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Assessment of Specific Coordination in Subjects with Handicaped Locomotor System

by

Ryszard Plinta[1], Edward Saulicz[2], Rafal Gnat[3], Grzegorz Juras[4], Zbigniew Waskiewicz[5]

The objective of the paper was to describe the possibilities of application of The Vienna Test System in diagnosing the potential of specific coordination abilities in disabled subjects. The study involved 2 groups of participants – 75 handicapped men aged from 18 to 48 years and 45 healthy men between 21 and 41 years of age. In each case the level of coordination was assessed by means of The Vienna Test System. During assessment of the quality of both simple and complex reactions the best outcomes, expressed either in the shortest times or the highest speed, were accomplished by healthy men. Slightly worse performances were typical for people with amputations or congenital dysfunctions of the locomotor system. Some parameters were at a similar level. Clearly the worst results were registered among handicapped with traumatic or pathological lesions of the Central Nervous System. The Vienna Test System is a quick, measurable and simultaneously simple way of diagnosing the potential of coordination abilities in disabled subjects. The handicap of lower extremities with neurogenic origin can affect the level of such abilities in a considerable degree.

Key words: *locomotor system, coordination, motor abilities, disabled*

[1] *- Department of Health Care and Education, Silesian Medical University, Katowice, Poland and Department of Basics of Physiotherapy, Academy of Physical Education, Katowice, Poland.*
[2] *Department of Basics of Physiotherapy, Academy of Physical Education, Katowice, Poland.*
[3] *Department of Ergonomics, Prosthetics and Orthotics, Academy of Physical Education, Katowice, Poland*
[4] *Department of Human Kinetics, Academy of Physical Education, Katowice, Poland*
[5] *Department of Sport Games, Academy of Physical Education, Katowice, Poland*

Introduction

The tests and trials adapted to research on handicapped subjects are first and foremost used for needs of physiotherapy. Among them two groups, first one serving for purpose of clinical evaluation and the second for supplementary examinations, are possible to distinguish. Most of these diagnostic techniques take advantage of analytical tests, which enable to assess selectively e.g. muscular power, range of motion, etc. On the other hand the synthetic approach allows to determine global fitness of the handicapped person. Moreover, it is a valuable measurement of improvement (Nowotny and Saulicz 1998).

Many tests are applied in the area of research on human motor activity. Depending on their individual purposes, they can be divided into pedagogical and laboratory tests (Osinski 1993). The Vienna Test System (VTS) outlined by G. Schuhfrid, Austria, should be classified as a laboratory one. It appears nowadays as abattery of computer-aided tests applied most commonly in Europe. Being used since 1978 it serves for diagnosing awide range of both motor and neurophysiological abilities and predispositions determining motor abilities of the human body. In the first period of existence it was applied in the field of clinical and experimental psychology exclusively. Nowadays it happens to be adapted by other scientific domains including those dealing with human motor activity. Within the confines of the VTS great possibility of evaluation of the human body is given by over 60 tests, each of them having several options furthermore. Application of computer techniques into evaluation procedures add to the qualitative and quantitative analysis of the obtained results (Juras and Waskiewicz 1998, Raczek et al. 1998, 2000,2001).

Knowledge concerning the level of motor abilities, especially coordination, among handicapped people is still fragmentary and incomplete. Presentation of the possibilities of the VTS in diagnosis of the motor potential in disabled people formed main aim of this study. Simultaneously an attempt of revealing the level of the specific coordination abilities that characterise people with handicap of the locomotor system in correspondence with the origin of the disability was undertaken.

Material and method

Two groups of subjects were involved in the research. Seventy five handicapped men aged from 18 to 48 years (28,2 ± 8,8; groups A-D) as well as 45 healthy subjects between 21 and 41 years of age (24,9 ± 4,9; group E). The main condition established for selecting subjects for the research was complete fitness of the upper extremities and absence of any ailments or discomfort felt in this area on the day of the performance. The handicapped were divided into 4 groups, depending on the origin of their disability (table 1). People with the history of acute anterior poliomyelitis or infantile cerebral palsy were qualified together under the name of neurological illnesses group. Informed consent was obtained from each of the participants.

Table 1

Different origin of disability in the group of handicapped men.

Group	N	Mean age	Duration of disability [years]
Paraplegics (A)	48	31,1 ± 9,5	11,9 ± 10,2
Neurological illnesses (B)	10	29,1 ± 11,7	27,7 ± 11,2
Amputations (C)	14	28,4 ± 10,1	14,2 ± 7,0
Congenital defects (D)	3	18,7 ± 1,2	18,7 ± 1,2

In each case coordination was evaluated with use of the VTS, which was comprised of: the control unit (computer) with appropriate hardware and software, depending on the sort of the test performed, the set of peripheral devices and computer tests executed by means of monitor, light pens and special control panel (Raczek et al. 1998, 2000, Raczek 2000).

From basic peripheral units of the VTS the following were used for evaluation:

- RG 8,0 device for evaluation of simple reaction time;
- DG 5,0 device for evaluation of complex reaction time;
- MLS 3,0 device for evaluation of frequency and movement coupling;
- 2Hand 3,0 device for evaluation of the hand-to-hand coordination through description of the speed, precision and combination of the right and left upper extremity movements.

For assessing simple reaction assessment, the following option was chosen: during 1 minute time the subject's task was to push the 'reaction' key and release the 'rest' key as quickly as possible upon the appearance of the yellow light. The software calculated: the median of the speed of simple reaction (time between start of the stimulus and push of the 'reaction' key [ms]), the median of the time of this reaction (time between start of the stimulus and release of the 'rest' key [ms]) and the median of the single movement time in response to optic stimulus (time between release of the 'rest' key and push of the 'reaction' key [ms]). During evaluation of the complex reaction the task was to react simultaneously both to the optic stimuli in form of the five colour lights (white, yellow, red, green, blue) to which five keys were assigned, and to the acoustic stimuli in form of high- and low-pitched tones, to which two separate keys were assigned. The test lasted 2 minutes and the software automatically calculated: the number of correct complex reactions, the mean speed of complex reactions (mean time between start of the individual stimulus [either optic or acoustic] and push of the appropriate key [ms]) and the standard deviation of speed of the response, both to the optic and acoustic stimuli. The frequency and movement coupling were assessed by means of tests such as: ‘tapping’ and ‘inserting the pins’ for both hands together as well as separately. The software registered the number of the taps executed with use of the right and left hand during one-handed tests and the number of simultaneous taps with right and left hand in two-handed performance. The test lasted 32 seconds. Besides that, the time of ‘inserting the pins’ for right and left hand, both separately and simultaneously was recorded. The last test evaluated the hand-to-hand coordination. Subjects with the use of two analogue regulators, one of which enabled vertical and the second horizontal shifts of the pointer on the screen, had to follow the established track, containing rounded, rectangular, acute and obtuse bends, as quickly and as precisely as possible (without crossing edges of the track). The test was repeated four times and parameters registered throughout were: mean time of realisation of one repetition, mean ratio of error times (time with cursor behind the border of the track) to the full time of one repetition as well as coefficient of coordinating difficulties (mean ratio of error time on straight sections of the track to the error time on incline and rounded sections within one repetition).

The statistical analysis of the collected data was mainly based on multi-factor variance analysis. The influence of age and disability duration time were eliminated (they were treated as accompanying variables) to emphasise interactions between the origin of the locomotor system handicap and the level of the individual coordinating ability. The revealed diversity of the level of such ability was thereafter estimated by means of post hoc Tukey’s test.

Results

Similar distribution of results was obtained during assessment of the quality of both simple (table 2) and complex (table 3) reactions. The best outcomes, expressed either in the shortest times or the highest speed, were accomplished by healthy men. Slightly worse performances were typical for people with amputations or congenital defects. Some parameters were at a similar level. The worst results were registered among handicapped with traumatic or pathological lesions of the Central Nervous System.

Table 2

The level of simple reaction ability in all investigated groups estimated by means of simple reaction mean time [ms], simple reaction mean speed [ms] and single movement mean time [ms] (mean value ± SD; range min-max).

Variable	Group A	Group B	Group C	group D	Group E
Simple reaction mean time	256,3 ± 55,0 176-461	236,9 ± 32,4 157-266	244,3 ± 30,2 198-286	224,0 ± 28,8 200-256	224,9 ± 27,5 185-308
Simple reaction mean speed	404,9 ± 107,9 271-867	391,0 ± 103,8 246-607	352,9 ± 46,2 287-446	336,7 ± 55,6 292-399	321,3 ± 41,8 236-422
Single movement mean time	147,5 ± 96,8 96-676	154,4 ± 96,6 83-369	108,6 ± 34,2 68-179	112,7 ± 26,8 92-143	96,4 ± 26,4 22-147

Group A– paraplegics; Group B – neurological illnesses; Group C – amputations; Group D – congenital defects; Group E – healthy.

Table 3

The level of complex reaction ability in all investigated groups estimated by means of number of correct complex reactions, complex reaction mean speed [ms] and mean standard deviation of complex reaction speed [ms](mean value ± SD; range min-max).

Variable	Group A	Group B	Group C	group D	Group E
Correct complex reactions	128,9 ± 24,1 50-174	133,6 ± 12,8 92-129	134,9 ± 18,7 100-165	146,0 ± 24,3 118-162	144,6 ± 16,2 99-176
Complex reaction mean speed	96,4 ± 25,4 68-225	106,1 ± 12,8 92-130	89,9 ± 13,6 72-119	83,0 ± 15,6 73-101	83,4 ± 10,6 67-120
Complex reaction speed – mean standard deviation	28,4 ± 23,4 12-160	32,3 ± 11,9 19-60	21,6 ± 6,1 14-35	18,7 ± 7,2 14-27	21,2 ± 8,1 12-55

Group A– paraplegics; Group B – neurological illnesses; Group C – amputations; Group D – congenital defects; Group E – healthy.

The disabled of the D (congenital defects) group obtained even more favourable results than healthy men when right and left hand movement frequency was tested (table 4). Nevertheless, the outcome of the two hand movement coupling was clearly better among healthy subjects. Again, distinctly worse results were registered among men comprising groups A (paraplegics) and B (neurological illnesses).

Table 4

The level of frequency and movements coupling abilities in all investigated groups estimated by means of mean number of taps executed with right/left hand during one- and two handed performance (frequency)[number / 32 s], and mean time of inserting 20 pins with right/left hand movements during two-handed performance (coupling)[s](mean value ± SD; range min-max).

Variable	Group A	Group B	Group C	group D	Group E
Right hand movements mean frequency	216,1 ± 30,1 149-275	194,4 ± 38,7 101-241	220,4 ± 16,6 185-248	233,7 ± 40,2 190-269	325,9 ± 25,2 192-318
Left hand movements mean frequency	188,7 ± 38,6 79-259	174,7 ± 39,3 105-233	191,6 ± 17,9 162-217	227,7 ± 46,5 175 -263	214,8 ± 26,9 164-267
Right hand taps in two-handed trial	197,5 ± 37 61-276	185,6 ± 37,2 129-245	209,7 ± 14,8 182-229	223,7 ± 36,4 182-249	221,4 ± 24,7 169-301
Left hand taps in two-handed trial	181,1 ± 36,1 61-268	173,0 ± 29,8 136-221	192,6 ± 14,7 171-223	222,7 ± 13,3 208-234	209,8 ± 26,2 158-260
Right hand movements coupling	72,27 ± 10,78 59,07-11,07	77,00 ± 10,43 63,26-94,07	70,68 ± 9,80 53,02-88,67	70,69 ± 14,35 60,65-87,11	64,73 ± 5,35 54,21-78,89
Left hand movements coupling	72,32 ± 10,75 59,42-11,07	76,87 ± 10,42 63,57-94,44	70,61 ± 99,09 52,80-88,50	70,92± 13,86 61,44-86,82	64,96 ± 5,53 54,46-82,13

Group A– paraplegics; Group B – neurological illnesses; Group C – amputations; Group D – congenital defects; Group E – healthy.

The overall picture was completed by thehand-to-hand coordination test, which confirmed previous observations (table 5). The best trials were usually recorded in group E (healthy subjects), the worst in men after acute anterior poliomyelitis or infantile cerebral palsy (group B) and with paraplegia (group A).

Multi-factor analysis of variance showed considerable diversity between investigated groups of handicapped of the locomotor system in regard to majority of measured parameters (tables 6 and 7). The post hoc Tukey’s test revealed that mentioned diversity was dictated by significantly worse results in participants with paraplegia (group A) as well as after acute anterior poliomyelitis or infantile cerebral palsy (group B) in relation to healthy men (group E).

Smaller values of standard deviation of response both to optic and acoustic stimuli speed, mean task time, error percentage as well as coefficient of coordinating difficulties obtained by handicapped paraplegics did not show features of statistical significance. As far as all remaining variables are concerned the differences were highly statistically significant (all p values in Tukey's test were between 0,00013 and 0,0088). Among disabled of group B (neurological illnesses) significantly worse results were recorded in case of: the number of correct complex reactions (p=0,0003), mean speed of complex reactions (p=0,0061), right hand movement frequency (p=0,00057), left hand movement frequency (p=0,0061), right hand movement coupling (p=0,0017), left hand movement coupling (p=0,0025), right hand taps during two-handed performance (p=0,0105) and left hand taps during two-handed performance (p=0,0054).

Table 5

The level of coordinating ability in all investigated groups estimated by means of mean tasks time [s], errors percentage and coefficient of coordinating difficulties (mean value ± SD; range min-max).

Variable	Group A	Group B	Group C	group D	Group E
Mean tasks time	20,41 ± 7,71 8,72-37,53	21,26 ± 8,58 9,11-35,13	19,90 ± 10,05 8,80-45,23	17,68 ± 1,80 16,01-19,60	17,40 ± 8,57 7,59-55,70
Errors percentage	9,51 ± 11,06 0,63-57,45	9,54 ± 12,71 0,81-42,85	8,67 ± 7,73 0,76-25,31	2,96 ± 2,26 0,45-4,86	8,46 ± 6,69 0,25-25,68
Coordinating difficulties coefficient	1,56 ± 0,36 0,88-2,40	1,67 ± 0,51 1,10-2,73	1,47 ± 0,29 1,12-2,09	1,57 ± 0,29 1,23-1,79	1,56 ± 0,46 0,79-2,64

Group A– paraplegics; Group B – neurological illnesses; Group C – amputations; Group D – congenital defects; Group E – healthy.

Table 6

Outcomes of multiple variance analysis for measured parameters of simple and complex reactions.

Variable	F	p
Simple reaction mean time	3,49	0,069
Simple reaction mean speed	6,59	<u>0,0007</u>
Single movement mean time	3,71	<u>0,012</u>
Correct complex reactions	6,78	<u>0,0059</u>
Complex reaction mean speed	4,69	<u>0,047</u>
Complex reaction speed – mean standard deviation	1,88	0,308

<u>Statistically significant</u>

Table 7

Outcomes of multiple variance analysis for measured parameters of frequency and movement coupling abilities and level of hand-to-hand coordination.

Variable	F	p
Right hand movements mean frequency	5,80	0,0017
Left hand movements mean frequency	5,91	0,00072
Right hand movements coupling	6,08	0,018
Left hand movements coupling	5,72	0,021
Right hand taps in two-handed trial	5,04	0,016
Left hand taps in two-handed trial	7,34	0,00019
Mean tasks time	0,98	0,94
Errors percentage	0,39	0,38
Coordinating difficulties coefficient	0,37	0,80

Statistically significant

The differences registered between this group of participants and healthy men were in other cases insignificant. No significant differences between other groups of the handicapped (groups C and D) and healthy subjects were recorded. Nevertheless, slightly worse outcomes concerned people with lower extremity amputations and with congenital defects. Analogous lack of significant differences in obtained results was observed between individual groups of handicapped subjects themselves, although results of almost all trials were slightly worse in men with neurogenic origin of disability (groups A and B).

Discussion

People after spinal cord injury with paralysis of lower extremities use their hands to move the wheelchair, to perform various daily-living activities and during physical exercises. However, such physiologic factors as relatively lower muscle mass subjected to free control, weakened cardio-vascular reflexes and inactivity of muscle pump (reduction of circulation speed) can significantly reduce physical capacity of the upper limbs. A sedentary lifestyle added to this status brings about further decrease in muscle power as well as circulatory and respiratory insufficiency. Research on subjects with spinal cord injuries moving with use of wheelchair proved that those who lead a more active life and regularly take part in sport activities have greater muscle power, higher circulatory and respiratory capacity and in consequence better psychomotor abilities (Cottus 1992, Jochheim 1988, Mayer et al. 1998, Midhaa et al. 1999, Plinta 1999, 2000, Shephardt 1991, Stotts 1986).

Physiologic responses to physical tasks performed with use of the upper extremities by people with spinal cord injuries can be different than among healthy ones. Usually: the bigger paralysed muscle mass the lower ability to free motor tasks and functional independence. With similar situation one has to perform deal in persons with lower limb paralyses originating differently than from injury of the spinal cord. This explains worse results in participants with lower limb paralyses in consequence of spinal cord trauma (group A) and after acute anterior poliomyelitis or infantile cerebral palsy (group B) in relation to other groups. Worse outcomes obtained by group B subjects (especially concerned response time, task time and number of conducted errors) were undoubtedly influenced by trials performed by cerebral palsy participants. Although total functional ability of upper extremity was the factor determining participation, yet it is well known that in dysfunction of such anature the disturbance of integrating function of the cerebral cortex can manifest itself in bradykinesia (Nowotny and Saulicz 1998, Nowotny and Krauze 1981) of sometimes very discreet character, imperceptible in typical clinical examination.

Presented research should be considered as a preliminary one. Its results can hardly be referred to resembling ones, based on similar material. It may be however assumed that VTS is not only asuitable tool for evaluation of insufficiency of the so called fine motor activity in disabled subjects but also can be helpful in verification of efficiency of these therapeutic procedures, which aim to improve specific coordination abilities during the process of rehabilitation.

Conclusions

1. The Vienna Test System is a quick, reliable and valid device in diagnosing the coordinating sphere of motor potential in disabled subjects.
2. The handicap of lower extremities with neurogenic origin affects the level of specific coordination abilities in a considerable degree.

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