and transversal body parts

	W1	W2	F1	F2
BGPNL	0.41619	0.08936	-0.61263	-0.89702
BGPRL	0.61266	-0.91718	0.30507	0.35733
BGPND	0.08116	1.12709	-0.47369	0.98931
BGPRD	0.22704	-0.18320	1.15725	-0.66552
BGTNL	-0.25191	0.43042	-0.15197	-1.34114
BGTRL	1.07107	-0.86155	-0.10009	-0.15757
BGTND	0.47259	0.33572	-0.83529	1.13074
BGTRD	-0.32609	0.82507	1.16082	0.07907

Key (see Table 1)
W1 - canonical variables
F1 - canonical factors

The second canonical dimension in the area of velocity of parallel body parts is defined with the velocity of the right leg and left leg with a negative sign and somewhat weaker with the right arm. In the space of the velocity of transversal body parts, significant projections on the second canonical dimension have reactions of the right leg and left leg with a negative algebraic sign. The obtained cohesion of latent bilateral (parallel and transversal) dimensions undoubtedly indicates towards the significance of the coherence process of detached and cooperative functions of the right and left cerebral hemispheres that can produce clearly differentiated reactions with transversal body parts. Although a clear preference of the right side and a prevalence of the lower limbs is indicated within certain similarities of the hemispheres' specializations.

3.2. Canonical Relations of Velocity of Transversal and Diagonal Body Parts

The velocity of transversal and diagonal body parts explains the canonical relations with two canonical roots (table 5). The canonical correlational analysis displayed that at the level of testing significance P = 0.00 in terms of the two stated groupations, a significant cohesion of the first pair of the canonical factors exists. The obtained results indicate strong cohesion (0.91) and a significant contribution to a joint variance of 83 %. The second canonical correlation that belongs to the second canonical factor has a somewhat lesser amount of cohesion (0.88) with 77% of joint variance. The obtained results indicate a significance level of P = 0.00.

Table 5. Canonical correlations, roots of the canonical equation and significance tests of canonical roots in the area of transversal and diagonal body parts

	C2	C	L	X2	DF	P
1	.8268	.9093	.0297	50.973	16	.0000
2	.7679	.8763	.1717	25.549	9	.0024
3	.2531	.5031	.7399	4.368	4	.3584
4	.0094	.0969	.9906	.137	1	.7116

Key (see Table 3)

The first canonical dimension in the area of velocity of transversal and diagonal body parts is defined in the transversal area of the left and right leg. In the velocity area of diagonal body parts, the right leg and left hand, which have a negative algebraic sign, have significant projections in the first canonical dimension. On the isolated second canonical dimension, significant projections have two variables in the transversal area in terms of velocity of the left leg and right arm. However, the velocity area of diagonal body parts is defined with the right and left leg (table 6).

Table 6. The vectors of transformation into canonical variables (W) and canonical factors (F) are isolated in the area of velocity of transversal and diagonal body parts

	W1	W2	F1	F2
BGTNL	-0.45170	0.38977	-0.75854	1.07935
BGTRL	1.39810	-0.32895	-0.53200	-0.16179
BGTND	0.55730	-0.09139	1.36390	-0.05452
BGTRD	-0.94284	1.09371	0.02260	-0.50093
BGDNL	-0.40380	0.30085	-0.48671	0.73814
BGDRL	1.01079	-0.45073	-0.98958	-0.02435
BGDND	-0.17038	0.16418	1.18808	0.72369
BGDRD	0.14289	0.98086	0.20991	-0.41143

Key (see Table 1 and 4)

A transversally and diagonally entwined symmetry of body parts is obtained in defining the extracted factors, thus developing as a result of the morphological- functional determinant of velocity. In addition to the cooperative function of the right and left celebral hemispheres that participate in the realization of velocity of the transversal and diagonal body parts, a larger celebral specialization of effector modalities directed at the diagonal and transversal structures towards activating the process of fast energy release and collaboration of the agonist and antagonist is also present. This is most likely about that particular part of the central processor in charge of direct adaptation of information reached from the receptive system, organization and distribution of information, as well as collaboration of the mechanism of contraction and relaxation of the agonist and antagonist muscles, required for efficient reaction of transversal and diagonal body parts, with an accent on the pertinence of transversal body structures.

3.3. Canonical Relations of Velocity of Diagonal and Parallel body Parts

The velocity distance of diagonal and parallel body parts can be explained by two canonical roots (table 7). The canonical correlations of the first pair of canonical dimensions explains the majority of the covariability of analysed groupations which amounts to 88% and the obtained cohesion of the first linear functions which amounts to (0.94), with a level of significance P = 0.00. A somewhat weaker canonical cohesion is represented by the second canonical dimension which amounts to (0.85) with 72% of extracted joint variance, which hence resulted in the significance level of P = 0.00.

Table 7. Canonical correlations, roots of canonical equation and significance tests of canonical roots in the area of diagonal and parallel body parts

	C2	C	L	X2	DF	P
1	.8764	.9362	.0249	53.543	16	.0000
2	.7168	.8466	.2016	23.222	9	.0057
3	.2720	.5215	.7118	4.930	4	.2945
4	.0224	.1495	.9776	.328	1	.5670

Key (see Table 3)

Table 8. Vectors of transformation in canonical variables (W) and canonical factors (F) isolated in the area of velocity of diagonal and parallel body parts

	W1	W2	F1	F2
BGDNL	-0.29362	0.37125	0.36868	-0.82180
BGDRL	0.87234	-0.56656	-0.70842	-0.78798
BGDND	-0.05840	0.06965	1.29857	0.54471
BGDRD	0.31583	0.93490	-0.15463	0.44513
BGPNL	0.24783	-0.05102	0.85260	-0.75513
BGPRL	0.74158	-0.22759	-0.86996	-0.28064
BGPND	0.28261	0.19234	0.62896	1.40270
BGPRD	-0.19763	0.89390	-0.63176	-0.79373

Key (see Tables 1 and 4)

From the variables groupation of velocity of diagonal body parts, the velocity of the right leg and left arm has the largest projection in terms of the isolated first canonical dimension. While in the field of parallel body parts' variables, the velocity of the left leg and left arm have significant projections in terms of the first canonical dimension, while the right leg and right arm have somewhat weaker yet significant projections (table 8).

The second canonical dimension in the velocity space of diagonal body parts has a significant velocity projection of the left leg and left arm that have a negative algebraic sign. In the velocity space of parallel body parts the largest projection has the right leg, while the right arm and left leg have somewhat weaker negative projections.

The obtained results are understandable considering that the primary velocity is dependent on the level of (excitation) velocity of the emission signal from the receptor and the velocity of the synaptic transmission. The central emission of the receptor signal is directed through the reticular formation whose functioning largely depends on the level of excitation of the highest areals of the central nervous system. The sensoric impulse leads to a strong excitation of the reticular formation or the bulboreticular facilitation field (mesencephalic and the upper pontin part of the). That contributes towards the majority of time being spent in nerve centers even for such a simple reaction. However, as the source and modality of the impulse were equivalent, the obtained differences in velocity didn't occur as the result of emission velocity from the receptor, rather as the result of the speed of data flow depending on the velocity of synaptic transmission and the number of synaptic connections in those central areals where impulses depart as effectors. As kinetic structures of alternative character were carried out in the realization of velocity, the most important role belongs to the impact of the mechanism for fast accumulation and velocity of releasing energy and to the mechanism for regulating the work of the agonist and antagonist.

Thus, for the velocity of bilateral body parts where a mechanism for velocity regulation of bilateral integration is responsible for its variability and covariability, forming ideomotoric structures and the control process of reeferentation and alternative muscle innervation. In addition, the obtained cohesion in this area undoubtedly indicates the significance of the left and right celebrum hemispheres which produces clearly differentiated evolved potentials for solving velocities. The larger cerebral specialization hemisphere is parallel to the distinct preference of lateralization of the left hemisphere (which is provoked by realizing the task presented by the right lateral structures). In the realization of velocity of bilateral body parts, there is a close collaboration between the excitation regulation and the regulation of synergism and tonus regulation. Furthermore, the velocity depends on the pace of exchange of excitation and inhibition of those central areas that govern velocity execution. The obtained variability is more significantly averted in the direction of the mechanism for excitation regulation and partly the excitation intensity directed towards conducting velocity.

4. Conclusions

The research was carried out with the goal to affirm a part of the entire variability separated by the velocity of bilateral (parallel, transversal, diagonal) body parts. The research study was conducted on a sample of 20 subjects, of male gender, ranging from 20 to 22 years of age. The process of collecting data and setting parameters was conducted by using an instrument called the KINESIOMETER (M. Dodig, 1987.), hooked up to an electronic computer, with an adequate perifery, with application of program support for analogue – digital conversion in the programming language SIMON'S BASIC. The instrumentarium uses 8 important analogue – digital converters (ADC) to which the kinesiometer and signal system were directly plugged into and synchronized with the measuring system. The relations between the velocity of bilateral body parts were analysed and affirmed via the technique of canonical correlational analysis (Coolly and Lohnes, 1971). Based on maximum cohesion between the pair of linear functions two groups of variables (parallel and transversal body parts), two characteristic canonical roots were extracted. One pair in the area of parallel lateralization, and one pair of characteristic canonical roots in the area of transversal lateralization. In the area of velocity of transversal and diagonal body parts one canonical root was extracted in the space of the velocity of transversal body parts, while one pair in the space of velocity of diagonal body parts. In the space of velocity of transversal and diagonal body parts one canonical root was extracted in the space of the velocity of diagonal body parts, while one pair in the space of velocity of parallel body parts.

The obtained results indicate a topological and functional dependency of the velocity of bilateral (parallel, transversal and diagonal) body parts. An efficient function of the pace of the signal's emission and the pace of the synaptic transmission signal (the number of synaptic connections and flow through synaptic barriers), efficient functioning of commissural connections between hemispheres and the efficiency of afferent and efferent paths directed towards parallel, transversal and diagonal body parts can probably be found at the basis of these indicators. The basic reason of obtained functional dependency between the velocity of bilateral body parts lies within the structure for excitation regulation and partly excitation intensity (activation of motor units) of varying degrees, synergic regulation and tonus regulation which are also determined according to bilateral structures. Thus, for the velocity of bilateral body parts, for whose variability and covariability the responsibility lies within a mechanism for regulation of bilateral integration velocity, forming ideomotoric structures and the control of the reeferentation process and alternative muscle innervation.

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