THE COMPUTER SUPPLEMENTED DIAGNOSIS OF MOVEMENT RHYTHM

by

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The main objective of this paper was to describe movement rhythm on the basis of the computer diagnosis that included the „TAP" test, one of the elements of the Vienna Test System (VST). An attempt was made to determine the diagnostic possibilities of a standard test used in the evaluation of movement rhythm. Such a procedure seems justified since one of the fundamental coordination abilities still does not posses a reliable diagnostic tool. Many such attempts have been previously published Polish scientific literature.

The rhythm of upper and lower limbs was evaluated under different conditions (uni- and bilateral) and frequencies. The research was conducted on 22 male and 26 female students of the Academy of Physical Education in Katowice and the testing procedures took place in the Department of Motor Control. The results of the conducted experiment indicate the lack of significant sexual dimorphism in relation to movement rhythm. At the same time the result indicate a high diagnostic value of VST in evaluation of rhythm.

Key words: co-ordination abilities, movement rhythm, Vienna Test System

Introduction

Rhythm is an indispensable element of many motor tasks and very often determines its effectiveness. In many physical activities the level of rhythm determines the success of the performance as well as its aesthetic outlook. In activities such as dance, ballet, gymnastics, sprinting and hurdling as well as swimming movement rhythm seems to be key factor determining success. Early research on rhythm goes back to the beginning of the century. Wundt (1914) underlined the sequential of motor tasks, while Riemann (1921) indicated time differences in particular phases of movement and the existence of strict relationships between particular phases of movement. The importance of

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rhythm has also captured the attention of sport scientists. Wyżnikiewicz-Kopp (1978) determines rhythm as regular and steady sequences of movement phases. Pöhlmann (1987) define rhythm in two different ways. The first definition has a scientific character and describes rhythm as psychomotor determinants of human's ability to perceive relatively schematic time-space division of movement flow. At the same time he defines the possibilities in this area as the ability to store information as a general, simplified rhythm pattern. This property also conditions the ordering and application of such a pattern as a regulator of main activity (motor control pattern). In the second, simplified and more popular definition of rhythm he defines this properties as possibilities of movement flow division through grouping and stressing time-space movement flow according to possible rhythmic patterns. Bauman and Reim (1994) define rhythm as the ability to perceive and sense imposed pattern and the adjustment of own activities to a given external pattern. Rieder (1987) underlying the complexity of this property in his works points to the many internal and external factors that conditions it and proposes an attempt to create new diagnostic methods.

A dualistic approach to rhythm seems very characteristic. Some specialists such as Meinel and Schnabel (1988) see rhythm as external outcome of movement describing in its structure two complexes: combining of movement (shifting of movement phases or whole movements, dominant role of head in movement initiation) and movement rhythm which includes movement stability, precision and fluency of movement. Others like Raczek and Mynarski (1992) defining rhythm as an ability to capture, reproduce and perform dynamic movement changes in a sequential cycle. This phenomenon is expressed in the adjustment of movements to a set rhythm (external pattern) or perception of intentional inner rhythm (internal pattern). Rhythm is expressed in time (acceleration or deceleration), force (contraction or relaxation), space (range and direction) and form (the time-force-space complex). Raczek and Mynarski (1992) indicate that the dominant role in case of rhythm is directed towards processing of auditory, kinesthetic and visual information what determines motor effectiveness in many sport disciplines.

Baumann and Reim (1994) suggest describing rhythm in four aspects:

1. Theoretical concepts
   - biological,
   - anthropological,

- philosophical,
- phenomenological.

2. Internal and external vision of rhythm
   - external – time, space and form,
   - internal – area of sensations (detected by kinesthetic senses).
3. Internal and external factors influencing rhythm
   - external – environment, partner, opponent, equipment,
   - internal – emotions, cognitive processes, muscular and physiological processes, injuries, diseases.
4. Factors determining the level of rhythm development.

In analyzing rhythm as a motor ability it is necessary to differentiate between internal and external rhythm. The first of this terms relates to dynamic functions and processes which influence muscular contraction and relaxation in the process of motor task performance independently of environmental circumstances (for example: stride length adjustment due to fatigue, internal movement vision changed under the influence of sensations and emotions). Internal rhythm is determined only by individual grouping or dividing rhythmic sequences. External rhythm may be described as the arrangement of movement dependent on external time patterns. Humans conduct it under the influence of particular external stimuli (for example: distance between hurdles, music in a gymnastic exercise). External rhythm implies to repetition of imposed dynamic and time movement structure with very little individual interference in its flow.

In each movement three specific elements can be extracted that describe the whole movement (Rothing 1982):

- division, which indicates that all parts of the movement, is mutually related thus creating the whole. In rhythmic movements particular phases and its individual characteristics (order, duration and subphases) play the same role.
- accent which relates a rhythmic structure developed through stressing particular phases of movement,
- repetition which relates to a characteristic order of movement and amplifies its rhythm.

Rhythm is highly dependent on the functions of the central nervous system (CNS) and only a well, highly developed CNS allows the human to perform complex motor tasks requiring high sense of rhythm.

Considering the above mentioned short review of literature the authors constructed the following research questions:

1. Is a precise measurement possible through the application of Vienna Test System?
2. Does the sexual dimorphism exist in relation to rhythm?

Methods

The research project was conducted in the Department of Motor Control of the Academy of Physical Education in Katowice and included 22 male and 26 female students aged 21 to 24 years. The main diagnostic tool consisted of a computer rhythm test ("TAPPING") which is a part of Vienna Test System (VST).

It seems appropriate to give a brief description of a mentioned above VST. This system was developed in Austria by G. Schuhfried and is acknowledged in Europe as one of the best computer tests used in the process of diagnosing motor abilities neuropsychological functions as well as physiological properties determining physical fitness. The system has been used in clinical and experimental psychology since 1978 and is currently adapted by different science fields. This fact is fully understandable when one considers the range of human properties underlying evaluation using the 60 different testing options the system offers. The measuring procedures have been improved through out the years and today they are fully computerized. The use of computer technology allows for quantitative and qualitative analysis and most of all the analysis of the performance itself. And thus to penetrate in the processes that determine performance. The reliability and validity of the system is very high and meets the demands of contemporary science. VST is composed of a managing device (PC computer), software (MENUE) and operational software (RSX) and optional dependently only peripheral devices and computer tests conducted with the use of the monitor, pointing lightpen and a special panel with pedals.

Among the basic peripheral elements of the system one must mention: the device for diagnosing the reaction time (RG) and decision making (DG), motor fitness (MLS), flimmer-flicker analyzer (FLIM), visual perception (TACH) as well as the device that registers physiological variables (PHYSIO). As an example of diagnosing procedures used with the application of remaining tests the following can be mentioned: the test for rhythm evaluation (TAPPING),

bimanual coordination (2HAND), signal detection (SIGNAL) or memory span (CORSI). The particular devices and tests included in the Vienna Test System allow through a logical analysis (experts) for the diagnosis of:

- reaction time,
- strength differentiation,
- time-space orientation,
- rhythm,
- movement combining,
- motor adjustment.

Structure of the test

The task the subject has to accomplish is to adapt his tap-rhythm to a given rhythm of sounds. This acquired tap-rhythm should then also be kept after a "guided" phase (with sounds) in an "unguided" phase (no sounds). The sounds are produced with sound generator. Their frequency is either 833 or 417 ms, which corresponds to 72 or 144 beats/min. For the input of the tap-rhythm the green and red buttons of the subject panel and special pedal are used.

Testing procedure

In the practice phase one has first to adapt his tap-rhythm, which is input with the buttons of the subject panel and/or a pedal, to a given rhythm of sounds. In the subsequent test phase the same rhythm should be kept, first with and than without sound presentation ("guided" phase and "unguided" phase). More tasks follow with new rhythms, until all tapping types of the selected parameter block have been made.

Instruction and practice phase

The instruction for each sub-test fills one screen page. The demanded tapping sequence is explained on it. The unguided and guided phases are mentioned. Finally subject is asked to try out the demanded tap-rhythm without sounds first. In the practice phase sounds are presented in the pre-defined rhythm. The length of the practice phase is defined by a certain number of sounds. In this phase the tapping sequence should be adapted to the rhythm of the sounds, which represents a learning process and therefore also requires a learning criterion. Certain number of subsequent correctly performed taps defines the learning criterion. A tap is considered as correct, i.e. corresponding

to sound, if lies in a certain critical time interval around the sound. It is considered, if:

- a tap does not lie within the time interval,
- no tap is made within the time interval,
- there is more than one tap within the time interval on the same side (right or left),
- a tap does not correspond to the required tapping sequence.

As soon as one of these errors is made, the counting of correct taps starts again at 0. After reaching the learning criterion, the test phase starts automatically, even if not all of the sounds of the practice phase have been presented. If the learning criterion has not been reached, the subject receives a feedback after practice phase, asking him to increase his concentration and to recall the practice phase. After this second practice test phase follows in every case, even if learning criterion has not been reached again.

Test phase

The test phase consist of two parts, the "guided" and the subsequent "unguided" phase. In the "guided" phase the subject has to input the tapping sequence which he has learned in the practice phase guided by a rhythm of sounds. In the "unguided" phase the inputs are made without the guidance of sounds. The guided phase is followed by the unguided phase without interruption.

Scoring

The evaluation of the test results is done separately for each tapping type. For the bilateral tapping types the evaluation is done separately for left/right or heel/tip of the foot. The main objective of evaluation is to determine:

- with which accuracy the given rhythm has been acquired and input,
- how accurately this rhythm can be kept in the long run

For this purpose the following variables are measured (time is measured in miliseconds)

Number of taps in guided phase

This is the total of inputs that are done in the guided phase and this figure serves for controlling if taps have been omitted.

Scored are only this inputs which:

- lie within a certain time interval of ±T/2 relative to the next corresponding sound
- if two taps lie within ±T/2, the input which is closer to the sound is counted
- if a tap lies outside ±T/2, it will be counted towards the next corresponding sound, as long as there is no further tap which lies even closer to the sound concerned
- if a tap lies exactly between two sounds the program counts the tap to the first sound if no tap has been registered at the first sound. If a tap has already been registered at the first sound it is counted to the second sound if no other tap lies ±T/2 around the second sound. If there is another sound in this interval the tap is not counted at all. Thus, per second only one tap is counted.

Average TAP-SOUND (ms)
Standard deviation TAP-SOUND (ms)
Average TAP-TAP-TIME (ms)
Standard deviation TAP-TAP-TIME (ms)

The TAP-TAP-TIME is the interval of subsequent taps in the unguided phase. The TAP-TAP-TIME is measured from the second tap on, because it can be expected that the first one deviates because of the transition from the guided to unguided phase. The average and the standard deviation of these values form the above variables.

Tendency in unguided phase

In order to assess possible input tendencies, the instant x(i) of the appearance of each tap (i) is being calculated after the start of the unguided phase. The start of the unguided phase is set at instant +T/2 after the last sound of the guided phase.

When the values of the intervals between each tap (i) to the subsequent one (i+1) are plotted on the Y-axis, each tap can be displayed as a point in two-dimensional system of coordinates. The co-ordinates of a tap in this system of co-ordinates is defined by the following variables:

- x_i the time since the start of the unguided phase until the i-th tap and
- Y_i the interval between tap i and tap i+1

The so defined taps of the unguided phase therefore form a group of points in the system of co-ordinates. Through these points one can apply a regression

line and calculate its gradient (y) at the start y_S and at the end y_E of the unguided phase.

The input tendency (T) equals the ratio of these two values: $\mathbf{T=Y_E/Y_S}$. The result of this calculation of the subject's input tendency is multiplied with 100 and displayed as a percentage. If this value is bigger than 100%, it means a deceleration, if it is smaller it means an acceleration of the inputs in the unguided phase.

The last three variables are: sequence errors in guided phase, sequence error in unguided phase and number of sounds in the practice phase.

In this research the parameter block S1 was used and four subtests were applied (tab. 1).

Table 1. The characteristic of applied subtests

Subtest	SS	NSPP	LC	NSGP	LDD	CTI
HAND UNILAT R	833	28	8	18	36	180
HAND UNILAT L	833	28	8	18	36	180
HAND BILAT	417	44	12	36	72	220
FOOT UNILAT R	833	28	8	18	36	180
FOOT UNILAT L	833	28	8	18	36	180
FOOT BILAT	417	44	12	36	72	220

SS – sound-sound period, **NSPP** – number of sounds in practice phase, **LC** – learning criterion i unguided phase, **NSUP** – number of sounds in guided phase, **NSGP** - number of sounds in unguided phase, **CTI** – critical time interval within which the tap has to be made in order to be considered „correct"), **HAND UNILAT R** – right hand tapping, **HAND UNILAT L** - left hand tapping, **HAND BILAT** – bilateral right and left hand tapping, **FOOT BILAT** - bilateral right and left foot tapping, **FOOT UNILAT R** - right foot tapping, **FOOT UNILAT L** - left foot tapping.

All operations and related to measurement are conducted with the use of the computer, panel and appropriate elements of VST. Acquisition and storing of data are also automated.

Results

The analysis of data started with the verification of normality through the use of Kolmogorov-Smirnov test. The test indicated normal distribution of results. In the next step the authors attempted to detect sexual dimorphism in relation to rhythm. The applied method (t-Student test) did not indicate a large

quantity of statistically significant differences among the analyzed variables diagnosing the level of rhythm (tab. 2). Only in seven cases females differed significantly from man in the level of rhythm. The variables in which this difference were statistically significant are listed below:

TT_SD3 - standard deviation of errors of right hand bilateral tapping in unguided phases,

T3 - tendency of bilateral right hand tapping rate,

TT_SD4 - standard deviation of errors of left hand bilateral tapping in unguided phases,

TS6 - average error of the left leg bilateral tapping,

TS_UD7 - standard deviation of errors left leg bilateral tapping in guided phases,

TT_SD7 - standard deviation of errors of right foot bilateral tapping in unguided phases,

T7 - tendency of bilateral right foot tapping rate,

TS_SD8 - standard deviation of errors left foot bilateral tapping in guided phases,

TT8 - standard deviation of errors left foot bilateral tapping in unguided phases.

It seems to be of interest that significant differences occurred only in relation to bilateral tapping. The data also indicates that in six of seven cases where differences occurred males presented higher level of rhythm (results equal to 100 indicate ideal reproduction of rhythm). One must remember that the nine variables considered above consist only 22,5% of all the variables taken into consideration thus it is difficult to state a definite tendencies in sexual differences related to rhythm. To solve this problem definitely further research in rhythm dimorphism should be continued on other populations.

At the same time it must be indicated that great possibilities arised in the use of computer based diagnostic methods this research project has confirmed the great diagnostic value of "TAPPING". It allows to diagnose a wide spectrum of variables characterizing rhythm and at the same time to evaluate human performance not only in associative manner (through the final result), but also processual way generating results on the basis of samples taken during flow of the movement.

Resuming the presented empirical data it is very important to indicate that the computer evaluation of rhythm through the TAPPING is very precise and

reliable. It seems this project creates new area of scientific research, which will allow for a better understanding of rhythm and increase the knowledge in area of motor control.

Table 2. The t-Student test results describing the sexual dimorphism in relation to rhythm

Variables	Girls		Boys			
	X	SD	x	SD	t	p
1	2	3	4	5	6	7
TS1	30,65	22,28	35,01	21,38	-0,822	0,414
TS_SD1	41,41	10,31	40,02	9,52	0,577	0,566
TT1	794,04	66,42	783,45	38,32	0,804	0,424
TS_SD1	145,19	20,37	141,77	10,67	0,864	0,390
T1	93,08	27,32	94,67	15,91	-0,293	0,770
TS2	32,43	19,90	31,28	19,75	0,241	0,811
TS_SD2	43,10	15,96	40,45	13,01	0,748	0,457
TT2	791,84	47,29	790,19	45,99	0,146	0,884
TT_SD2	144,34	14,34	144,31	12,55	0,012	0,990
T2	95,20	22,55	93,07	21,99	0,393	0,695
TS3	37,00	28,40	27,63	20,08	1,569	0,121
TS_SD3	36,35	11,18	36,46	13,96	-0,035	0,972
TT3	796,14	36,05	779,33	37,60	1,879	0,064
TT_SD3	**145,33**	**12,96**	**139,37**	**11,09**	**2,033**	**0,046**
T3	**80,84**	**39,54**	**95,51**	**15,86**	**-2,004**	**0,049**
TS4	32,93	19,48	38,02	18,13	-1,115	0,268
TS_SD4	29,79	6,86	33,52	10,19	-1,765	0,082
TT4	780,91	115,46	779,72	37,49	0,057	0,955
TT_SD4	**145,53**	**16,97**	**137,97**	**9,96**	**2,235**	**0,028**
T4	97,17	16,26	92,82	21,43	0,941	0,350
TS5	43,69	25,84	43,23	22,49	0,077	0,939
TS_SD5	46,33	11,20	46,17	12,23	0,058	0,954
TT5	1465,40	108,62	1444,78	121,79	0,736	0,464
TT_SD5	403,00	77,54	403,86	70,75	-0,048	0,962
T5	102,86	28,30	99,81	24,04	0,479	0,633
TS6	**45,78**	**22,19**	**39,42**	**15,19**	**2,048**	**0,044**
TS_SD6	65,50	39,94	50,94	11,01	-0,490	0,626
TT6	1460,66	221,45	1480,62	85,37	-0,060	0,953
TT_SD6	388,77	38,07	389,40	48,51	-0,703	0,484
T6	98,07	17,47	100,52	10,31	-0,703	0,484
TS7	35,90	25,14	42,02	22,36	-1,192	0,237

Table 2

1	2	3	4	5	6	7
TS_SD7	**60,69**	**48,25**	**44,79**	**13,74**	**2,079**	**0,041**
TT7	**1478,44**	**73,17**	**1436,26**	**119,31**	**1,976**	**0,051**
TT_SD7	394,42	54,07	397,54	80,93	-0,210	0,834
T7	**119,91**	**56,69**	**102,06**	**18,21**	**1,967**	**0,053**
TS8	44,25	17,92	41,77	24,83	0,530	0,597
TS_SD8	**65,50**	**38,63**	**49,23**	**12,15**	**2,635**	**0,010**
TT8	**1494,27**	**72,52**	**1444,30**	**94,09**	**2,758**	**0,007**
TT_SD8	376,97	39,69	373,36	55,90	0,345	0,731
T8	97,60	17,60	97,72	14,78	-0,033	0,974

TS – TAP-SOUND difference (guided), **TT** – TAP-TAP difference (unguided), **TS_SD** – TAP-SOUND standard deviation (guided), **TT_SD** – TAP-TAP standard deviation (unguided), **T** - tendency

1 – right hand unilateral, **2** – left hand unilateral, **3** - right hand bilateral, **4** – left hand bilateral,

5 – right foot unilateral, **6** – left foot unilateral, **7** - right foot bilateral, **8** – left foot bilateral

Conclusions

1. The "TAPPING" test being part of VST is a reliable and valid diagnostic tool.
2. The sexual dimorphism in the relation to rhythm occurs only in particular forms (bilateral tapping).

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