REVIEW ARTICLE

Original methods and tools used for studies on the body balance disturbation tolerance skills of the Polish judo athletes from 1976 to 2016

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
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Abstract

Background & Study Aim: As far as judo and other combat sports are concerned, the specificity of maintaining a stable posture is related to the distortions generated by a competitor and their offensive activity as well as defensive or motor preparatory actions. Body balance disturbation tolerance skills (BBDTS) result in situations during which an athlete maintains contact with the ground with only one leg and often only part of the foot in conditions of great dynamics of action of both participants. Meanwhile, specialists recommend balance tests (related in particular to the so-called static balance) which involve maintaining the stable posture for a relatively long time. It does not matter whether a person is standing on one leg (e.g. Flamingo Balance Test). Lack of the most important factor – disturbance of balance by external forces and/or their dynamic activity. The purpose of this review is knowledge about the original evaluation methods, and results of the BBDTS exhibited by Polish judo athletes from 1976 to 2016.

Material & Methods: A major review of articles published in years 1980-2016 pertains to the results of Polish judo athletes of different ages, varied training practice and sporting achievements. The results of original methods and tools applied by Polish scientists are based on the Marching Test (preceded by the throwing a judoka off balance using Barany's chair) and the "Rotational Test". These observations are analysed in respect of the results of the recommended tests (mainly Flamingo Balance Test) related to judo athletes and reference groups (people who do not practice sports, combat sports athletes, practising other sports, firefighters, bodyguards, military cadets).

Results: The results of applied non-apparatus and quasi-apparatus tests provide the most convincing evidence that judo and other combat sports optimally stimulate BBDTS at the initial stage of sports training. Review of original studies conducted by Polish scientists on the phenomenon of BBDTS also produces a proof of the development of coaching thoughts.

Conclusions: Original studies on BBDTS with use of non-apparatus and quasi-apparatus tests carried out for the last 40 years in Poland involve the general use of the "Rotational Test" at every stage of the multi-annual training (from selection for health-related training to judo or another combat sports). The question of intercorrelation between and impact of Flamingo Balance Test, Marching Test, "Rotational Test" on posterior adaptive effects of the training and sporting achievements obtained by each selected group is an interesting matter of cognitive and application nature to be tackled.

Keywords: Flamingo Balance Test • Marching Test • non-apparatus test • quasi-apparatus test

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The authors dedicate this publication to the memory of Professor Ewaryst Jaskólski, on the 10th anniversary of his death.

Balance – *noun* **1**. the act of staying upright and in a controlled position, not stumbling or falling **2.** a state of emotional and mental stability in which somebody is calm and able to make rational decisions and judgments **3.** the proportions of substances in a mixture, e.g. in the diet [1].

Body balance disturbation tolerance skills (BBDTS) – the ability to maintain the vertical posture in circumstances of the fall hazard [6].

Definiens – *noun, plural definientia*: **1**. something that defines, especially the defining part of a dictionary entry. **2**. *logic*. an expression in terms of which another may be adequately defined.

Stages of long-term judo training – in Poland a three-stage system of long-term judo training has been adopted: a comprehensive training stage (14-15 years old), a directed training stage (16-18 years old), and a special training stage (since 19 years old) [10, 12].

Position – *noun* **1**. the place where a player is standing or playing **2.** the way in which a person's body is arranged [1].

A positive/negative position (in agonology) –"An acting subject places itself in a positive position towards an action's aim if it does not need to strain in realization of this aim (...) in a negative position (...) in it must strain in achieving it because an automatic course of events without its interference is tending to a discordant to intended state of matter" [5, p. 131].

Posture *noun* the position in which a body is arranged, or the way a person usually holds his or her body when standing [1].

Postural sway – *noun* changes in the exact weight distribution of a person, caused by muscle contractions involved in maintaining proper posture [1].

Postural – *adjective* relating to posture [1].

Non-apparatus test – that motoric test (exercise endurance test) of the required reliability (accurate and reliable), which use does not require even the simplest instruments [69].

INTRODUCTION

"Balance" is an ambiguous term which is also used in sports science (see glossary). Authors of scientific papers devoted to the phenomenon of body balance using various definitions. Their sense remains similar. Their main point is to emphasise that it is the act of staying upright and in a controlled position (posture!) – instead of stumbling or falling [1]. Furthermore – sports science and broadly understood motor control and performance [2] have adopted a simplified division (which is often criticised) into "static balance" and "dynamic balance". The word "control" is used as the *definition* of "balance", which does not only refer to "body balance" in either static or dynamic sense. A state of balance in the broad sense always refers to the cumulative effect of factors which control this phenomenon.

It is controversial to use interchangeable words "position" and "posture" while defining or interpreting the phenomenon of body balance. Moreover, the term "position" in sport and agonology (science about struggle which explores all varieties of fighting [3, 4]) refers to the place in which a player is standing or playing, the way in which a person's body is arranged in space [1], and also determines the relationship of competitors (athletes or teams) with an actual outcome of the struggle [5].

In judo and other combat sports, the specificity of maintaining a stable posture is related to the distortions generated by a competitor and their offensive activity as well as defensive or motor preparatory actions. In the general distinction of circumstances posing fall hazard (developed by Kalina et al. [6] and based on three criteria), judo fight may be classified to the CFR 3 category, as it "involves cumulative effects of any external force(s) and internal factors concerning a person performing an action" [6, p. 60]. This is the broadest group of circumstances. However, we are leaving aside a "b" sub-group variant, which includes also throwing a competitor off balance caused by their fall. This is a group of *sutemi waza* throws, which may be divided into two subgroups, namely *ma-sutemi* and *yoko-ukemi* (nota bene *suples* in wrestling is equivalent to one throwing from *ma-sutemi* subgroup).

The phenomenon of maintaining own body balance and throwing an opponent off balance during a judo fight (in sport or self-defence) is complex in a cognitive sense (investigation and interpretation) and a sense related to its application (teaching and training optimisation). Body balance disturbation tolerance skills (BBDTS) result in situations during which an athlete maintains contact with the ground with only one leg and often only part of the foot in conditions of great dynamics of action of both participants in a struggle. Meanwhile, specialists recommend balance tests (related in particular to the so-called static balance) which involve maintaining the stable posture for a relatively long time. It does not matter whether a person is standing on one leg (e.g. Flamingo Balance Test). Lack of the most important factor – disturbance of balance by external forces and/or their dynamic activity.

Fifty years ago, Drowatzky and Zuccato [7] correlated the results of six attempts during which participants were to keep their balance (three static ones: *stork stand*, *diver's stand*, *stick stand* and three dynamic ones: *sideward stand*, *bass stand*, *balance stand*). The highest correlation coefficient amounted to 0.31. Perhaps this methodological dilemma is the main reason that scientists studying motor abilities of judo athletes and candidates (choice and selection problem) base their observations made during longitudinal studies on measurements of endurance, speed [8] and strength [9]. Władysław Jagiełło [10] (whose observations were based on an article written by Kaplin [11]) lists the following indicators among standards of physical performance during sport-specific preparation: endurance, speed-strength, agility, flexibility (including weight category). These indicators are the basis of his monograph devoted to theoretical and methodical foundations of the system of long-term physical training of young judokas [12].

Waldemar Sikorski was a coach of national Polish judo team in years 1967-1980 and the head of the judo research team at the Institute of Sport in the subsequent 10 years. Sikorski has been synthesising a centralised judo research in Poland since 1967 to be used in studies of this Olympic sport [13]. He confirms that this judo scientific team based their assessment of general fitness on indicators, such as endurance, speed-strength, agility and flexibility.

Ewaryst Jaskólski [14, 15] was a first scientist in Poland who pointed out that external factors of balance disturbance should be included in the measurement of body balance of judo athletes. After 1978, he was appointed as a coordinator of studies on body balance and reaction of judo athletes who were forced to lean out in a laboratory setting [13]. In his studies (already in 1976 [16]), he used methods and tools original from the perspective of these times, which may form two categories: apparatus tests (stabilogram from a disturbance device) and quasi-apparatus tests (*Marching Test*). Furthermore, he combined these categories – *Marching Test* preceded a disturbance of balance with the use of Barany's swivel chair. This was the time of martial law in Poland, and therefore the results of these observations were mainly published in master theses developed under the direction of Jaskólski and in reports intended for central sports authorities.

Inspired by views of this mentor (he was the first PhD student of Jaskólski), Roman M. Kalina developed a "Rotational Test" (RT), which primarily did not involve any apparatus (non-apparatus). The first paper was published in 2001 [17]. Afterwards, in the next several years he established a comprehensive validation procedure (the sixth stage [6]) as part of research projects and theses devoted to sports science (bachelor, master, PhD and habilitation theses).

"Rotational Test" in quasi-apparatus version has two significant advantages while using both in sport-related evaluations and any other assessment of human activities in the course of which BBDTS remains one of the most primary motor abilities, as well as in rehabilitation and therapy. RT results provide data not only about the nature of errors made (evaluated using scores) by a studied individual but also about how long it took to perform all six tasks. The estimated results of the RT quasi-apparatus version of women aged 21 (n = 100) who declared to be occasionally active are as follows: average 14.24 seconds; ±2.41 s; minimum 10.4 s; maximum 22.69 s [6].

Among persons who perform RT without errors in a motor sense, time remains an indication of the actual efficiency of neuroanatomical or neurophysiological mechanisms responsible for the quality of BBDTS. If the errors committed during RT by given individual are of similar nature in a longer period (observations confirm that such status sometimes persists for many months), time indicator becomes a primary source of information about the effects of training or therapy. If an individual decreases duration of RT (sometimes even by few seconds) and this does not result in new errors, it may be assumed that such person improves their motor safety [18]. If body balance is disturbed several times (this is typical during judo fight in vertical position), the shortened time needed to regain balance increases the likelihood of coping with another stimulus. If an error were equal to a fall or collision, the shorter motor response would not be so fundamental. It is crucial to learn safe falling techniques (this is an elementary part of preliminary judo education – *ukemi waza*), how to collide safely with vertical obstacles (offered by innovative agonology [19]) and how to avoid collision (during particular judo exercises *tai sabaki* and unique exercises, motor simulations and fun forms of martial arts in innovative agonology [19, 20]).

The purpose of this review is knowledge about the original evaluation methods, and results of the BBDTS exhibited by Polish judo athletes from 1976 to 2016.

MATERIAL AND METHODS

A major review of the published work from 1976 to 2016 concerns the results of Polish judo athletes of different ages, differentiated training practice and sporting achievements. The results of original methods and tools of Polish scientists are based on *Marching Test* (preceded by the disequilibrium in Barany's chair) and 'Rotational Test'. We are selected 10 works (according to the aim of this review) of which only one is available in the global science space. Other original methods and tools described (along with the general description) in the section "discussion".

Marching Test

A truss consists of five three-metre beams (10-cm high) permanently connected with each other, arranged parallel to each other, each 15 cm away from the other. Beams have various width: first one (the widest) is 9 cm wide, second 7 cm, third 5 cm, fourth 3 cm, fifth (the last one) 1 cm. Markings are placed on the beams every 20-cm. There are 14 markings on each beam, i.e. a beam consists of 15 (20-cm) sections, and each is an equivalent

Quasi-apparatus test – can be conducted with simple instruments (a stopwatch, a ruler, a measuring tape, etc.) [69].

Motor safety – is consciousness of the person undertaking to solve a motor task or consciousness the subject who has the right to encourage and even enforce from this person that would perform the motor activity, who is able to do it without the risk of the loss of life, injuries or other adverse health effects [18].

Sutemi-waza – sacrifice techniques.

Ma-sutemi – forward sacrifice projections.

Yoko-sutemi – side sacrifice projections.

Suples – specific throw in wrestling, when the attacker first down on his back.

Abilities (motor abilities) – stable, enduring traits that, for the most part, are genetically determined and that underlie a person's skill in a variety of tasks. People differ with respect to their patterns of strong and weak abilities, resulting in differences in their levels of skill [2].

Skill – the underlying potential for performance in a given task, which changes with practice experience, and a host of situational and environmental factors [2].

Ukemi – the term for break falls designed to process the body when thrown [70].

Ukemi waza – safe fall technique.

Sabaku – to move to an advantageous position. Also called ***tai-sabaki*** (body movement) and ***ashi-sabaki*** (footwork) [70].

Tai-sabaki – body movement [70].

Harai-goshi – sweeping hip throw.

Tori/uke – the person who applies a technique in jūdō training. The receiver of the technique is referred to as uke [70].

Global science space – conventionally, the global science space is associated with the ability to provide the latest scientific knowledge through prestigious electronic scientific journals [34].

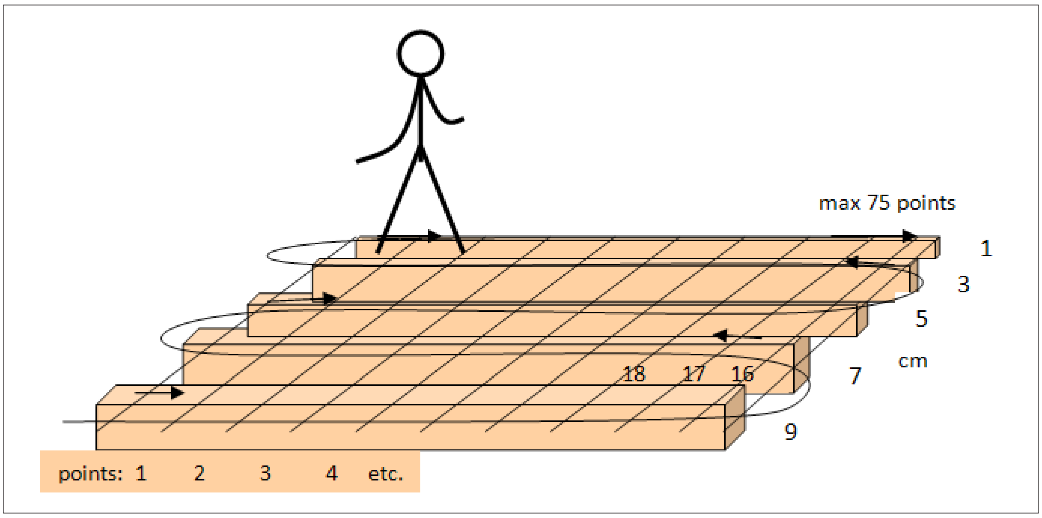

Figure 1. Model of the quasi-apparatus test – *Marching Test*.

Figure 2. A wooden version of the truss used during the *Marching Test.*

Figure 3. The Barany's swivel chair with an electric motor that serves to put the chair in a rotary motion.

of 1 test point. The task of examined person is to march over a truss from point '0' putting one foot before another (Figure 1). Thus, maximal test result amounts to 75 points. If a tested person walks through less than 75 (each 20-cm) sections (loses balance and leans one foot on the ground), the result is equal to some points as the equivalent of the sum of walked 20-cm sections [21].

The truss version used by Jaskólski and his colleagues is made of wood (Figure 2). The prototype was made of wood and sheet metal [22, 23].

Marching Test (preceded disturbance of balance with the using Barany's swivel chair)

The tested person was told to sit at ease, place their arms and feet on the appropriate rests and keep their head up-right. Next, the chair (Figure 3) was rotated counter-clockwise. The number of turns was called aloud, and after 10 turns (18 seconds) the press-button was released, and the judo athlete was told to stop the chair. The judoist now left the chair and repeated the *Marching Test* [24].

Figure 4. Rotational Test observation post [6].

'Rotational Test'

Details of procedure (also if this is the first performance of the 'Rotational Test'(RT) see in [6]. The movie is available at the website of this journal in the left menu (section: ArchBudo Academy) under link Rotational Test (http://www.archbudo.com/text.php?ids=351). Each set of 'jump-landing-posture correction' should last about two seconds and the principal investigator of research starts a stopwatch while pronouncing "r" during the first command, i.e. 'right' and stops it during the pronunciation of "t" in the last command, i.e. "left". The main test consists of 6 tasks, starting with the jump with a 360° rotation to the right.

Evaluation method: An assistant provides documentation for motor effects of the test: landing after the jump on the designated line with both feet and maintaining balance means the lack of the mistake (the result is recorded as "0"), no contact of one foot with the line after landing is assessed as "1" (first degree mistake), "2" means the lack of contact with the line after landing or not maintaining this contact while correcting the posture (second degree mistake), **"3"** records leaning against the ground with a hand/hands or a fall (third degree mistake).

Test execution time – the optimal result is obtained after ca. twelve seconds. It is a complementary information (documented with an accuracy up to 0.01 second). The examined person should not be pressed to perform the test as fast as possible. In fact, the attention should be paid to the accurate performance of individual tasks, simultaneously respecting the commands, adaptation to the rhythm of jumps with rotations of a given person and necessary corrections.

The principal investigator of research should remain in a distance of ca. 2 meters in front of the examined person (if necessary the principal investigator can additionally indicate the direction of the jump with rotation). An assistant stands at the side of the principal investigator of research so that he can observe the feet of examined person (Figure 4). While gathering observations an assistant cannot look at the document (after completion of the test, the results can be rewritten from the working paper to the research card). An examined person should be provided with comfort. The place where the test is performed should be free of any movement of other people or objects (i.e. fan, flash). Any noise or talks are unacceptable.

Non-apparatus version of the test can be conducted by one person, who is simultaneously giving commands and documenting the motor effects. Each subsequent RT implementation does not require the initial assessment (two initial jumps with rotation – first to the right, second to the left).

Evaluation criteria for both versions of the test (quasi-apparatus and non-apparatus). The overall result is the sum of the six tasks (consecutive jumps with body rotation) and includes 0 to 18 stipulated points. **"0"** indicates a very high ability to tolerate imbalances, while **"18"** means the exact opposite of that assessment. Corrected (in relation to the pilot version [17, 25]) criteria of an individual level assessment determined by the 'Rotational Test' (RT) are as follows: very high (0-1), high (2-3), average (4-9), low (10-12), very low (13-15), insufficient (16-18) [6].

RESULTS

Results of studies conducted both by Paszkiewicz [26] and Witkowskiego et al. [24] provide the broadest information on two factors which modify BBDTS (Table 1). Rotations on the Barany's chair in laboratory setting constitute the first factor. Impact of training is the second factor. Rotations on the Barany's chair are a particularly strong stimulus for teenagers aged 12-13 who have been training judo for only a few months. Individual results of *Marching Test* after rotations on the Barany's chair are highly differentiated (1-75 points, whereas the oldest teenagers with longest experience obtained 7-75 points). The youngest judokas are an exception – they obtained 1-8 points in an experiment carried out by Paszkiewicz [26] and 1-10 points in the one conducted by Witkowski et al. [24]. Observations made by Wojsa [27] – limited to the results of *Marching Test* after rotations on the Barany's chair obtained by children/teenagers before they started to train judo and after 3 months of training – confirm that participants insignificantly adapted in a short time but also that the group consisted of units with extraordinary BBDTS-related skills (they obtained 56 points before training and 60 points after 3-month training).

Impact of long-term training may be observed with weaker stimulus interfering with body balance (decreasing support area during the *Marching Test* [21. 24, 26, 28-30]). It is proven by an average result of 73.4 points obtained by judo athletes who have been training judo for 8-14 years, with results ranging from 63 to 75 points [24]. At the same time, a proof of two phenomena becomes clear. The first one involves strength of an external stimulus interfering with body balance, such as rotations on the Barany's chair, which decreases the test result to 1 point. The second one is related to the fact that judo training enhances neuroanatomical or neurophysiological mechanisms responsible for the quality of BBDTS. The result of 75 points indicates that even if both external stimuli occur at the same time (i.e. rotations and decreasing support area while marching), this does not prevent participants from performing the *Marching Test* in a correct manner (Table 1).

The results of "Rotational Test" [31-33] provide empirical evidence that efficiency of neuroanatomical or neurophysiological mechanisms responsible for the quality of BBDTS caused by an internal stimulus (rotations of the body generated by judo athletes) is being enhanced along with extending training experience (Table 2). On the other hand, unique studies conducted by Krakowski [33] provide clear evidence that refraining from judo training at the pre-training stage is a counterproductive activity not only about motor safety.

DISCUSSION

This review is linked to three important issues. Firstly, it provides empirical evidence that political obstacles (*the Iron Curtain*) and consequently limited access to most state-of-art knowledge and technology do not hinder the development of free and independent science. Furthermore, it also shows that substantive solutions and simple research tools (non-apparatus and quasi-apparatus tests) used in such circumstances are still inspiring. Secondly, it reveals that the Internet (electronic journals) and systematic evaluation of scientific achievements (selection of scientific journals according to qualitative criteria) allow nowadays for the dissemination of such scientific achievements (of scientists beyond the *Iron Curtain*) in global science [34]. Effectively breaking the barriers of distrust and primarily overcoming access to unique scientific knowledge being blocked, regardless of when and at which side of the *Iron Curtain* it was created – a vision of Barczyński et al. [35] is being fulfilled. Thirdly, it is worth emphasising cognitive and application value of non-apparatus and quasi-apparatus tests used to study BBDTS not only for judo-related purposes.

Ewaryst Jaskólski was one of the pioneers in overcoming the paradigm that balance had been divided into static and dynamic one. He

Table 1. Results of *Marching Test* (points) different of the groups of Polish judo athletes (the ordinal variable is the year of publication).

Year Author(s) [references]	Gender	Age [years] min-max	Somatic indicators		N	Judo practice [years] min-max	Basic version				Preceded disturbance of balance with the using swivel chair			
			height [cm]	weight [kg]			M	SD	Min	Max	M	SD	Min	Max
1978 Jagielski [28]	male	**22.74**	**174.89**	**73.37**		judo students **3.37**	**64.21**	9.45						
		17.35	**168.9**	**64.85**		junior **1.45**	**59.5**	7.76						
1982 Paszkiewicz [26]	male	**18.05** 17.5-19	**179,66** 173-185	**78,44** 61-117	9	junior **2.96** 0.33-6	**60.63**	12.27	48	75	**29.66**	30.47	1	75
		16.57 15.5-17	**172.14** 160-187	**61.42** 52-75	14	junior little **1.64** 0.33-6	**54.92**	16.27	17	75	**16.35**	21.71	1	75
		14.30 13.5-15	**163.13** 145-177	**51.10** 38-68	30	colt **1.39** 0.33-3	**60.63**	8.89	45	75	**9.96**	20.29	1	75
		12.38 12-13	**151.44** 142-161	**43.66** 31-66	9	children **0.56** 0.08-2	**49.44**	14.9	32	71	**2.77**	2.09	1	8
1987 Witkowski et al. [24]	male	**24.95** 18-24	**178.55** 162-192	**79.15** 62-98	20	**11.55** 8-14	**73.4**		63	75	**56.2**		7	75
		17.85 14-21	**177.20** 165-192	**73.55** 57-115	20	**4.13** 3-7	**66.1**		41	75	**35.9**		1	75
		14.00 13-15	**169.68** 152-183	**59.25** 42-85	40	**1.74** 1.5-2.5	**57.0**		34	75	**14.5**		1	75
		13.81 12-16	**163.63** 148-178	**52.96** 37-74	40	**0.53** 0.5-0.66	**55.5**		38	75	**5.4**		1	10
1987 Wojsa [27]	boys (n =23) girls (n = 4)	11.3 10-12	**150.2** 130-160	**43.6** 27.5-78	27	before judo training					**9.78**	10.17	2	56
						after 3 months					**14.0**	10.89	2	60
2004 Witkowski et al. [29]	boys	13-15			23		**50.74**	14.21						
		10-12			32		**52.22**	13.55						
		7-9			25		**39.12**	11.12						
2014 Witkowski et al. [21]	boys	14-15			26	less than 2	**57.07**	9.81	42	75				
2016 Maśliński et al. [30]	boys	**24.92** 20-42	**176.8** 162-198	**83.75** 64-118	28	senior **13.28** 6-29	**69.1**	9.35	40	75				
		18.04 17-19	**180.04** 165-192	**84.37** 60-141	24	junior **7.85** 0.5-13	**63.83**	11.75	34	75				
		15.35 15-16	**173.4** 154-190	65.8 45-92	32	junior little **4.65** 0.5-11	**53.64**	13.56	19	75				

Table 2. Results of 'Rotating Test' (points) non-apparatus version different of the groups of Polish judo athletes (the ordinal variable is the year of publication).

Year Author(s) [references]	Gender	Age [years] min-max	Somatic indicators height [cm]	Somatic indicators weight [kg]	N	Judo practice [years] min-max	Points M	Points SD	Points Min	Points Max
2002 Cegiełko [31]	male	21.5 19-24	**176.3** 168-182	**79.15** 60-95	18	**8.4** 4-14	**3.4**	1.4	0	12
2003 Bajda [32]	male	**21.5** 18-25			16	**12.19** 10-15	**2.69**	2.36	0	7
		20.86 19-24			7	**7** 5-9	**5.43**	3.6	0	10
		16.83 16-18			12	**5.17** 3-9	**3.17**	2.86	0	9
		12.5 11-14			6	**3.5** 3-5	**5**	3.35	1	10
	female	**19.44** 16-23			9	**7.4** 3-12	**2**	2.5	0	7
2004 Krakowski [33]	boys	**9.24** 6-11	**138.57** 119-161	31.25 22-53	21	before judo training	**7.3**	4.6	1	16
						after 3 months judo training	**5.48**	3.7	0	11
	boys who have dropped out of training	**8.94** 8-12	132.38 120-144	**35.24** 20-48	16	before judo training	**11.06**	4.25	2	18
	girls	**9.8** 8-12	**136.7** 127-157	**33.6** 24-49	13	before judo training	**5.8**	3	0	10
						after 3 months judo training	**4**	3.14	0	10
	girls who have dropped out of training	**9.13** 8-11	**132.38** 122-151	**32.125** 24-40	8	before judo training	**9.25**	2.38	6	14

introduced a term "rotational balance" and measured there three types of balance in an original manner. Under his supervision, Gancarek [36] studied judo athletes aged 16-19 (study group consisted of 35 persons and control group consisted of 35 persons, who did not practice judo). Measurement of static balance consisted in assuming a balanced posture on an 80x10x3 cm board after being thrown off balance (3 rotations around a vertical axis on a circular wooden board of 50 cm in diameter and 3 cm in height). While trying to maintain the static balance, arms and trunk could keep any position relative to the ground. The time from a signal to "start" (after rotations were finished) to maintaining balance, i.e. no movement at all, was a criterion used to measure the effectiveness of static balance in such laboratory setting. Dynamic balance was measured by a quality of straight march on a special lane after the previous shuttle run at a distance of 24 m with six forward rolls. The lane was 900 cm long, 10 cm wide and had 3 transition zones of 300 cm each (the authors does not discuss how it is constructed). March time was measured from the moment a foot was placed on the starting line until the finishing line was crossed. First attempt was performed without being thrown off balance and the second one – after being thrown off balance. Placing 1/3 of foot beyond the right of the left border of the lane was considered as a deviation to the side. Duration of the march along the line and some deviations to the right and/or left constituted the assessment criteria. Measurement of **rotational balance** consisted in maintaining balance on circular board of 50 cm in diameter and 3 cm in height while rotating (after hearing to "start") on one's own with a maximum rotation speed around vertical body axis until finding oneself beyond the circle. Time and number of rotations were measured.

Both results of Gancarek [16] and the ones presented in Tables 1 and 2 provide empirical evidence that judo athletes have more effective BBDTS. The tools applied (and this means that some tests are less demanding than others) equally confirm that judo is a great form of physical activity that stimulates the neurophysiological mechanisms responsible for BBDTS quality.

The same conclusion was drawn by analysis of studies carried out by Goloka [36] who used modified Barany's swivel chair (Figure 3). The three-phase motor propelled a set consisting of worm gears which allowed direction of rotation of the chair to be changed. Such manoeuvre is possible by changing the phases in the chair's distributor box (the switch installed in it allows for starting or stopping a rotational trial in a fast manner, without encumbering movements). During marching trial, Golonka used a gymnastics bench (placed at a distance of 0.5 m from the radius circled from the chair). After 30 second rotational trial, studied person was marching on the gymnastics bench as quickly as possible after hearing to "start". When a person lost balance and got down from the bench before given attempt ended, he or she was supposed to get on the bench at the same place and continue marching. Afterwards, a judo athlete studied performed two *harai-goshi* throws (two competitors standing next to each other: *uke*). The total time of both tasks was measured. Time was stopped when the second throw was completed. Control group did not perform any throws (task 2). The first experimental group consisted of 18 top-level Polish judo athletes from AZS AWF Wrocław and Gwardia Wrocław, aged 19-25. The second experimental group consisted of 21 junior judokas from AZS AWF Wrocław (aged 14-16). Twenty-three students of physical education (aged 19-22) formed the control group. They trained other sports disciplines than judo. Judo athletes performed marching trial faster than students in the control group. Goloka did not find significant differences in the BBDTS measured among judo athletes aged 15-25.

Doctoral thesis of Jarosław Nazarewicz [37] was an important scientific event in that time. He studied judo athletes and used a stabilograph with a disturbance device (so definitely more complex device compared to quasi-apparatus tests applied by Jaskólski's team). While characterising biomechanical properties of body stability and the phenomenon of body posture correction after external disturbances towards body stability, Nazarewicz used the following indicators: the amplitude of instability, frequency and dynamics of instability and time needed to stabilise posture after disturbance. He found out that greater amplitude and speed of instabilities are typical of judo athletes with higher sports mastery and longer experience. The frequency of instability was comparable among judo athletes, whereas time needed to achieve body stability after imbalance was shorter in athletes with higher sports mastery and longer experience.

Results obtained using a more complex device measuring the reaction of judo athletes on BBDTS (compared to control groups) confirm general pattern which can be determined using non-apparatus and quasi-apparatus tests. The biomechanical analysis reveals more detailed indicators. Thus, it allows for a more in-depth analysis of the nature of these phenomena. This apparently obvious conclusion is also confirmed by results obtained during studies on other adaptive effects of long-term judo training from the perspective of broadly understood motor safety: fall to the side [38], collision with a vertical obstacle [39], avoiding collision [40, 41]. Effects on motor performance (expressed in points) observed during *the susceptibility test of the body injuries during the fall* [42] and *tested for safe falls* [43] do not differ much among judo athletes, one of whom is 41 years older than the other. They perform non-apparatus tests at an excellent level. Only biomechanical characteristics reveal higher adaptive effects of the older one (which cannot be identified with a naked eye). This data is not relevant for judo coaches oriented at sports success (and this trend prevail in scientific articles devoted to judo [19, 44]). Nevertheless, they are important for experts in health-related training [45] and for all other persons who are interested in their own or patients (clients) motor safety during fall and collision [46-50].

The categories of non-apparatus and quasi-apparatus tests do not imply that they may be easily performed outside of laboratory setting. The "Rotational Test" is the only exception. This fact is confirmed by studies carried out in a real-life setting involving regular activities performed (e.g. survival training [51-54]) or permanent training of fire-fighters [55], soldiers [25, 56] body quarts [57, 58], along with self-defence or health-relation training [59, 60]. RT results are combined with observations of specific motoric simulations and do not necessarily have to be highly correlated with simple statistical tests. Synthetical interpretation of the results obtained is definitely of more importance. Results of such a synthesis of fire-fighters [55] are a good example. There is no statistically significant correlation of RT results with. Leaders with special predispositions to participate in rescue operations requiring a high level of tolerance for imbalances, however, stand out from the other fire-fighters with high ranking positions in both categories: motoric test (RT) and specific motoric simulation.

Unfortunately, results obtained during studies on judo athletes presented in Table 2 [31-33] are based on the non-apparatus version of the "Rotational Test". The advantage of using this version is that one person can easily document the results of such observations, giving commands at the same time. However, on the other hand, there is no significant information on about the time function of the investigated phenomenon (time differences may be of elemental significance with identical RT result expressed in points). The advantages of other tests in a non-apparatus version during recreational judo training (for health-related purposes) were confirmed in Mosler's experiment [61, 62]. It provides important evidence that non-apparatus tests may constitute a significant element in the intellectualization of training. However, this is a separate concept strongly related to the future use of the potential of judo in prophylactic and therapy agonology [19] and in other areas linked to rehabilitation, in which conventional methods are not effective [63-66]. Important scientific and metric evidence indicates the intellectual potential of Polish experts in the science of martial arts (experts in judo are the leaders) [67, 68].

CONCLUSIONS

Lasting over 40 years in Poland original research of BBDTS with use of non-apparatus and quasi-apparatus tests show the general use of the 'Rotational Test' at every stage of the multi-annual training (from selection for health-relation training basic on judo or another combat sports). Question about intercorrelation of Flamingo Balance Test, Marching Test, 'Rotational Test' on the stage of selection with posterior adaptive effects of the training and sporting achievements is an interesting to challenge of the cognitive and application nature.

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