Acta of Bioengineering and Biomechanics
Vol. 1, No. 1, 1999

Psychomotor efficiency profiles of the members of the senior and junior Polish national table-tennis team

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The psychomotor efficiency of 10 senior and 10 junior players of the Polish national table-tennis team was tested. Two factors were differentiated in the structure of psychomotor efficiency: psychomotor control and psychomotor state. The table-tennis simulator was used in the research. The psychomotor efficiency was measured in complex and analytical ways. The speeds of anticipatory (complex factor) and simple (psychomotor state) ball-hitting movements were investigated. The anticipation (movement control) and behavioural fluctuation (psychomotor control) indexes were introduced. These factors were used to draw up psychomotor profiles of seniors, juniors, a champion (the best senior) and a freely chosen player. Differences between the champion's profile and those of the groups and the freely chosen player were found. The seniors' and juniors' profiles differ in complex efficiency, but among the structural factors only in motor speed potential (psychomotor state).

Keywords: psychomotor efficiency, table tennis, psychomotor profile

1. The structure of psychomotor efficiency

Motor behaviour in sport may be treated as a *psychomotor activity* – a psychic and motor process directed at achieving a goal, which is based on situational and potential conditions. Connected by the neuro-sensory system, both the psychic and motor spheres are involved in such a psychomotor activity. The psychic sphere is responsible for the control of movement and the psycho-energetic state of a human being.

The *control of movement* consists in preparing and modifying the motor programme and setting the human body in motion on the basis of this programme. This control takes place in an open or closed loop. *Open-loop control* occurs during the execution of fast movements and in motor reactions. On the other hand *closed-loop control*, which occurs in slow movement and in motor learning, is based on feedback, which comprises information received by the brain from exterio- and propriosensors.

The *psycho-energetic state* is linked with the level of attention concentration, motivation and arousal; it determines the degree of energisation of the human body and limits the sources of information about the internal and external conditions of movement. The purpose of *psycho-energetic state control* is to maximise the quality of sensory-motor anticipation in the movement control responsible for the quality of movement performance. Yearkes and Dodson's first and second laws link the psycho-energetic state and quality of movement performance. These show that the quality of movement performance is highest when the psycho-energetic state is optimal; this in turn depends on the degree of difficulty that the execution of the movement involves.

Sensory-motor anticipation, the principal process governing the movement control, requires information derived from the sensors and memory to be processed. When this happens, the information is interpolated and the probability of achieving the intended goal of the movement is subjectively assessed. However, the interpolation of information is encumbered with error, as the divisions of interpolation are an area of uncertainty; moreover, the subjective estimation of probability in itself expresses a degree of uncertainty. In connection with this, the processing of information in motor control is necessarily of an anticipatory nature.

In table tennis, sensory-motor anticipation consists in predicting the ball's flight path and speed, where and how the ball is to be struck, and the way in which the requisite movements are to be performed (their structure and speed).

The quality of this anticipation depends not only on the speed and precision of information processing, but also on the level of advancement of the so-called *anticipatory schemata* (Łapszo, 1996): these are the mental structure containing concrete information remembered from previous performances of movements. The conception of such a schema is based on Schmidt's motor schema model (Schmidt, 1975) and constitutes the foundation of open skills (Schmidt, 1988). The level of advancement of these schemata can be treated as the *state of movement learning*. This changes in accordance with the quality of closed-loop movement control, which governs the speed and quality of motor learning. Closed-loop movement control in the motor learning process relies on such a modification of the motor programme that will raise the subjective estimation of the probability of achieving the intended goal of the movement. This kind of motor control is based on consciousness, sensory differentiation, attention, imagination and memory. The quality of sensory-motor anticipation depends not only on the state of movement learning (anticipatory potential of movement), but also on the quality of psycho-energetic state control. This latter permits only the most important information necessary for the correct performance of a movement to be received from the external and internal environments. The state of body energizing, which influences the programming of movement, also depends on the quality of this control.

The motor sphere (motus – movement, motor – propulsion) comprises the motor conditions and manifestations (Raczek [in:] Osiński [Ed.], 1994). Motor conditions relate to the morpho-functional factors connected with the constitution and working of the human body (height, mass, body proportions, number of motor units, proportion of FT and ST fibres in muscles, efficiency of enzymatic processes, etc.). These factors determine the biomechanical and energetic limitations to the execution of different movements. The level of these factors defines the current *motor state* of a human being. This in turn depends on ontogenetic development, genetic conditions, and on the quality of *morpho-functional control*. This kind of control governs changes in the motor state caused by effort (tiredness), training, nutrition and resting, physiotherapy, etc. Constant changes in the motor state or those occurring over a long period of time have been called *adaptation*. As a result of ontogenetic development, genetic conditions and adaptation, the motor state can be treated as *motor potential*. Thus, the current motor state of a human being is the upshot of motor potential and the quality of morpho-functional control.

Together, movement, psycho-energetic and morpho-functional control make up *psychomotor control*. The psycho-energetic state, movement learning and the motor state can jointly be regarded as the *psychomotor state* of a human being.

The motor manifestations of psychomotor activities (displacement of the body in space and the result of this movement) in a particular situation depends on the *psychomotor efficiency*, i.e. on the quality of psychomotor control and on the current psychomotor state. These two factors comprise the *structure of psychomotor efficiency*. This can be assessed in a complex manner or analytically. In the latter case, these factors are assessed separately, as they are bound up with psychomotor control and psychomotor state, and influence the quality (degree of energy consumption) and efficacy (degree of goal achievement) of the motor manifestations of psychomotor activity.

Contemporary table tennis has become a game requiring a very high speed and precision of ball-hitting movements. In this paper, psychomotor efficiency in table tennis will be assessed on the basis of the ball-hitting movement speed, anticipation, psycho-energetic control and motor speed potential.

The purpose of this paper is to discuss the complex-analytical method of assessing psychomotor efficiency on the basis of *psychomotor profiles*. By means of graphs and statistical parameters, these profiles constitute the indexes of psychomotor efficiency distribution (complex and analytical) expressed on a uniform scale (Skorny, 1974). The method is presented on the basis of research on 10 senior and 10 junior members of the Polish national table-tennis team.

2. The complex-analytical method of psychomotor efficiency measurement

The table-tennis play simulator was used in the research (Łapszo, 1991). This simulator is controlled by computer and consists of a stimuli board, a set of sensors and a special table-tennis bat (Fig. 1). The construction of the simulator enables seven different *anticipatory* and *simple ball-hitting movements* to be investigated.

The anticipatory movements were simulated by seven constant pairs of lamps (one on the board and another in the sensor), which are the anticipatory schema. Both lamps were switched on sequentially (simulated ball flight). The memorising of this schema allows the place of the required simulated ball-hitting movement to be predicted on the basis of switching on the lamp on the stimuli board. Only the lamps in the sensors stimulated the simple ball-hitting movements. The photoelectric sensors identified the instant of the simulated stroke. The speed of both kinds of tested movements was timed in seconds from the instant the lamps in the sensors were switched on in a series of 17 movements. The result of the test was the average speed of these 17 measurements.

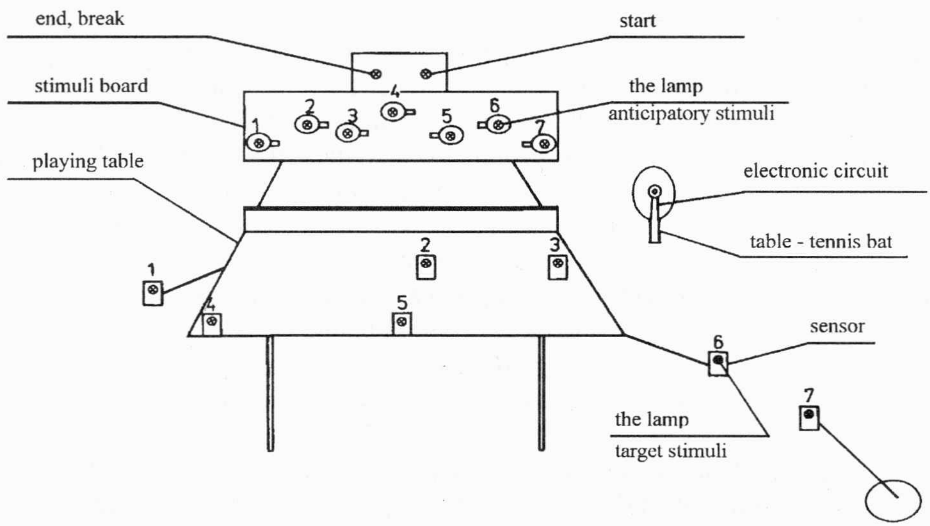

Fig. 1. The simulator of table-tennis play

The speed of anticipatory ball-hitting movements (*Ta*) is the complex index of psychomotor efficiency with respect to the psychomotor control and state. The anticipation and behaviour fluctuation index, and the speed of a simple ball-hitting movement can be treated as analytical indexes of this efficiency.

The anticipation index (*Wa*) expresses the relative increase ($Tp - Ta/Tp$) in the ball-hitting movement speed as a result of the ball's flight having been anticipated (Łapszo and Morawski, 1994; Łapszo, 1997). This index reflects the quality of movement control.

The behavioural fluctuation index (*Wb*) is given by the statistical parameter R^2 (Draper and Smith, 1973) which expresses the scatter of measurements around the learning curve of the anticipatory schema (Łapszo, 1997). This index refers to the quality of psycho-energetic control. The closer this parameter is to unity, the better the quality of psycho-energetic control. The speed of the simple ball-hitting movement (*Tp*) is primarily dependent on the motor speed potential of players. The speed of the anticipatory (*Ta*) and simple (*Tp*) ball-hitting movements were timed, so the shorter the time, the higher the speed.

3. The psychomotor efficiency profiles

The results were used to draw up the psychomotor efficiency profiles (Fig. 2). Figure 2 shows the profiles of both groups tested and of two members of the senior national Polish table-tennis team. One of these players is a champion, as his results are world-class. The other player was freely chosen from the senior group.

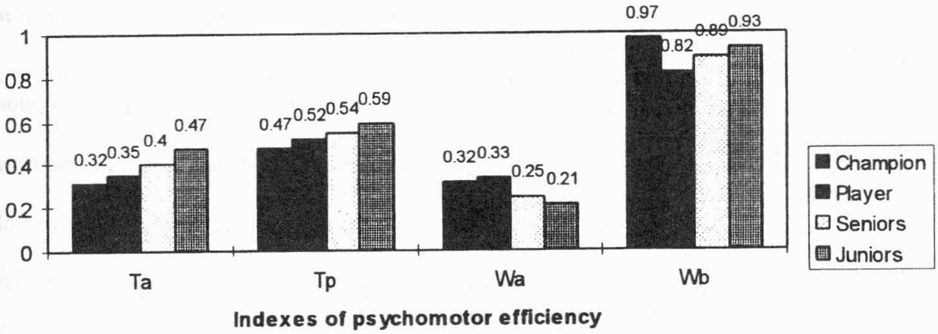

Fig. 2. The psychomotor efficiency profiles of the senior and junior Polish national table-tennis team, the champion and the player freely chosen

The champion was shown to possess the highest psychomotor efficiency. The complex psychomotor efficiency index (*Ta*) of the seniors is higher than that of the juniors. However, with respect to the structure of this efficiency, statistically significant differences were found only in the speed of the simple ball-hitting movement (*Tp*).

The differences in psychomotor efficiency profiles are given as percentages. It was found that the psychomotor efficiency of the juniors was lower than that of the seniors by 14.4% and that of the champion by 32.5%. The efficiency of the seniors is 21.2% poorer than that of the champion. The motor state (*Tp*, motor speed potential) of the seniors is 8.9% higher than that of the juniors but 13.9% lower than that of the champion. The respective indexes of anticipation (*Wa*) and behavioural fluctuation (*Wb*) of the juniors are lower than the corresponding figures of the champion by 33.8% and 20.3%; the indexes relevant to the seniors are lower by 4.1% and 8.2%.

The respective psychomotor efficiency, motor state and behavioural fluctuation indexes of the freely chosen player are lower than those of the champion by 9.2, 11.1 and 15.5%, but the anticipation index of this player is 3.1% higher than the champion's.

This method of research into psychomotor efficiency allows this parameter to be measured in a complex and analytical way, as well as to assess the differences of this efficiency and its structure between different groups and particular players. The results of such research can be implemented to guide and individualise the learning and training process.

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The research has been supported by the State Committee for Scientific Research (KBN) within the framework of the grant No. 4 P05D 031 17.