

Correlation of different factors of balance and the quality of realization of movement techniques in aikido

Authors' Contribution:

- A** Study Design
- B** Data Collection
- C** Statistical Analysis
- D** Manuscript Preparation
- E** Funds Collection

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Abstract

Background & Study Aim:

Balance is the ability of maintaining the body in a “balanced” posture, i.e. in a state of equilibrium. The goal of this study was the relation of three factors of balance as the possible predictors of successful movement *aikido* techniques based on the isolated factors of balance.

Material & Methods:

The sample comprised 58 recreational athletes, aged 25 ±3 years (36 males, 22 females). Tests: static balance without visual control (standing on one leg with eyes closed); static balance with visual control (subject stood on one leg longitudinally on a balance bench with his/her eyes being open); dynamic balance with visual control (comprised walking on a balance beam). The tests were directed to the motoric space for establishing different factors of balance. The *aikido* quality of technical performance (QTP) was evaluated by a judge committee with comprised three members, black belt (1st dan), that were graded from 5 to 10 (QTP Index).

Results:

Multiple regression analysis showed the existence of a statistically significant correlation of the dynamic balance and the static balance with eyes open. Correlational analysis showed a significant correlation with all three tests with the grade of the technique of movement.

Conclusions:

Specific significance of this paper is the fact that there is a possibility to predict the quality of realization of movement techniques in aikido based on the results obtained by testing the three factors of balance.

Key words:

budō arts • dynamic balance • static balance • recreational athletes

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Aikido – „At the heart of *aikidō* is the concept of 'ki' or one's 'life-force'. *Aikidō* training seeks to fuse universal *ki* which flows within each individual. *Aikidō* translates as «the Way of harmonious spirit», and like other *budō* arts, seeks for the unification of technique, body and mind.“ [2, p. 205].

Dan (dan'ī) – a term used to denote one's technical level or grade [2].

Dynamic balance – the ability to maintain a chosen body posture (position) and its changes in a series of moves in which the vertical projection of the base of support falls outside of the supporting area.

Movement – by moving, space is conquered and distance is maintained, and if necessary, evasion from the direction of the eventual attack is achieved.

Balance – the ability maintaining an upright body posture (position), i.e. in equilibrium.

Static balance – the ability to maintain a balanced position of the body that is not moving as long as possible.

Body balance disturbance tolerance skills – the ability to maintain the vertical posture in circumstances of the fall hazard [12].

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 [33].

Quasi-apparatus test – can be conducted with simple instruments (a stopwatch, a ruler, a measuring tape, etc.) [33].

INTRODUCTION

balance is the ability of maintaining the body in a “balanced” posture, i.e. in a state of equilibrium. Primarily, there are three components of balance (this is in some sense the traditional approach). First one is static balance of the body that presents the ability to maintain a balanced posture of the body that is not moving as long as possible. The second one is dynamic balance of the body that presents the ability to hold in the desired posture and perform changes in a series of movements in which the vertical projection of the centre of gravity falls outside of the supporting surface. The third component presents balancing of objects that is defined as the ability to maintaining certain objects in a state of equilibrium as long as possible. This factor of balance is not a subject of research in this project.

In case of martial arts and combat sports an issue is complex [1, 2]. Part rely on precipitation opponent off balance (judo, sambo, sumo, wrestling etc.) at the need to keep oneself vertical posture. In other martial arts and combat sports (boxing, kick-boxing, fencing, karate, kendo, taekwondo etc.) the condition for the effective stroke or avoid it by an opponent is stable posture. There is another group of martial arts and combat sports, that combines these motor capabilities (ju-jitsu, kung-fu, unifight [2, 3]). The specificity of *aikido* (defined either as *budō* art [2], or as counter techniques against judo [4], or as self-defence art [5]) relies on that *aikido* practitioners does not take offensive action but counterattack, or adapts own body movements in order to defend from the attack by an aggressor (stroke, grip the clothing or limbs, etc.) without hurting him.

Regardless of practicing martial arts, combat sports, self-defence arts [1-7] balance (in a broad sense) definitely represents one of main motorical abilities co-deciding on the effectiveness of offensive and defensive action during the fight. It is proven empirically, that balance is one of crucial factors determining the success in martial arts, combat sports and self-defence art [8-16].

According to some research, a factor of balance with visual contact, as well as factor of balance without visual contact is mentioned as well [17-20]. Paspalj [21] examined the influence of basic motor abilities on the efficacy of executing the technique of “cleaning” and “throwing” from the program of Specific Physical Education (SPE)

on a sample of 110 subject of first-year student of the College of Internal Affairs. For the technique of cleaning on this level of training, motor abilities of coordination, explosive strength and endurance in strength were shown to be important, while for the technique of throwing, the motor abilities of coordination, explosive strength and endurance in strength, as well as the motor ability of executing rhythmic movement.

Some authors pointed to a possibility of the existence of two functional structures that are activated depending whether the eyes are open or closed [21]. Research that was conducted with a battery of tests evaluating balance was carried out on a sample of 350 female students and the following factors were extracted: general locomotion factor, general kinaesthetic sensitivity, general ampullary sensitivity, functioning of two perpendicular semi-circular canals, as well as the factor of tension that secures a neurological amplification of kinaesthetic mechanisms. Later on, the existence of static balance (determined with tasks that require maintaining a given position with static tension) and dynamic balance (determined with tasks in which, during movement, a force that obstructs balance is mastered) was established.

The link of the research mentioned with the subject matter is viewed through vivid differences of certain factors of balance, but also in the effect of certain motor abilities on the quality of realization of techniques in combat sports and combat skills. Some researches [22] undoubtedly links the influence of the techniques of *aikido*, placed through a form of polygons on static balance without visual control. It was established that the factor of polygon in practices showed a strong influence on the balance of subjects, and the possibility that the applied experimental factor can be safely used in the development of balance on the population of recreational athletes. For these reasons, this research represents an upgrade and elucidates the influence of different factors of balance on the quality of realization of techniques in *aikido*.

In *aikido*, the greatest number of combination of techniques with which the opponent is managed is linked to to movement techniques [4, 23]. By moving, space is conquered and a distance is kept, and, if necessary, moves away from the direction of the attack can be made [24].

In *aikido*, the number of combinations techniques that do not require movement are close to none. Having in mind that almost all combination techniques are performed while moving, in order to „use the force of the attacker“, on what was primarily insisted by the founder of *aikido* – Ljubomir Vračarević, in this work, the movement „step“, „turn“, „small turn“ will be elaborated. The mentioned movement presents a combination of a few simple (individual) movements, and in *aikido*, it is the most complex movement technique. For these reasons, this movement, and especially its part „small turn“, presents them moment when a competitor, who is defending with a combination of the mentioned movement and other individual techniques, disturbs the balance of the attacker by changing his posture from vertical to horizontal. In fact, during the execution of the movement „step“, „turn“, „small turn“, and especially during the execution of the final part of this movement, i.e. „small turn“, in a large number of cases, especially in novice athletes, there is a disturbance of his/her own balance, which had a deleterious effect on the quality of realization of the complete combination technique with which the opponent who is defending wanted to overpower the attacker.

The mentioned movement, although analysed in this research, is not of highest priority in terms of efficacy in relation to other movements in *aikido*, but is excluded from other movements due to its complexity. Most movements in *aikido* are comprised of semi-circular movements, so that similar movement structures can be applied only in traditional *aikido*, and very rarely in some other martial art or combat sport.

Division and Classification of movement that would be generally accepted for martial arts and skills is very hard to do, because movements in certain combat sports and skills, due to their differences depending on the specific demand of the particular sport [1, 2, 4, 25]. Our research is dealing not only with creating a link between balance and the quality of movement techniques, but also with analysing factors of balance, which is responsible for executing movement techniques in *aikido* successfully.

The Vestibular system (responsible for the sense of balance) has the role of registering head movement in space, and with this system, coordination of motor movement that maintains the balance of

the body can be achieved, as well as coordination of head and body movement and allowing the eyes to stay fixated on an object that is perceived. We are not aware of this process, since information from the vestibular system do not reach the cortex of the brain, as in the case of other senses [26].

As the factors of balance both with and without visual control could be implemented on the factor of static balance, they could also be implemented on the factor of dynamic balance, and in accordance with that, it could be tested as well. However, the safety risks from testing the factors of dynamic balance without visual control suggest that this procedure should not be carried out due to the possibility of injuries that could occur during their evaluation. Balance depends on multiple factors, but among the important ones are surely the status of the vestibular system and the centre for balance, certain motor abilities, age, level of centre of gravity, amplitude and level of motor habits, stance surface, physical condition, focus, emotional state, and the genetic code [27].

The goal of this study was the relation of three factors of balance as the possible predictors of successful movement *aikido* techniques based on the isolated factors of balance.

MATERIAL AND METHODS

Participants

The sample in this research was drawn from the population of novice athletes of *aikido*, and encompassed 58 subjects, aged 25 ±3 years (36 male, 22 female), who are practicing *aikido* between 3 to 10 months and are bearers of a white belt. They are practicing 3 times a week, in a total workout time of 5 hours. This sample was intentionally used, and it is formed of units of a certain group that we chose based on our personal belief as typical or representative for a basic group.

Local Ethics Committee has given consent to the study. All participants voluntarily agreed to participate in this study and were informed in advance of the testing protocol described in the study project. It is important to note that all participants were medically fit, without injuries prior to testing, were regularly attending practices, and were mentally relaxed during the testing process, without being burdened with practices prior to testing.

Protocols

In this research, 3 predictor variables of motoric space were evaluated with tests for establishing different factors of balance: (1) static balance without visual control; (2) static balance with visual control; (3) dynamic balance with visual control.

The criterion variable was the *aikido* movement technique in: „step“, „turn“, „small turn“. The system of predictor variables were used to examine the correlation and the possible prediction of efficacy of executing movement techniques in *aikido*. The criterion variable were used to evaluate the quality of execution of the specific *aikido* movement technique.

Predictor variable

Static balance without visual control (SBWVC)

The test of standing on one leg with eyes closed is performed in the following way: the subject, bare footed, stands still on one leg, by his/her preference which leg. The other leg is lifted from the ground and turned to the side, trying to find balance, and then the subject closes his/her eyes. The upper extremities are laterally raised. The task of the subject was to stay balanced in that posture for as long as possible (max. 30 seconds). The number of errors that the subject makes is counted – when opening eyes, or when the leg that is raised from the ground touches the ground, in order to aid in recovering balance. At the moment when the subject commits an error, the surveyor stops the clock, and time measuring is continued when the subject regains the posture he is requested to, with eyes closed. A higher number of errors present lower scores.

Static balance with visual control (SBVC)

The test of standing on one leg longitudinally positioned on a bench. The subject is barefooted, and stands on one leg (by his own choice, which is then used throughout the entire testing) on a balancing bench, and the other leg is raised from the ground, which serves to establish balance. The hands of the subject are adjacent to the body. The task is repeated six times, with a pause between each attempt. It is stopped if the subject changes the posture of upper extremities into any other posture, touches the ground or the balance bench with the leg that is raised from the ground, or if this posture is held for more than 120 seconds. Results are measured in tens of seconds from the moment when the subject's foot is not on the

ground, up to the moment when an error of any type is committed. If the subject is able to maintain the requested posture for 120 seconds, the process is stopped, and the subject receives a score of 120. Since the task is repeated six times, each attempt and its result is separately noted. Values of these results are expressed in a unit of time, and if the values are higher, the score is higher.

Dynamic balance with visual control (DBVC)

Balance beam walking test. The task is performed on a small balance beam. The subject is standing with both feet on a balance beam, with one foot placed in front of the other, with hands laterally raised. The test starts when the subject attempts to walk on the beam, during which he is trying to maintain balance, and tries to move along the beam. Test is stopped when the subject loses balance and starts shuffling in one side or the other, or falls from the beam. At that point, time is stopped, and the test is continued from the site where the error occurred. Results depend on the number of errors, with greater amount of errors denouncing a lower score.

Criterion variable (description of criterion variables and evaluation method)

For this variable, the estimation of the efficacy of execution, the *aikido* movement technique: „step“, „turn“, „small turn“ was selected.

The subject stands in the basic stance with his left leg forwardly placed in relation to the right leg. With the right leg, the subject makes a semi-circular turn forwardly for 180 degrees, and places it in front of his/her left leg, which depicts the movement „step“. After that, a semi-circular turn is made with the left leg towards his/her back for 180 degrees, which depicts the movement „turn“. Finally, the subject is rotated around its own axis for 180 degrees, with the axis of rotation being the heels of the subject, which depicts the movement „small turn“. The arms are, during the movements, placed in front of the chest, with hands open and moving together in a harmonic fashion together with movements of the legs.

The evaluation committee comprised three members that have a minimal title black belt (1st dan) in *aikido*, and evaluated the execution quality of the given technical elements with grades from 5 to 10 (QTP Index) with the established criteria (Table 1). The judges were handed video materials with recorded *aikido* movement techniques

that were performed by subjects, and the grading criteria was clarified with the emphasis on the details they should pay attention to during the evaluation process.

Table 1. Criteria of grading of *aikido* quality of technical performance (QTP).

Grade	Criteria
10	Excellent (harmonic and synchronized) execution of movement technique in an accentuated rhythm, which satisfies the basic biomechanics principles.
9	Excellent execution of movement technique in an optimal rhythm, which satisfies the basic biomechanics principles.
8	Very good execution of movement technique, during which one of the components was somewhat violated, but the execution is still performed securely.
7	Good execution of movement technique, with minor errors, during which the basic structure of the technique is not violated, and the execution is still securely performed.
6	The basic structure of the technique is partly violated, there is a somewhat larger amount of errors, with certain principles not largely violated, but there is a sense of insecurity during movement.
5	Poor execution, substantial flaws, the structure of the technique is substantially violated and strong insecurity during movement.

Once they were introduced with the process, the judges filled out the lists for evaluation independently of one another, for each subject individually. The grading scale mentioned previously satisfies the criterion of discrimination, which enabled the judges a precise nivelation of quality within the tested population. The grade for *aikido* movement technique is formed based on the mean value of the grades received by the three judges, which presents the grade for the criterion variable, ie grade of efficacy of execution of the *aikido* movement technique.

Statistical analysis

Statistical data analysis was conducted in the program SPSS for Windows 8.0. In order to establish the existence of statistically significant correlation of predictor and criterion variables, correlational and multiple regression analysis were used.

RESULTS

Results of the correlation analysis (Table 2) showed a statistically significant link between all tests of static and dynamic balance, both as inter-correlations, as well as correlation with the grade

of quality of technical performance (QTP Index). The highest value of correlation to the QTP Index showed the variable DBVT ($r = -0.89$), then the variable SBVC ($r = 0.87$) and the variable SBWVC ($r = -0.58$).

Table 2. Correlation matrix (all $p < 0.01$) of observed empirical variables of examined recreational *aikido* athletes ($n = 58$).

Empirical variable	The value central and variability		Correlation between empirical variables		
	Means	SD	SBWVC	SBVC	DBVC
SBWVC (N errors)	2.91	1.14	-		
SBVC (seconds)	90.12	16.53	-0.69	-	
DBVC (N errors)	5.90	3.85	0.50	-0.86	-
QTP Index (from 5 to 10)	7.43	1.52	-0.58	0.87	-0.89

SBWVC – static balance without visual control; SBVC – static balance with visual control; DBVC – dynamic balance with visual control; QTP – quality of technical performance

Regression analysis, however, showed that the QTP Index is significantly statistically correlated by a highest degree of correlation ($p = 0.00$; Beta = -0.57) with dynamic balance (DBVT) and the static balance with visual control ($p = 0.02$; Beta = 0.33), which evidently points to the role of vision and visual sensory input in successful realization of movement techniques (Table 3).

Statistically significant correlation of *aikido* movement technique (QTP Index) with the test DBVT ($p = 0.00$; Beta = -0.57) was shown by negative correlation, meaning that a higher grade was given to subjects that had a fewer number of errors; while with the test SBVC, statistical correlation ($p = 0.02$; Beta = 0.33) was shown by positive correlation, which means that a higher grade was given to subjects that held a balanced posture for a longer period of time.

DISCUSSION

Results of statistical analysis showed the existence of a statistically significant link of static and dynamic balance. Results of research conducted by part of authors [28, 29] show that both the sensory and motor systems have a specific role in maintaining dynamic and static balance. In an

Table 3. Results of multiple regression analysis of observed empirical variables of examined recreational *aikido* athletes (n = 58).

Empirical variable	Regression summary for dependent variable: QTP Index (balance 2.sta) R=0.914; R ² = 0.836; Adjusted R ² = 0.827; F(3,54) = 91.665; p < 0,05 Standard error of estimate: 0.63396					
	Beta	Standard error Beta	B	Standard error B	t(54)	p-level
Intercept			6.27	1.51	4.16	0.00
SBWVC	-0.07	0.08	-0.09	0.10	-0.88	0.38
SBVC	0.33	0.13	0.03	0.01	2.51	0.02
DBVC	-0.57	0.11	-0.23	0.04	-5.15	0.00

SBWVC – static balance without visual control; SBVC – static balance with visual control; DBVC – dynamic balance with visual control

important experiment conducted by Drowatzky and Zuccato [17], which was based on matching the results of six attempts to maintain the balance (three static: *stork stand*, *diver's stand*, *stick stand* and three dynamic: *sideward stand*, *bass stand*, *balance stand*), the highest correlation coefficient equalled 0.31 (coefficient of determination was only 9.61% [12]). Jagiello et al. [30] found no statistically significant correlation between body balance disturbance tolerance skills (as measured by the 'Rotational Test' [12]) and simulation of rescue tasks: move (there and back) on the balance beam (for board about the width of 20 centimetres and the length of 4 meters) fixed to the platforms located on two scaffolding 3 meters above the concrete ground.

Significant statistical correlation between applied in our researches the balance test can be explained by the motor similarity. In the methodological meaning, there is still no answer to the question which from tests are accurate. For example, Pion et al. [13] in investigating the non-sport-specific characteristics for talent orientation in young male judo, karate and taekwondo athletes among others assessed the backward balance (participants had to walk backwards along balance beams of decreasing width: 6 cm; 4.5 cm and 3 cm).

There is some similarity of tool used for testing by Witkowski et al. [8, 14]. It turns out that balance tests of non-apparatus and quasi-apparatus types are widely used not only in the researches of martial arts and combat sports practitioners.

The correlation of movement techniques in martial arts with static balance can be observed [31]. In this research a group of subjects was included in regular physical activity through practicing the martial art *tai chi* once per week, for one hour, for

one full year, in relation to a control group without regular activity, showed significant improvement of static balance after 6 months of workout. Some studies [32] also shows positive effects of planned physical workout of martial arts (*tai chi*) on the control of balance in different conditions through evaluation of subjects with closed and open eyes.

It is important to point out that the link of static balance with open eyes, and especially dynamic balance with open eyes, was expected. The result can be explained by the largest number of errors that novice athletes in *aikido* make during the execution of movement "step", „turn“, „small turn" are due to loss of balance in the final segment of this movement, i.e. during the attempt of the subject to stay in posture after the movement "small turn" – when, after a relatively quick 180 degree turn around his/her axis, should stay in position without losing balance. For these reasons, these evidence that, to a more or less extent, link certain factors of balance and the quality of realization of movement techniques, are significant, amidst other reasons, for the potential selection when it comes to novice athletes in regard to possible predictions that refer to the quality of movement realization, on the basis of different factors of balance.

The obtained results point to a need for further investigation of the correlation of specific movement techniques with dynamic balance, depending on the rank of competition.

CONCLUSIONS

The issue that is being the topic of this research, that elucidates the link between different factors of balance and the most complex movement in

aikido offers valuable data, especially if we have in mind the fact that this evaluation was performed on novice athletes, for whom the movement “step“, „turn“, „small turn” presents a relatively new movement structure, which they have not encountered before. These statements solidify the relation of different factors of balance with the quality of realization of movement techniques (QTP Index), and makes them acceptable, because the factor of physical fitness is adjusted to a minimum having in mind that novice athletes were a part of this study.

From this research, it can be observed that the relation of dynamic balance tested by walking on a balance beam and the QTP Index is seen through linear movement, having in mind that both tasks are performed with open eyes, i.e. with sensory control.

The correlation between static balance with open eyes and the observed movement can be found

in the fact that after the execution of the movement, the subject must maintain a proper posture, which is the information that the given balance test and the actual movement bring into a tight connection. Together with the previously mentioned correlations, a specific significance of this paper is observed through the fact that there is a possibility to predict the quality of realization of movement techniques in *aikido* based on the results obtained by testing the three factors of balance, and i.e. body balance disturbance tolerance skills.

In accordance with these facts, further research that would be done on the population of recreational athletes of *aikido*, could head into the direction of researching the correlation between other motor abilities and the quality of realization of both individual elements, as well as the combination of elements of *aikido*. Valuable data would be obtained with research that would be conducted also on different sport level in *aikido* (black belt).

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