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Static and dynamic balance in 14-15 year old boys training judo and in their non-active peers

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Abstract

Background & Study Aim: Maintaining vertical posture and throwing a competitor off balance during a judo fight is a fundamental mechanism in this sport. Maintaining vertical posture in numerous circumstances when other motor activities occur is, however, an essential element of injury prevention due to a fall. The aim of the experiment is to confirm the following hypotheses: (1) young male judokas possess better dynamic and static balance when compared to their non-active peers; (2) there is a lower asymmetry of static balance among young male judokas than among their non-active peers; (3) despite the choice of tests in accordance with the assumptions adopted in this paper, correlation of the results of dynamic balance test and static balance test is at most low, whereas physical activity index or its lack does not have differentiating meaning.

Material & Methods: The experiment involved 51 boys aged 14-15 years, including 26 training judo for at least 2 years; 25 not practicing any sport ('non-active'). Two quasi-apparatus tests have been used in the study. Dynamic balance was measured by means of Marching Test, whereas static balance by means of Flamingo Test in modified version.

Results: Boys who train judo possess higher level of dynamic balance than non-active ones (different results of Marching Test $p<0.01$). All results obtained in the tests are positively correlated with each other ($p<0.01$) in 'judo' group. On the other hand, there are no significant correlations of results in 'non-active' group.

Conclusions: Providing important empirical data on the relationship between the ability to effectively solve motor tasks and sense of dynamic and static balance is an essential cognitive value of the study. Positive correlations of those indices occur when a person is subjected to frequent, intensive stimuli acting on both manifestations of body balance. Application aspect extends the usefulness of study results beyond the field of sport. Increase especially in human dynamic balance ability by means of judo training translates directly into their motor safety during daily physical activities and consequently into health safety.

Key words: motor safety • postural control • Flamingo Test • Marching Test • vertical posture • quasi-apparatus tests

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Introduction

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 [9]

Posture – *noun* the position in which a body is arranged, or the way a person usually holds his or her body when standing [34]

Skill – The underlying potential for performance in a given task, which changes with practice experience, and a host of situational and environmental factors [9]

Sports technique – a method of performing a motor task specified in the rules of a given sports discipline that depends on particular athletes' somatic, motor and psychic properties [32]

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 [30]

Quasi-apparatus test – can be conducted with simple instruments (a stopwatch, a ruler, a measuring tape, etc.) [30]

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 [31]

Sutemi (jap.) – the state of sacrificing one's all in a match, or executing a technique without thinking about the outcome [33]

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

The views of scientists about mechanisms governing body balance maintenance are generally consistent. It is assumed that basis is mainly constituted by data obtained by tactile, kinaesthetic, optical and vestibular analyzers [1-6]. The division into static and dynamic balance is widespread albeit controversial. Static balance is associated with maintaining body posture (the example of vertical posture is usually provided in this context), whereas dynamic balance with maintaining or regaining this state during motor activity (in one direction or around body axis) or after its completion [7-9]. Fetz [4] distinguishes also stable, neutral and unstable balance as one of the components of the above-mentioned divisions.

The results of the tests measuring either static or dynamic balance are not mutually highly correlated (well-known experiment conducted by Drowatzky and Zuccato [10]). Therefore, it seems that supporters of this division have a forceful argument: lack of correlation contradicts the hypothesis that one common mechanism is fundamental for maintaining body balance in various circumstances of motor activity (locomotor activities, postural activities, manipulating activities combined either with locomotor activities or postural activities) [11].

Golema [12] while studying the control of human balance concluded that it is a dynamic process which is performed involuntarily. In further experiments he measured free forward or backward inclinations of a body, determined dislocation of various body parts during a push (disturbance), recorded forces observed during non-central collision, compared free inclinations of a body to the model of a rod leaned against the arch of a circle, registered dislocation of an application point of ground reactive force. Studies conducted by Golema allowed to adopt appropriate simplifications to formulate mathematical model of balance regulation process by a human. Such research plays a very substantial cognitive role, especially as for exploring the nature of human balance regulation process.

On the basis of previous research it has been established that the highest level of static balance falls on 16-17 years of age both in girls and boys, whereas the highest dynamic balance occurs in 16-year-old boys and 17-year old girls [7]. The general trend is relatively fast development of abilities to maintain balance in girls under 13 and in boys under 14 years old. This ability, as well as many others, may be significantly stimulated mainly by appropriate sports training, preparations to become a circus artist, dancer, etc. [11].

Researchers studying human motoricity and judo practitioners are aware of the fact that ability to maintain body balance during tournament fight (or training fight – *randori*) is one of the most important traits (motor abilities). Apart from the possibility to obtain penalty points during a tournament fight or even disqualification, maintaining stable body posture is a basic prerequisite to gain an advantage over a competitor due to one's defensive or offensive actions. Thus, the issue of body posture stability of judo athletes (as well as wrestlers, sumo athletes, etc.) is not identical with body stability of a marksman, archer, weightlifter, gymnast, rower, etc. in the sense of the need to fulfil biomechanical and neurophysiologic conditions of specific adaptation. The perspective is set by expected optimal effectiveness of controlling own body in a given sports activity. In wrestling combat sports there is another significant factor, namely control over own body is hindered by a competitor (causing fall of a competitor while simultaneously maintaining own balance is a main task).

Sport differs from most forms of daily physical activity in the fact that specific motor activities (sports technique) are repeated in week microcycles during several or more training sessions. In case of combat sports there is a high intensity of exercises repeated in numerous series separated by rest. In sport shooting, however, frequent muscle contractions (characteristic not only for combat sports) occurring while shooting from standing posture are reduced to certain manipulation at the expense of maintaining stable vertical posture. This disproportion of the types of muscle work is lower in archery. Awareness of these regularity entails elementary question whether recommended tests can be used without reservations to assess human body balance regardless of the specificity of their daily motor activity.

During studies on individual people one of the most significant methodological dilemma is a choice of appropriate test measuring specifics of motor activity, which is believed to have stimulating effect, in this case, on development or maintaining expected level of body balance. However, as important dilemma is quite obviously lack of certainty whether adopted theoretical foundations are true. This is enhanced by competitive concepts of defining and interpreting body balance phenomenon in relation to environment, in which given person may potentially act (or in fact very often acts and therefore is subjected to defined specific stimuli).

Kalina's et al. [11] concept of body balance disturbance tolerance skills (BBDTS) constitutes an excellent example of reaching beyond the paradigm of defining and measuring human body balance. Kalina et al. defined BBDTS as the ability to maintain the vertical posture in the circumstances of the fall hazard [11]. BBDTS is measured by means of 'Rotational Test' either in non-apparatus or quasi-apparatus version. According to division of circumstances posing threat of a fall into three categories adopted by Kalina et al., judo is categorized to CFR 3 (b): "includes the cumulative effects of any external force(s) and internal factors concerning a person performing an action… (b) intentional action to cause a fall of another person or the need to maintain vertical posture for a specified time or in a fixed point of action (e.g. a sumo bout), or by preceding this situation by own fall (it is possible to end judo fight by throwing somebody from the group of *sutemi-waza* or *suples* in wrestling, self-defence as well as saving a person from a collision with some object in motion)" [11, p. 60].

Our research stems from basic assumption that for scientific cognition of phenomena concerning human motoricity as well as for perspective to develop research methodology, associating results of various recommended tests with this category of motor phenomena for which there are justified ground that they are subjected to modifying environmental (training) impact will invariably be the current problem. Maintaining especially methodological perspective, we adopted as in a sense standard factor correlating the results of body balance tests (quasi-apparatus), which measure, according to the experts, two different types of this phenomenon, namely dynamic and static balance. Scientific curiosity is intensified by using *Marching Test* (which is quasi-apparatus test) developed by Ewaryst Jaskólski [13] to measure dynamic balance, which was not common in previous studies. However, the last mentioned aspect is not crucial. While measuring dynamic balance and static balance of people training judo, we attempt to use tests which satisfy the assumption based on three criteria. First of all, a test should differentiate motor activities in the course of testing. Secondly, they must have at least one significant common or very similar element. Thirdly, motor activities in the course of testing reflect to some extent the most general conditions that must be fulfilled by a judoka to maintain stable vertical posture without losing the possibility to effectively influence a competitor in order to throw him off balance. Broader justification of this assumption (especially of third criterion) is provided in the section devoted to description of methods used.

The aim of the experiment is to confirm the following hypotheses: (1) young male judokas possess better dynamic and static balance when compared to their non-active peers (excluding the activity related to physical education classes); (2) there is a lower asymmetry of static balance among young male judokas than among their non-active peers; (3) despite the choice of tests in accordance with the assumptions adopted in this paper, correlation of the results of dynamic balance test and static balance test is at most low, whereas physical activity index or its lack does not have differentiating meaning. The study was approved by the Local Ethics Committee.

Material and Methods

Participants

The experiment involved 51 boys aged 14-15 years, including 26 training judo for at least 2 years; 25 not practicing any sport (excluding the activity related to physical education classes) – 'non-active' control group. All were pupils in Junior High School in Rybnik (large town in southern Poland).

Procedures

Two quasi-apparatus tests have been used. Dynamic balance was measured by means of *Marching Test* (walking on the truss) developed by Ewaryst Jaskólski [13], whereas static balance by means of *Flamingo Test* (based on EUROFIT [7]) in modified version [14, p.154], taking into account two parts – balance while standing on the right leg and afterwards on the left leg.

The selection of those tests was determined by three criteria (assumptions) defined in the introduction. Common element of both tests in the necessity to maintain balance on limited support surface – once standing, then moving along with the change in movement direction after each 3-meter section with simultaneous reduction of support surface (first and second criteria). Specificity of motor activity observed in judo athletes who fight in vertical posture is mainly that (while attacking or defending oneself) an athlete is frequently forced to maintain balance on one leg leaning on the mat only with part of a foot and perform manipulating activities with other leg (offensive or defensive), and simultaneously perform dynamic manipulating activities with both hands (compensating for balance disturbances generated by a competitor and at the same trying to throw him off balance). Such model of motor activity of judokas is typical while performing the following leg techniques (*ashi waza*): *o soto gari, o uchi gari, ko uchi gari, hiza guruma etc.,* or some hip techniques (*goshi waza*): *uchi mata, hane goshi, harai gosh, etc.* All mentioned specific

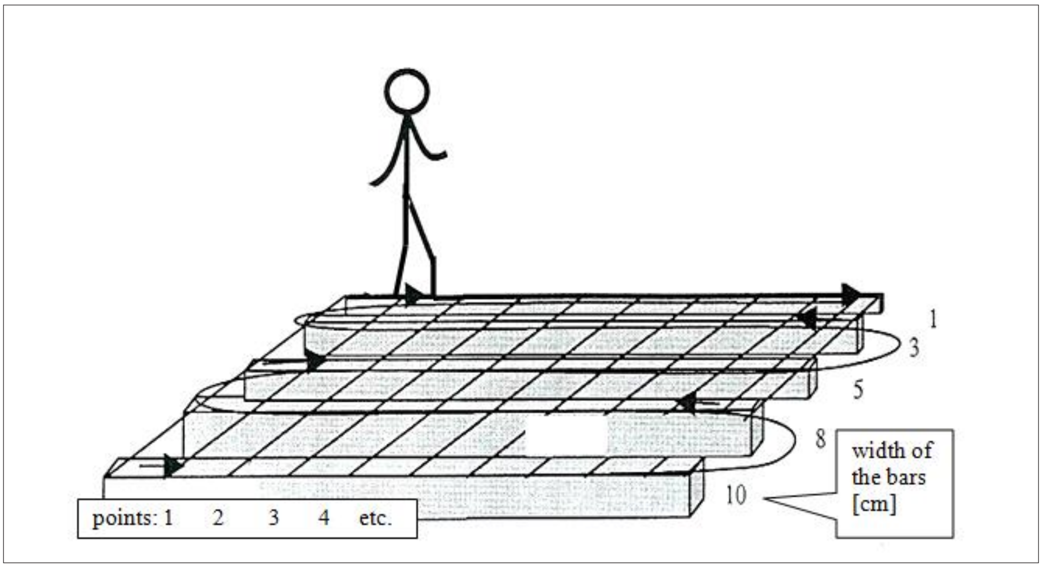

Figure 1. Model of the quasi-apparatus test – *Marching Test* – measuring dynamic balance

motor activities (repeated in the course of training in various conventional and situational forms especially during tournament fight) result in stimulation of nervous system. The motor system is at the same time the control system and the system to be controlled. Systems operate according to the principle of control in back coupling loop [15].

Assessment of dynamic balance

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 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 tested person walks through less than 75 (20-cm) sections (loses balance and leans one foot on the ground), the result is equal to a number of points as equivalent of the sum of walked 20-cm sections.

Assessment of static balance

The task of tested person is to maintain balance while standing on one leg on a 50-cm long, 3-cm wide and 4-cm high beam. Stability of a beam is ensured by two transverse supports, each 15-cm long and 2-cm wide. Tested person, while standing on right leg (foot is placed along the beam), catches a foot of left leg bent at a knee with a left hand and attempts to maintain balance in this posture maximally for 60 seconds (Figure 2) from turning on a stopwatch (when a posture is stable). Right hand may be leaned against an arm of a person conducting the study to help starting the task. A scientist turns a stopwatch on, when tested person stands on one's own. A stopwatch is turned off if a tested person loses balance (touches the ground with various body part or releases a grip on the leg) or after 60 seconds. After at least 2-minute break the task is repeated, this time while standing on left leg. Assessment criterion is the duration of maintaining balance (analyzed separately for each leg).

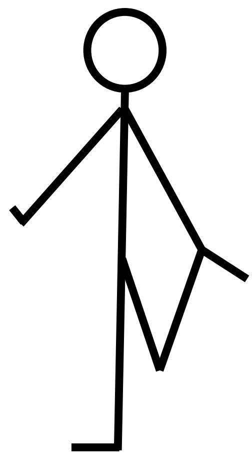

Figure 2. *Flamingo Test* measuring static balance

Statistical analysis

Arithmetic means, standard deviations, limits of results' distributions (minimal and maximal values) as well as skewness (g_1) and kurtosis (g_2) have been calculated. Significance of a difference between pairs of means for independent samples and correlated samples (between 'judo' and 'non-active' groups and within groups) have been determined. Correlation matrixes of examined indices for 'judo' and 'non-active' groups have been calculated. Normalization for arithmetic mean and standard deviation has been performed in multivariate analysis of indices of examined phenomena [16]. 'Non-active' boys have been accepted as a reference group. Conventional points of individual profile (this is sum of points obtained in *Marching Test* and seconds in *Flamingo Test*) have been adopted as a criterion for individual characteristics (leaders and the last ones in ranking groups).

Results

Results of both tests indicate that boys training judo have better dynamic and static balance when compared to their non-active peers (in terms of nominal value) (Table 1 and 2). However, only better dynamic balance is statistically significant (difference in *Marching Test* results $p<0.01$). Standard deviation and minimum and maximum value suggest that there is less variation of this characteristic within 'judo' group. There are no statistically significant differences between time to maintain balance on right and left leg both in 'judo' group and 'non-active' group. Nonetheless, there is greater differentiation in this respect among young judokas as indicated by SD.

Table 1. The estimation of the balance tests' results in the experimental 'judo' group (n = 26)

Statistical indicator	Empirical variable		
	Marching Test [points]	Flamingo Test [seconds]	
		left leg	right leg
	57.07	8.86	10.55
SD	9.81	5.62	6.41
min	42	1.2	2
max	75	26.1	22.8
skewness (g1)	0.48	1.16	0.81
kurtosis (g2)	–1.01	2.12	–0.46

Positive skewness of *Marching Test* results (g_1 0.48) obtained by young judokas show that they diverge from normal distribution. In fact, this is an asymmetrical bimodal distribution, whereas the majority (exactly 16 of 26 judokas) obtained score lower than 57.07 points. Negative value g_2 (–1.01) is a mathematical proof that distribution is strongly flattened (platykurtic) (Table 1).

Characteristics of results obtained in *Flamingo Test* by young judokas concerning right leg is similar. Positive skewness (g_1 0.81) indicates that the distribution is even more positively skew, whereas g_2 (–0.46) that it is less flattened. Characteristics of the results for left leg is, however, different. Positive skewness (g_1 1.16) reveals distinct rightward skewness (exactly half of judokas obtained score higher/lower than average value of 8.86 seconds but only two extremely favourable results (61.1 and 17.6 seconds) determined this value of g_1). Positive value of g_2 (2.12) indicates highly leptokurtic (pointed) distribution (Table 1).

The distribution of the *Marching Test* results of 'non-active' boys is less asymmetrical (g_1 0.32) because 56% of the results is below the average of 45.28 points. It is also less flattened (g_2 –0.49) than judokas' results. Distribution of the *Flamingo Test* results for left leg can be described with higher positive skewness (g_1 0.72) and as slightly flattened (g_2 –0.14). The distribution of the *Flamingo Test* results for the right leg is the most positively skewed (64% of the results is lower than the average of 8.53 seconds) and moderately pointed (Table 2).

Table 2. The estimation of the balance tests results in the control group 'non- active' (n = 25)

Statistical indicator	Empirical variable		
	Marching test [points]	Flamingo test [seconds]	
		left leg	right leg
	45.28	6.72	8.53
SD	13.61	4.00	5.57
min	20	0.9	2
max	70	15.4	23.1
skewness (g1)	0.32	0.71	1.04
kurtosis (g2)	–0.49	–0.14	0.46

All results obtained in the tests are positively correlated with each other ($p<0.01$) in 'judo' group. On the other hand, there are no significant correlations of results in 'non-active' group (Table 4).

Profiles of averaged results obtained in 'judo' and 'non-active' group as well as leaders and the last ones in the rankings reveal qualitative aspect of training effects (Figure 1).

Table 3. Correlation matrix of balance tests results in the experimental judo' group (n = 26)

Tests results	Marching Test	Flamingo Test (left leg)
Flamingo Test (left leg)	0.589**	-
Flamingo Test (right leg)	0.522**	0.706**

*p<0.05 ** p<0.01

Table 4. Correlation matrix of balance tests results in the control 'non-active' group (n = 25)

Tests results	Marching Test	Flamingo Test (left leg)
Flamingo Test (left leg)	0.311	-
Flamingo Test (right leg)	0.275	0.316

Discussion

The result of *Marching Test* obtained by examined young judokas indicates similar level of dynamic balance to 13-15 year old judokas (n = 40), who had similar training experience, examined over a quarter of century ago in large Polish city being one of the best judo centers in Poland [17]. The average results of the test are almost identical (experimental 'judo' group 57.07 points, previously tested judokas 57 points). Nonetheless, the range of *Marching Test* is lower in contemporary young judokas (from 42 to 75 points) in comparison to previously studied group (34 to 75 points). Similarly, the dispersion measured with standard deviation is also lower (9.81 and 13.53 respectively).

The oldest judokas (n = 20, age 24.95, ranging from 18 to 32 years old) examined at that time by Witkowski and Cieśliński [17] represented high sporting level, had 8-14 years of training experience but most of all they had highly developed dynamic balance: average result of *Marching Test* amounted to 73.4 points ranging from 63 to 75 points (±3.21). Novices trained judo for no longer than a year but were highly differentiated in terms of age (13.81 years; from 12 to 16 years; ±1.04). The result of *Marching Test* amounted to 55.5 points (ranging from 38 to 75 points, ±8.94) and indicates that novice judokas differ only a little in this result from both groups of young judokas compared in the first paragraph. However, contemporary Polish 14-15-year-old boys who belong to 'non-active' group do not match in the dynamic balance neither to novice judokas examined a quarter of century ago nor contemporary peers training judo.

This comparison provides important empirical arguments that judo is an excellent mean to stimulate dynamic balance of a human. This characteristic, or even body balance, is mentioned as very significant by some scientists who attempt to establish factors determining success in judo [17, 18] and in other combat sports [19, 20]. In our opinion there are still not enough recommendations directing towards judo as an attractive sport of life that may play an important role in development and maintaining motor safety of a human to the old age.

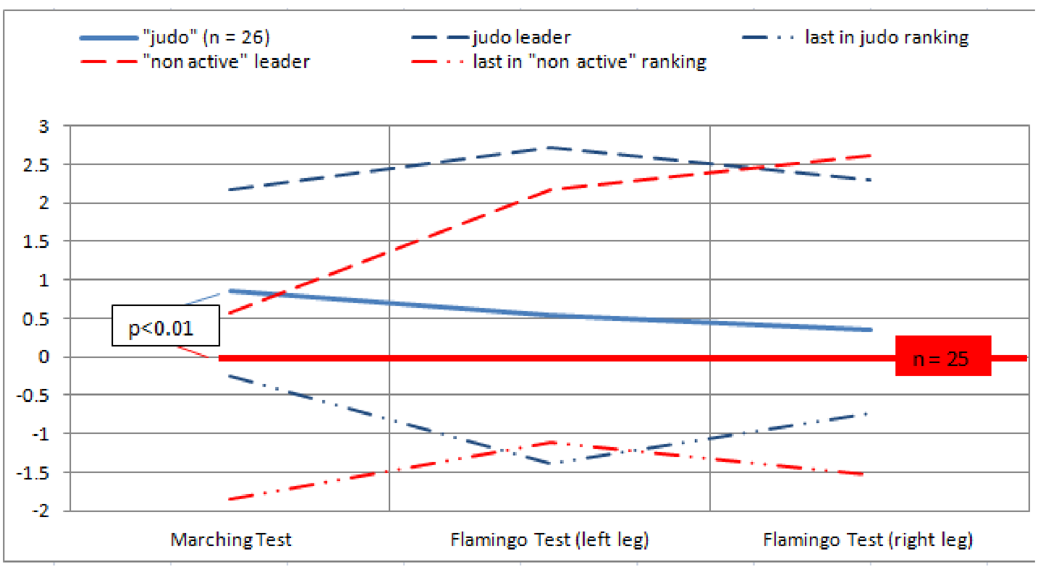

Figure 3. Normalized to arithmetic means and standard deviations of 'non-active' group (n = 25) results of the tests in 'judo' group as well as leaders and the last ones in the rankings of both examined groups of 14-15 year old boys (conventional points: 'judo' leader 113.0, 'non-active' leader 91.5, last judoka 47.6, last non-active 29.3).

The diversity of methods and applied measuring tools constitute a factor hindering making comparisons between study results. Recent studies are based on modern measurement instruments, such as posturograph, force platform etc. [21, 22], supported by various, virtually created circumstances of motor functioning, including small and high amplitude of disturbances [23]. This does not prevent numerous scientists from formulating general and true conclusions that combat sports and martial arts stimulate mechanisms responsible for stability of human body posture [17, 19-22, 24]. Moreover, modified *Flamingo Test* used in the experiment (modified also with respect to version, which we have followed [14]) is a simple quasi-apparatus test available to every coach, physical education teacher, physiotherapist, etc. but in this case comparison with results obtained by other authors can hardly be made.

As a part of major project concerning coordination abilities of young Slovaks (10-, 14-, 17-, 20-year-old), Balej et al. [14] measured the duration of maintaining balance while standing on one leg freely chosen by each examined person in the 'test-retest' procedure at the intervals of 4 to 5 weeks. Examined 14-year-old boys (n = 100) maintained balance on average for 5.782 seconds (±5.161) during the first attempt and 8.670 seconds (±10.501) during retest. Only the result of retest is similar to the result of judokas examined for the purposes of this paper and this applies only to left leg. Due to methodological differences in testing, there are no grounds to conclude that the level of static balance does not differentiate both populations. On the contrary, longer duration of maintaining balance on right leg by Polish judokas confirms conclusions about stimulating influence of judo training on this coordinance abilities.

Practitioners (coaches, physiotherapists, etc.) can make use of non-apparatus and quasi-apparatus tests with verified accuracy and reliability. Such criteria are fulfilled by *Rotational Test* [11], whereas typology of BBDTS developed on its basis is very important during selection of candidates for judo and other sports as well as numerous championships, where high level of body balance is an essential condition for increasing personal safety and selection of task groups, e.g. firefighters to difficult rescue actions [25]. The results of *Rotational Test* and the typology of BBDTS are useful also during ongoing monitoring of the effects of sports, military, police and rescue training as well as in therapeutic treatment.

Long research with the use of this test (due to its scientific value, simplicity of use almost in all conditions and low cost) allowed for comparative study of the adaptative effects of athletes (female and male) representing 15 disciplines. The results of the analysis [11] provide very convincing evidence that judo training (after performing on horse-back, gymnastics, sport dance and basketball) is a fifth mean in this ranking that can optimally stimulate widely understood body balance. Judokas belong to group I of BBDTS (have the ability to maintain vertical posture during all physical activities): between "type A", ability to perform all motor tasks without an error (0 pts.) a "type D", lack of ability to perform half of motor tasks without an error (4–12 pts.). Such comparative study is not currently possible either on the basis of *Marching Test* or even less of *Flamingo Test* mainly due to numerous modifications of this test.

Leaving aside the opinion on the degree of verification of the hypothesis, correlation of the results of *Marching Test* and *Flamingo Test* allows to make critical assessment of the experiment results conducted by Drowatzky and Zuccato [10]. Statistically significant correlations of the results measuring static balance (separately for each leg) and results measuring dynamic balance were obtained twice in 'judo' group. Thus, there is new empirical evidence that conclusion about common neurophysiological ground responsible for control of our balance regardless of the nature of performed motor actions if specified external conditions and those concerning traits of a human acting in this conditions are met. Perhaps sufficient explanation (until obtaining further empirical evidence) would be to develop objectives formulated in the introduction and detailed while justifying the choice of those tests. Adopted in this paper, the three assumptions (criteria) of tests' selection remaining in logical relationships with each other and external criterion (given motor activity subjected to continuous training) may constitute the starting point for reasoning and constructing appropriate research procedures.

In our opinion, the validity of the last sentence is well illustrated by more in-depth analyses of the results obtained in our experiment (delivered by in-depth analysis of skewness). Examined people performed *Flamingo Test* while standing on a 3-cm wide beam. The march on the truss on 3-cm beam (*Marching Test*) was completed by 38% of judokas (who continued the march on 1-cm beam with various effect). This was completed only by 16% of non-active boys. Among non-active boys 56% ended the march before reaching to 3-cm beam. This failure related only to 8% of judokas. Remaining 54% of judokas, apart from those who walked the entire

3-metre long and 3-cm wide beam, continued the march on the section from 60 to 180 cm.

Therefore, the similarity criterion (assumption two) being the width of support surface during two different motor tasks was fulfilled only partially. Due to higher level of adaptation it was 92% of judokas who continued the march on 3-cm beam at least for 60 cm. This was accomplished only by 40% of non-active boys. Nevertheless, the differences of results obtained in correlation tests ($p<0.01$ and only in judo group) with the study results obtained by Drowatzky and Zuccato should, in our opinion, be connected with partial similarity of motor action forced by external conditions (3-metre long, 3-cm wide fourth beam in a sequence i.e. identical with the width of a beam used in *Flamingo Test*). The scientists found no significant relationship between test results measuring dynamic balance or static balance [10]. We would like to emphasize that in our experiment judokas were the ones who were better prepared to act in both, partially similar circumstances. In-depth analysis of skewness of results distribution for both groups and significant correlation of *Marching Test* results with *Flamingo Test* results obtained in judo group as well as lack of such correlation in non-active group provides confirmation.

Thus, more confidence in the set of tests should enhance the correctness of the first hypothesis also in the context of previously expressed conclusion that judo training is a very important mean to stimulate human body balance [11, 17] similarly to other combat sports and martial arts [19-22, 25]. The hypothesis is also confirmed by qualitative analysis of balance abilities profile of tested judokas against reference group ('non-active') and leaders and the last ones in the rankings. If we assume that before staring judo trainings the groups did not differ in dynamic balance ability, probably motor safety (measured with the result of *Marching Test*) of the last person in the ranking comprising judokas would have been much lower.

Empirical evidence for the lower asymmetry of static balance among young male judokas than non-active peers (second hypothesis) essentially related to correlation amounting to 0.706 ($p<0.01$) of *Flamingo Test* results (left leg – right leg) only in judo group. If we assume that boys were not statistically significantly different before they started judo trainings, another aspect emerges here. Namely, judo training has a significant advantage in developing the ability of correcting own abilities to control the body. This effect is associated with brain plasticity phenomenon, on which judo may have greater influence than expected. Obtained correlations of test results in 'judo' group lead to a conclusion that trained person in certain circumstances may effectively solve given motor task regardless of used limb (in this case leg).

Third hypothesis turned out to be only partially true. Empirical data provide evidence that correlation of dynamic balance test and static balance test results is crossed and not, as we previously thought, low (coefficient of determination 27% to 37%, $p<0.010$) only in 'judo' group. No wonder that we adopted such hypothesis if existing study results [10] provide information on lack of or very low correlations of dynamic balance test and static balance test results. Third hypothesis proved to be false also in informative terms that physical activity index or lack of physical activity do not have differentiating meaning. It turned out the opposite. Only two years of training (consistently with the basic assumption that groups did not differ before staring the training) are sufficient to obtain positive, expected adaptative effects.

The results of our study may encourage to more in-depth exploration of the problem of relationship between body balance and predictions about sports career in combat sports. The aspect of selection of appropriate tests (i.e. having high predictive power) for a given combat sport or group of combat sports is primarily interesting. Good premise for such reasoning are e.g. study results obtained by Miller et al. [19] concerning correlation between coordination motor abilities and technical skill of taekwondo athletes at different levels of proficiency. 'Dynamic balance ability' was the most strongly related (for seniors $r = 0.68$; for juniors $r = 0.61$) of 10 used indices correlated with the level of technical skills. For seniors 'complex reaction time B1' ($r = -0.30$) turned out to be second in the ranking, whereas for juniors it was 'adaptation ability' ($r= -0.33$).

Unfortunately, longitudinal studies on young Polish judokas monitor neither dynamic balance ability nor static balance ability [26-28]. Waldemar Sikorski [29] summarizing research lasting for half of a century for the needs of judo determined four profiles of judo athletes: physiological, psychological, biomechanical and anthropometrical. Biomechanical profile lacked, however, recommendations concerning balance ability.

Conclusion

The results of our experiment may indicate the cognitive and application meaning of studies on human body balance without the need to use sophisticated tools and research techniques. More importantly, providing important empirical data on the relationship between the ability to effectively solve motor tasks and sense of dynamic and static balance is an essential cognitive value of the study. Positive correlations of those indices occur when a person is subjected to frequent, intensive stimuli acting on both manifestations of body balance. Application aspect extends the usefulness of study results beyond the field of sport. Increase especially in human dynamic balance ability by means of judo training translates directly into their motor safety during daily physical activities and consequently into health safety.

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Competing interests

The authors declare they have no competing interests.

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