

# Criteria of assessing quick reaction in taekwondo athletes aged 12-25

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## Abstract

### Background & Study Aim:

There are a number of factors that determine the effectiveness of technical and tactical activities in combat sports. The cognitive aim of the research was to acquire the knowledge about basic credibility criteria (reliability and diagnostic validity) of selected tests included in *Batak Lite* as measuring criteria of quick reaction. The application aim was to adapt norms for controlling quick reaction of female and male taekwondo athletes at various levels of sports advancement.

### Material & Methods:

The research sample was 292 taekwondo athletes (112 females, 180 males); aged 12-25 years. The analysis included 4 selected tests included in *Batak Lite*. To define the reliability of the tests, the research was carried out twice with an interval of 3-5 days (test-retest). Diagnostic validity was determined with the use of the selected tests included in the *Vienna Test System* and two main criteria: technical and coordination levels (TC) of competitors and their sports mastery (SM). Norms for female and male athletes were defined in four age categories.

### Results:

*Batak Lite* selected tests demonstrated reliability coefficients  $r > 0.50$  and, in most cases, validity coefficients  $r > 0.30$ . Thus, they met the credibility requirements within the applied criteria. The highest validity coefficients were observed in tests of the *Vienna Test System* assessing choice reaction in females ( $r = 0.34$  to  $0.62$ ) and males ( $r = 0.31$  to  $0.38$ ) and simple reaction in male competitors only ( $r = 0.30$  to  $0.50$ ).

### Conclusions:

Four *Batak Lite* tests (I, II, IV and V) displayed sufficient reliability and diagnostic validity, which proved their usefulness when assessing quick reaction of taekwondo athletes.

### Key words:

Batak Lite, diagnostic validity, norms, reaction time, reliability, test-retest method

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**ITF** – International Taekwon-do Federation

**Taekwon-do** – a Korean martial art based mainly on punches and kicks. In the scientific literature there are various forms of spelling: **taekwondo**; **tae kwon do**; **tae-kwon-do** [13].

**Reaction time** – is the time from the occurrence of a stimulus to the first initiation of movement of the relevant segment of the body [32].

**Reaction time (RT)** – was determined by the time period, which started by lighting of LED and finished with the movement of epee goblet on a horizontal highly sensitive obstacle, which can be identified as motor response [32].

**Choice reaction** – consists in reproducing previously acquired motor programmes in response to adequate stimuli [33, p. 30]

**Simple RT** – the interval of time that elapses between the presentation of one possible stimulus and the beginning of its associated response [34, p. 33].

**Test-retest method** – a method of determining stability in which a test is given one day and then administered exactly as before a day or so later [35, p. 200].

**Technical and coordination levels (TC)** – the current level of technical advancement in taekwondo is the assessment criterion. It is calculated according to the following scale (in points): 10 kup (3), 9 kup (8), 8 kup (11), 7 kup (14), 6 kup (17), 5 kup (20), 4 kup (24), 3 kup (30), 2 kup (36), 1 kup (45), I dan (56), II dan (68), III dan (83), IV dan (100) [36, p. 41]

**Sports mastery (SM)** – a point scale of results (1-100) was created for taekwondo competitions at various levels (World, European or Polish Championships, etc.) taking into account the event (taekwondo competition consists of four events) and the place won [37, p. 127-128].

## INTRODUCTION

There are a number of factors that determine the effectiveness of technical and tactical activities in combat sports [1-5]. They also include psychomotor abilities, e.g. reaction time [6, 7]. They have often been the subject of research carried out by enthusiasts of combat sports and martial arts.

Auditory reaction time and visual reaction time in taekwondo athletes were assessed by Asia and Warkar [8] and Saulite et. al. [9], while Fisekcioglu [10] focused on auditory reaction time in right-handed taekwondo competitors. When assessing motor skills in taekwondo athletes, Pieter and Heijmans [11] concentrated on timing and speed. In turn, Fong and Ng [12] examined various types of reaction and speed as well as their changes resulting from taekwondo training. Ervilha et al. [13] compared reactions to a signal or a move of an opponent in females and males practising taekwondo. Chung and Ng [14] studied the influence of taekwondo training on neuromotor excitability and the reaction of large and small muscles, while Santos et al. [15] tested the effects of caffeine on reaction time among taekwondo competitors. Song and An [16] assessed how taekwondo training affected premotor and motor reaction time in mentally challenged upper-secondary school students who were able to acquire knowledge. The findings of all aforementioned investigations revealed differences in speed of reaction between women and men and proved that elite and more advanced athletes as well as left-handed competitors demonstrated better reaction. Typical taekwondo exercises improve quick reaction (also among children with developmental coordination disorders and mentally retarded children). Exercises in pairs improve reaction of

12-14-year-olds, while caffeine shortens reaction time in rested competitors and delays fatigue processes during matches. Quicker reaction makes it possible to respond to an opponent’s moves and score points more effectively, while the level of motor abilities (including speed of reaction) ought to be monitored during a training process in taekwondo.

Despite numerous attempts at estimating reaction time, it has not been possible to establish uniform methodology as well as developing adequate norms with regard to gender, age or the level of sports advancement. One of the options is *Batak Lite*, which has recently been introduced in assessing quick reaction of wrestlers [17]. If adapted to the needs of other combat sports, the device may turn out to be significant in making a training process optimal in terms of controlling performance levels.

The cognitive aim of the research was to acquire the knowledge about basic credibility criteria (reliability and diagnostic validity) of selected tests included in *Batak Lite* as measuring criteria of quick reaction. The application aim was to adapt norms for controlling quick reaction of female and male taekwondo athletes at various levels of sports advancement.

## MATERIAL AND METHODS

The research was conducted on 292 female and male taekwondo athletes aged 12-25 years during an international training camp in 2014. According to the rules and regulations of the Polish Taekwon-do Association, the subjects were divided into four age categories (Table 1). Prior to the research, their technical and coordination levels (TC) were assessed on the basis

**Table 1.** Characteristics of the taekwondo athletes (n = 292) participating in the research

Gender and age category (years)	N	Age (years)	Training experience (years)	TC (points)	SM (points)	
Female (n=112)	12-13	40	12.3±0.6	3.8±1.6	24.9±11.2	20.9±13.2
	14-15	22	14.8±0.7	5.0±2.2	41.8±12.9	40.5±26.8
	16-18	22	17.0±0.9	7.8±1.8	49.9±10.3	46.0±22.2
	19-25	28	23.3±2.2	11.5±3.9	50.4±21.0	51.9±22.1
Male (n=180)	12-13	60	12.3±0.9	3.9±1.5	24.8±17.7	18.7±16.0
	14-15	42	15.3±0.9	6.1±2.6	35.9±13.6	33.3±15.4
	16-18	40	17.1±0.3	8.2±2.1	49.5±12.1	47.7±18.4
	19-25	38	24.2±1.6	11.4±3.9	47.8±20.9	47.8±18.9



**Figure 1.** *Batak Lite* (the authors' own resources)

of coaches' opinions. Also, their sports mastery (SM), which was determined on the basis of the athletes' sports results achieved in the last year, was evaluated.

The study involved performing 4 out of 6 tests included in *Batak Lite*. The device, measuring 1143 (w) x 1800 (h) x 950mm (d), has a steering unit (microcomputer) with 8 light signals [18]. The microcomputer controls the sequence in which the light signals appear. Subjects have to use their hands to press the buttons which light up. The *Batak Lite* framework is a simple construction that can be transported easily, which is particularly important when it comes to research, training and outdoor use (Figure 1).

The research was carried out in standard conditions by the same research team. The subjects performed the tests in their free time in the morning hours. All the subjects were provided with detailed information concerning the test protocol and they took part in a pilot test. The tests were performed at 10-minute intervals.

The research included 4 selected tests which differed in duration or the number of light signals:

- test I: the participant stood in front of the device. Six lower buttons lit up randomly. The subject had to hit as many of them as possible in 30 seconds. As soon as one target was struck, the next one lit up. The score was the number of lights that were pressed;

- test II: standing in front of the device, the subject had to hit 8 buttons that lit up at a pace set by the programme. The duration of the test was 25 seconds. The score was the number of lights that were pressed;

- test IV: standing in front of the device, the subject had to press 8 randomly lit buttons in 30 seconds. The score was the number of lights that were pressed;

- test V: standing in front of the device, the subject had to hit as many lights as possible in 2 minutes. The score was the number of buttons that were pressed.

The research was conducted in two stages. The first stage included all the athletes and their scores were used to develop norms. The second stage (whose objective was the main credibility criteria) included 56 female and male taekwondo competitors aged 16-18 years demonstrating the highest level of SM.

**Credibility** of the tests was determined on the basis of two criteria, i.e. **reliability** and **diagnostic validity** [19].

A test-retest method was employed to assess the **reliability** of the tests. Therefore, the research was carried out again 3-5 days later and it was conducted on 24 female and 32 male competitors selected from the whole group of the study participants (n = 292). Analogous procedure and research tools were applied. The sequence of tests was the same as well. The data obtained from both measurements were compared by

calculating Pearson’s linear correlation coefficient (*r*). The tests used to assess validity included those in which reliability coefficients turned out to be statistically significant ( $p < 0.05$ ) and higher than  $r = 0.50$ .

**Diagnostic validity** was determined by means of two main criteria, i.e. TC and SM. Furthermore, the correlations between *Batak Lite* selected tests results and the psychomotor tests results included in the *Vienna Test System* that measured simple reaction time (RT test, S1 version; A1-A2 index) and choice reaction (DT test, S1 version, B1-B3 index) were defined [20].

Spearman’s rank correlation ( $\rho$ ) was applied to assess validity. *Statistica 6.0* programme was used for all calculations.

On the basis of *Batak Lite* selected tests results, the norms for taekwondo athletes in four age categories were developed (Table 1). The methodology applied was designed by experts [21]. In particular tests, a better result was the one in which more buttons which lit up were pressed. The norms were calculated in the following manner: *very high level*  $\bar{x}$  score + 1SD; *high level* between  $\bar{x}$  score + 0.5SD and  $\bar{x}$  score + 1SD; *medium level* from  $\bar{x}$  score + 0.5SD to  $\bar{x}$  score – 0.5SD; *low level* from  $\bar{x}$  score – 1SD to  $\bar{x}$  score – 0.5SD; *very low level* the score below  $\bar{x}$  score – 1SD.

**RESULTS**

Differences between mean scores from the two sets turned out to be statistically significant ( $p < 0.05$ ), while result variability coefficients (V%) in both trials (set I and II) ranged between 8% and 20% (Tables 2 and 3).

All the tests under investigation were sufficiently reliable. The tests displayed reliability coefficients  $r > 0.50$ , thus meeting credibility requirements within

a given criterion. The highest reliability was observed in the case of task V, where correlation coefficient in female and male taekwondo competitors was  $r = 0.88$  and  $0.85$ , respectively. The lowest (but still sufficient) reliability in females was noted in test I, where  $r = 0.63$  (Table 2), while in males it was in test IV, where  $r = 0.69$  (Table 3).

Both in the group of girls and boys the verified tests (I, II, IV and V) displayed clear correlations between the first criterion (TC) and the second one (SM). The majority of validity coefficients turned out to be higher than 0.30, thus meeting the credibility criterion. In tests II and V all validity coefficients ranged between 0.30 and 0.75 (Table 4).

Validity coefficients turned out to be similar in the female and the male group. In girls they ranged from 0.05 to 0.75, while in boys from 0.27 and 0.53 (Table 4).

The highest validity correlations of *Batak Lite* tests with the psychomotor tests of the *Vienna Test System* (Table 4) concerned choice reaction time (B3;  $r = -0.31$  to  $0.38$ ) and motor reaction time (A2;  $r = -0.30$  to  $-0.50$ ) in the male group (GRII). In the female group (GRI) the highest validity values were obtained only in the case of choice reaction (B1 where  $r = 0.34$  to  $0.47$  and B3 where  $r = -0.40$  to  $-0.62$ ).

In all the tests, exemplary norms were developed both for female (Table 5) and male (Table 6) taekwondo athletes of different ages.

When analysing individual results of the subjects, it was observed that their distribution for both genders was similar. Most individuals (approx. 60-80%) demonstrated scores within three central norms (below medium, medium and above medium). Very high and very low levels were obtained by 10-20% of the

**Table 2.** Reliability coefficients of *Batak Lite* selected tests (16-18-year-old female taekwondo competitors,  $n = 24$ ).

<i>Batak Lite</i> test	$\bar{x} \pm SD$		V (%)	$\Delta\%$	r
	set I	set II			
I	54.0±5.0	55.1±5.4	9.3-9.8	1.1	<b>0.631*</b>
II	23.3±3.4	24.1±2.9	14.6-12.0	0.8	<b>0.684*</b>
IV	47.5±4.9	48.6±4.6	10.3-9.5	1.1	<b>0.746*</b>
V	173.3±19.6	177.6±17.8	11.3-10.0	4.3	<b>0.881*</b>

\*coefficients meeting reliability criteria

**Table 3.** Reliability coefficients (test-retest) of *Batak Lite* tests (16-18-year-old male taekwondo competitors, n = 32).

<i>Batak Lite</i> test	Test	Retest	V (%)	Δ%	Reliability coefficients (r)
	mean score and SD				
I	56.8 ± 6.2	57.3±5.1	10.9-8.9	0.5	<b>0.725*</b>
II	25.5±5.1	26.4±4.1	20.0-15.5	0.9	<b>0.864*</b>
IV	51.2±5.4	52.5±4.1	10.6-7.8	1.3	<b>0.686*</b>
V	187.9±22.5	191.3±20.0	12.0-10.5	3.4	<b>0.845*</b>

\*coefficients meeting reliability criteria

**Table 4.** Correlations between the main criteria of dividing the subjects as well as psychomotor tests results of *Vienna Test System* and *Batak Lite* tests results in female (GRI, n = 24) and male (GRII, n = 32) taekwondo athletes.

Main classification criteria	Batak Lite tests							
	I		II		IV		V	
	GRI	GR II	GRI	GR II	GRI	GR II	GRI	GR II
T-C	0.103	0.302	0.391	<b>0.439*</b>	0.395	0.268	<b>0.749*</b>	<b>0.533*</b>
SM	0.053	<b>0.414*</b>	<b>0.451*</b>	0.298	0.386	<b>0.396*</b>	<b>0.606*</b>	0.339
A1	0.085	-0.198	-0.068	-0.130	0.046	-0.079	-0.188	<b>-0.534*</b>
A2	-0.173	-0.297	-0.282	-0.242	-0.397	-0.296	-0.265	<b>-0.495*</b>
B1	0.336	0.211	<b>0.447*</b>	-0.041	<b>0.467*</b>	0.118	<b>0.473*</b>	0.205
B2	0.249	0.176	0.105	0.085	0.243	0.188	0.069	0.205
B3	-0.403	<b>-0.375*</b>	<b>-0.507*</b>	-0.138	<b>-0.434*</b>	-0.306	<b>-0.617*</b>	<b>-0.359*</b>

**TC** technical and coordination levels (points); **SM** sports mastery (points); **A1** sensory reaction time (ms); **A2** motor reaction time (ms); **B1** number of correct visual and auditory stimuli; **B2** number of incorrect and omitted visual and auditory stimuli; **B3** reaction time (choice reaction, s); \* level of validity meeting the adopted criteria

subjects. This regularity was found in all four *Batak Lite* tests that had their norms developed.

## DISCUSSION

On the basis of two credibility criteria it was revealed that four *Batak Lite* tests aimed at controlling quick reaction meet the requirements of metrology and thus they can be called motor tests. Reliability coefficients of tests I, II, IV and V (ranging from 0.63 to 0.88 in females and between 0.69 and 0.84 in males) as well as validity coefficients (in most cases above 0.30) indicate that these tests meet the credibility requirements within the applied criteria [19]. It shows they are useful in diagnosing quick reaction in taekwondo competitors. According to experts who deal with an issue of psychomotor abilities, the value of 0.50 in the case of reliability and 0.30 in the case of validity should be treated as sufficient. It is

connected with considerable lability of the nervous system and its sensitivity to diverse internal stimuli (motivation) and external stimuli (e.g. weather) [22, 23].

As for the assessment of diagnostic informativeness of *Batak Lite* tests, there occurred no substantial differences of the results within the adopted criterion. Validity coefficients ranged from 0.16 to 0.54 in females and from 0.27 to 0.53 in males. Such similar results most probably stemmed from the same testing procedures and uniformity of the group regarding their speed levels, performance levels, etc.

Similar results were obtained when assessing reliability and diagnostic validity of *Batak Lite* tests in Greco-Roman wrestlers. It was also observed that in the case of tests I, II, IV and V the applied credibility criteria were met [17].

**Table 5.** *Batak Lite* tests norms (number of pressed buttons which light up) for assessing quick reaction in female taekwondo athletes aged 12-25 (based on results of 112 persons).

<i>Batak Lite</i> tests	Age category	Level of quick reaction				
		very low	low	medium	high	very high
I	12-13	<34	34-36	37-43	44-46	>46
	14-15	<42	42-44	45-51	52-54	>54
	16-18	<47	47-49	50-56	57-59	>59
	19-25	<48	48-50	51-57	58-60	>60
II	12-13	<13	13-14	15-19	20-21	>21
	14-15	<16	16-17	18-22	23-24	>24
	16-18	<19	19-20	21-25	26-27	>27
	19-25	<22	22-23	24-28	29-30	>30
IV	12-13	<35	31-33	34-40	41-43	>43
	14-15	<37	37-39	40-46	47-49	>49
	16-18	<41	41-43	44-50	51-53	>53
	19-25	<42	42-44	45-51	52-54	>54
V	12-13	<125	125-132	133-149	150-157	>157
	14-15	<139	139-146	147-163	164-171	>171
	16-18	<164	164-171	172-188	189-196	>196
	19-25	<174	174-181	182-198	199-206	>206

The testing procedure employed in the study helped to reveal that the strongest correlations occurred between *Batak Lite* tests and indices assessing choice reaction. It may serve as a recommendation for using *Batak Lite* to assess this psychomotor ability in taekwondo athletes depending on gender, age and sports levels.

Participating in sports competitions is the best method of controlling athletes' performance levels in combat sports. In martial arts, training fights are used for this purpose. However, in all cases it is the opponent who determines the quality, dynamics and intensity of the fight. It requires maximal concentration on the part of a competitor in the course of the whole fight. Perhaps that is the reason why the highest validity coefficients were observed in the case of the test that lasted two minutes (test V).

The obtained research results were used to develop norms for four *Batak Lite* tests with regard to subjects'

gender and age. The distribution of individual results of female and male taekwondo athletes turned out to be similar. The highest number of the subjects demonstrated scores within three central norms, while the remaining results were distributed equally in extreme norms. The findings are in line with the observations of other authors [21, 24] who noted that in various motor tests approximately 70% of the results ranged from  $\bar{x} - 1SD$  to  $\bar{x} + 1SD$ . About 15% of the results ranged from score  $-1SD$  to score  $-2SD$  and below (low level) and the same goes for the range from  $\bar{x}$  score  $+1SD$  to  $\bar{x}$  score  $+2SD$  and above (high level).

The comparison of individual test scores obtained by the subjects with the developed norms makes it possible to determine weaknesses regarding psychomotor preparation of an athlete and to develop individualised training programmes aimed at improving or complementing performance shortages. In the case of quick reaction, it is necessary for competitors to

**Table 6.** *Batak Lite* tests norms (number of pressed buttons which light up) for assessing quick reaction in male taekwondo athletes aged 12-25 (based on results of 180 persons).

<i>Batak Lite</i> tests	Age category	Level of quick reaction				
		very low	low	medium	high	very high
I	12-13	<36	36-38	39-45	46-48	>48
	14-15	<45	45-47	48-54	55-47	>47
	16-18	<50	50-52	53-59	60-62	>62
	19-25	<52	52-54	55-61	62-64	>64
II	12-13	<15	15-16	17-21	22-23	>23
	14-15	<18	18-19	20-24	25-26	>26
	16-18	<22	22-23	24-28	29-30	>30
	19-25	<24	24-25	26-30	31-32	>32
IV	12-13	<36	36-38	39-45	46-48	>48
	14-15	<41	41-43	44-50	51-53	>53
	16-18	<46	46-48	49-55	56-58	>58
	19-25	<47	47-49	50-56	57-59	>59
V	12-13	<130	130-138	139-157	158-166	>166
	14-15	<149	149-157	158-176	177-185	>185
	16-18	<173	173-181	182-200	201-209	>209
	19-25	<178	178-186	187-205	206-214	>214

attempt to reach high level, which may be treated as the model value at a given age.

It is worth highlighting the fact that the norms were provided for each age category taking gender into account. Numerous investigations show that there are differences in quick reaction between females and males [25-28]. Reaction time reflects motor and sensory efficiency and may serve as a risk indicator for sports injuries. Therefore, it is an essential health indicator both among professional and non-professional sportspeople [29]. Periodical assessment of simple reaction may be used for talent identification and selection [30] as well as determining individual athletes' performance compared to a group and observing their reactivity to applied training means in a non-invasive and economical way [8]. Regular evaluation motivates athletes to improve their performance

and provides them with an opportunity of self-assessment and getting to know their own value [31].

## CONCLUSIONS

Four *Batak Lite* tests (I, II, IV and V) displayed sufficient reliability and diagnostic validity, which proved their usefulness when assessing quick reaction of taekwondo athletes. The highest validity coefficients were observed in the case of the test that lasted two minutes. The strongest correlations were noted between *Batak Lite* tests and psychomotor tests of the *Vienna Test System* assessing choice reaction.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## REFERENCES

- Lyle J. *Sports Coaching Concepts: A Framework for Coaches' Behaviour*. London: Routledge; 2002
- Donovan OO, Cheung J, Catley M et al. An investigation of leg and trunk strength and reaction times of hard-style martial arts practitioners. *J Sports Sci Med* 2006; 5: 5–12
- Roschel H, Batista M, Monteiro R et al. Association between neuromuscular tests and kumite performance on the Brazilian Karate National Team. *J Sports Sci Med* 2009; 8: 20–24
- Sadowski J, Gierczuk D, Miller J et al. Success factors in elite WTF taekwondo competitors. *Arch Budo* 2012; 8(3): 141-146
- Pankhurst A, Collins D. *Talent Identification and Development: The Need for Coherence Between Research, System, and Process*. *Quest* 2013; 65: 83-97
- Harasymowicz J, Kalina RM. Training of psychomotor adaptation – a key factor in teaching self-defence. *Arch Budo* 2005; 1(1): 19-26
- Bompa TO, Haff GG. *Periodization. Theory and Methodology of Training*. Champaign, IL: Human Kinetics; 2009
- Asia AA, Warkar AB. Auditory and Visual Reaction Time in Taekwondo Players. *Int J Recent Trends in Sci Tech* 2013; 8(3): 176-177
- Saulite S, Čupriks L, Fedotova V et al. Reaction Time of Preparation for Side-kick in Taekwondo. In: *Abstracts of the 5th Baltic Sport Science Conference "Current Issues and New Ideas in Sport Science"*. Lithuania: Kaunas; 2012: 188-189
- Fisekcioglu B. Relations of Hand Preference, Muscle Power, Lung Function and Reaction Time in Right-Handed Taekwondo players. *World Appl Sci J* 2011; 12(8): 1288-1290
- Pieter W, Heijmans J. Development of a Test for Evaluating Beginning Taekwondo Students' Motor Skills. *J Asian Martial Arts* 2007; 16(2): 8-17
- Fong SM, Ng SS. Korean Martial Arts and Health – Taekwondo. In: Fong SM, editors. *Martial Arts for Health: Translating Research into Practice*. USA: OMICS Group Incorporation; 2014: 22-26
- Ervilha UF, Silva VF, Araujo RC et al. Elite female taekwon do athletes have faster reaction time and longer movement time than males during a striking kick. *Arch Budo Sci Martial Arts Extreme Sports* 2014; 10: 1-9
- Chung P, Ng G. Taekwondo training improves the neuromotor excitability and reaction of large and small muscles. *Phys Ther Sport* 2012; 13: 163-169
- Santos VG, Santos VR, Felipe LI et al. Caffeine reduces reaction time and improves performance in simulated-contest of taekwondo. *Nutrients* 2014; 6(2): 637-649
- Song KY, An JD. Premotor and motor reaction time of educable mentally retarded youths in a taekwondo program. *Percept Motor Skill* 2004; 99(2): 711-723
- Gierczuk D, Bujak Z. Reliability and accuracy of Batak Lite tests used for assessing coordination motor abilities in wrestlers. *Pol J Sport Tour* 2014; 21: 72-81
- <http://www.batak.com> (accessed April 14, 2015)
- Raczek J, Mynarski W, Ljach W. Developing and diagnosing coordination motor abilities. In: *Studies on human motor abilities*. Katowice: AWF; 2002 [in Polish]
- Gierczuk D, Ljach W. Evaluating the coordination of motor abilities in Greco-Roman wrestlers by computer testing. *Hum Movement* 2012; 13(4): 323-329
- Zaciorski WM. *Sportivnaja metrologia*. Moskwa: Fizkultura i Sport; 1982
- Meining D. Zur Bestimmung der Validität sportmotorischer Tests. *Theorie Prax Körperkultur* 1975; 1: 51-56 [in German]
- Godik M. *Sport metrology*. Moscow: Physical Education and Sport; 1988
- Witkowski Z, Ljach W. Norms for technical preparation of talented male and female football players. In: Stula A, editors. *Modern football – theory and practice*. Gorzów Wielkopolski: IWF; 2003: 99-110 [in Polish]
- Landauer AA, Armstrong S, Digwood J. Sex difference in choice reaction time. *Br J Psychol* 1980; 71: 551-555
- Bloughm PM, Slavin LK. Reaction time assessments of gender differences in visual-spatial performance. *Percept Psycho* 1987; 41(3): 276-281
- Adam JJ, Paas FG, Buekers MJ. Gender differences in choice reaction time: evidence for differential strategies. *Ergonomics* 1999; 42: 327-335
- Der G, Deary IJ. Age and sex differences in reaction time in adulthood. Results from the United Kingdom health and lifestyle survey. *Psychol Aging* 2006; 21(1): 62-73
- Nakamoto H, Mori S. Sport-specific decision-making in a Go/NoGo reaction task: difference among non-athletes and baseball and basketball players. *Percept Motor Skill* 2008; 106: 163-170
- Cojocariu A. Measurement of reaction time in Qwan Ki Do. *Biol Sport* 2011; 28(2): 139-143
- Kalina RM, Barczyński B. From "physical fitness" through "motor competence" to the "possibility of action". *Arch Budo* 2000; 4: 106-109
- Balkó Š, Borysiuk Z, Balkó I et al. The influence of different performance level of fencers on muscular coordination and reaction time during the fencing lunge. *Arch Budo* 2016; 12: 49-59
- Borysiuk Z. Time structure of information processes in selected combat sports. Warszawa: AWF; 2006 [in Polish]
- Schmidt RA, Wrisberg CA. *Motor Learning and Performance. A Situation-Based Learning Approach*. Fourth Edition. Human Kinetics; 2008
- Thomas JR, Nelson JK, Silverman SJ. *Research Methods in Physical Activity*. 5th ed. Windsor: Human Kinetics; 2005
- Bujak Z. Physical development and fitness of taekwon-do athletes. In: Kalina RM, Klukowski K, Jędrzejak K et al., editors. *Contemporary Trends of Physical Education Development in Defensive Formations*. Warszawa: PTNKF; 2000; (5): 39-46 [in Polish]
- Bujak Z. The analysis of sports results of younger juniors in taekwon-do ITF. In: Kalina RM, Jagiełło W, editors. *Educational and utilitarian aspects of combat sports*. Warszawa: AWF; 2000: 125-130 [in Polish]

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