ORIGINAL ARTICLE

Journal of Combat Sports and Martial Arts
© MEDSPORTPRESS, 2016; 1(2); Vol. 7, 43-49
DOI: 10.5604/20815735.1222834

Body balance in judokas

Jarosław Maśliński[(A,B,C)], Kazimierz Witkowski[(A,B,C,D)], Wojciech Cieśliński[(A,B,C)], Tomasz Śliz[(A,B,C)]
Academy of Physical Education, Wrocław

Keywords: judo, combat sports, martial arts, body balance, truss walking, Flamingo Test

Summary

Introduction. One of the objectives of a judo contest is to gain advantage by throwing the opponent onto the mat. In order to create the best possible mechanical conditions for a throw, a judoka tries to unbalance the opponent. The opponent is thrown off balance and will find it more difficult to defend himself or herself against the throw. However, an unbalanced opponent is by no means a passive opponent. His or her task is to try to stay on balance. Maintaining balance also depends on e.g. a judoka's morphological features, including body mass and body height, height at which the judoka is gripped during throwing, and position of the centre of gravity. The height of the grip influences the arm of the rotational force used in off-balancing and the arm – the torque. Bearing the above in mind, the authors of the present study decided to examine body balance in judokas. The objective was to compare body balance in judokas at various levels (lower junior, junior and senior category) in terms of both their age and training experience. The experimenters compared their static and dynamic balance. The following research hypotheses were adopted: 1. Calendar age has a considerable impact on the development of balance in judokas. 2. Judo training is of crucial importance to the development of dynamic and static balance in judokas. 3. Body balance improves with age and with training experience.

Material and methods. The study featured 84 active judokas aged between 15 and 42, who were members of Wrocław judo clubs. Two tests were used to check their balance. Dynamic balance was measured by means of the Walking Test (walking over a special truss) developed by Ewaryst Jaskólski [2]. Static balance was measured by means of the Flamingo Test [3].

Results. The results show that dynamic balance improves with calendar age and training experience. This may be linked to the nature of the discipline, which involves being constantly in motion, changing the position of the body and loosing balance during contests. Dynamic balance is statistically significantly different between the lower junior and junior categories. On the other hand, static balance does not improve with calendar age. The researchers have even noted a regression in the junior category, which may be linked to a rapid growth in body height, changes in body proportions etc.

Introduction

Physical fitness has always been inextricably linked to human existence in nature. It is determined by various elements, above all by motor abilities, which can be shaped and developed. According to various theories [4,5], there are two sides to human motoricity: potential and effective. The potential side comprises predispositions, motor skills and abilities; the effective side – motor and physical fitness. Raczek et al. [3] have distinguished three groups on the basis of motor abilities. The first comprises conditioning abilities – energetic and morpho-structural. The second group comprises coordination and information abilities – neuro-sensory and psychological predispositions. The group includes ability to combine movements, differentiate movements, ability to maintain balance, orientation, rhythmicisation of movements, reaction and ability to adapt in terms of movement. The third group is made up of complex or hybrid abilities – determined by factors from the first two groups but without either of them becoming dominant: speed, agility. The coordination area of human motor abilities has been studied by numerous researchers seeking to identify the characteristic elements of its inner structure as well as the predispositions making up these elements. The research was started by American psychologists. Drawing on empirical research, Guilford [6] distinguished three groups of factors: responsiveness of the nervous system (reaction time, frequency), static precision (static balance, arm precision) and dynamic precision (dynamic balance, lower limb aiming). In Europe, research into the coordination part of human motor abilities was conducted by Gundlach [7,8] and Schnabel [9,10]. When it comes to the expansion of knowledge of motor coordination and, above all, the structure of the motor control process, Hirtz's publications [11,12] are of particular importance.

Maintaining a balanced posture in everyday life is necessary and is usually done without an individual being conscious of it. Interest in the topic was and still is so big that a large part of the literature on physical education is devoted to the problem of measuring balance, which could be called a component of physical fitness. There is a common definition according to which from the mechanical point of view body balance is defined as a state meeting the following conditions: the sum of vertical forces equals zero, the sum of horizontal forces equals zero, the sum of moments equals zero [13,14].

A slightly different approach is proposed by Raczek, who defines the sense of balance as an ability to maintain a balanced body position (static balance) and maintaining or regaining this state (dynamic balance) during a movement or immediately after it has been completed [15]. The available literature comprises a number of publications emphasising the benefits of judo [16, 17, 18]. Balance is one of the abilities playing an important part in this discipline. One of the objective of a judo contest is to gain advantage by throwing the opponent onto the mat. In order to create the best possible mechanical conditions for a throw, a judoka tries to unbalance the opponent at all cost. The opponent is thrown off balance (*kuzushi*) and will find it more difficult to defend himself or herself against the throw. On the other hand, the attacker is in a good position to perform stage II of the attack, i.e. entering the throw (*tsukuri*) and executing the throw (*kake*). However, an unbalanced opponent is by no means a passive opponent. His or her task is to try to stay on balance. A crucial role in the defence against an off-balancing attack is played by the muscles responsible for maintaining body balance. The strength of these muscles changes depending on a contestant's strength training. Thus defensive strength is one of the most important elements of a judoka's abilities. Maintaining balance also depends on e.g. the judoka's morphological features, including body mass and body height, height where the judoka is gripped during a throw. The height of the grip influences the arm of the rotational force used in off-balancing and the arm – on the torque [1]. Balance exercises in the early stages of training involve mainly off-balancing to create conditions in which judokas will be able to learn how to shift their centre of gravity, necessary to maintain their body position. These conditions are achieved by reducing the base surface in the standing position and in motion, making the base surface unstable, shifting the centre of gravity by changing the position of the body, and quick rotational movements [19]. The aim of the present study is to compare the development of balance in lower junior, junior and senior category judokas depending on their calendar age and training experience. The research questions were as follows: What are the differences in the results of dynamic and static balance tests? In which type of balance (dynamic or static) are theses differences at their most pronounced and why? What are the differences between the various age groups? The following hypotheses were put forward: Calendar age has a considerable impact on the development of body balance in judokas. Judo training is of crucial importance in the development of dynamic and static balance in judokas. Body balance improves with age and with the length of time in judo training.

Material and methods

The study featured 84 active judokas aged 15 to 42 from Wrocław clubs. They were divided into three age categories: lower junior, aged 15-16 (32 individuals); junior, aged 17-19 (24 individuals); and senior, over 20 (28 individuals). The experimenters took into account the subjects' calendar age, training experience, measurements of such somatic features as body mass and body height, and, additionally, the BMI (Body Mass Index). The level of body balance development was measured by means of two tests. Dynamic balance was measured by means of the Walking Test (walking over a special truss) developed by Ewaryst Jaskólski [2]. The truss comprised 5 three-metre-long beams connected by a fixed link (Fig. 1). The beams were of varying widths (9 cm, 7 cm, 5 cm, 3 cm and 1 cm) and were divided into 20-cm sections marking successive points from 1 to 75. The subjects performed the test, standing at point 1 with one foot on the widest beam and then walking along the beam, with the heel of the forward foot touching the toe of the back foot. Thus they were supposed to walk across each beam without touching the ground with either foot. The test was interrupted when a subject put the foot on the ground or failed to position the feet on the beam in the correct way. At the spot where the foot touched the ground the experimenters noted the number of points marked

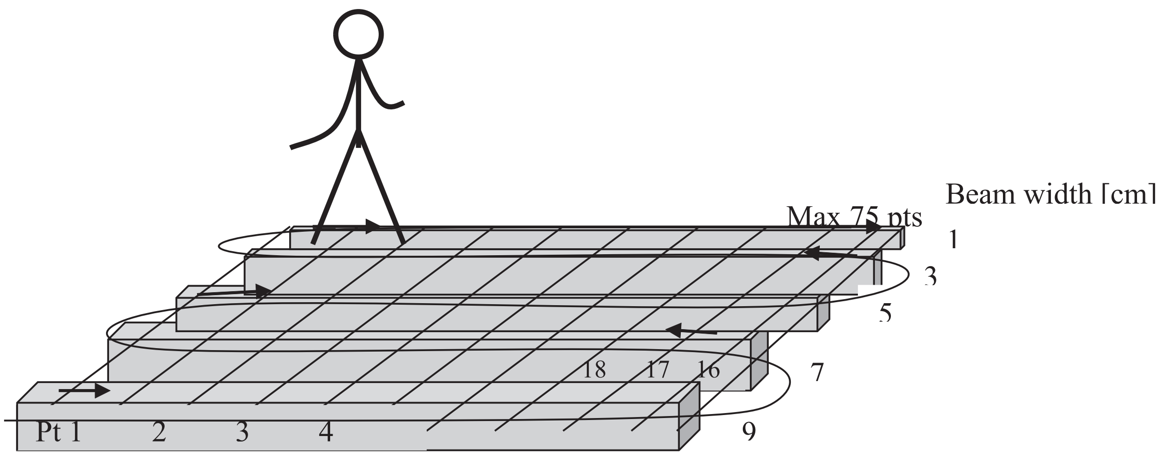

Fig. 1. "Truss walking" Test

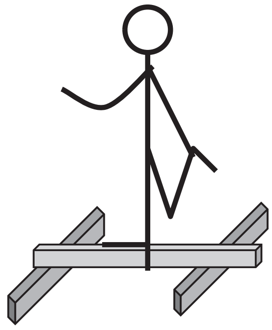

Fig. 2. Flamingo Test

on the beam. The test was performed once. Static balance was measured by means of the Flamingo Test [3].

The test was performed on a wooden beam measuring 50 cm (length) by 4 cm (height) by 3 cm (width) and resting on two supports (15 cm long and 2 cm wide) making the beam stable (Fig. 2). Each subject stood on one leg on the beam (with the foot positioned along the beam), gripping the free leg bent at the knee by the foot. The free hand rested on an experimenter's arm. The test started when the subject let go of the experimenter's arm and ended when the subject lost his balance, letting go of the foot of the free leg or touching the floor with any part of the body. The results were analysed by means of basic statistical methods. The experimenters calculated the arithmetic average, standard deviation and coefficient of variation for each feature in all groups. The differences in the averages between the study groups were assessed by means of the Student's t-test for independent samples. The critical value for the Student's t-test was obtained from statistical tables at the level of a = 0.05.

Results

The study featured two simple tests to assess balance. They demonstrated some differences depending on the age group. The results for the various analysed groups are presented in Tables 1-3. Table 1 contains the results for the lower junior category. When it comes to dynamic balance, the average score for this group was 53.634. The arithmetic averages in the Flamingo Test for the right and left legs were similar, 7.181 sec. (right leg) and 7.877 sec. (left leg) respectively.

Table 1. Statistical data for the results in the lower junior category

	Unit	N	Arithmetic average	Standard deviation	Coefficient of variation	Minimum	Maximum
1. Age	Years	32	15.355	0.486	3.17	15.000	16.000
2. Body weight	Kg	32	65.806	11.011	16.73	45.000	92.000
3. Body height	M	32	1.734	0.074	4.29	1.540	1.900
4. Years of training	Years	32	4.652	2.389	51.37	0.200	11.000
5. Dynamic balance	Points	32	53.645	13.568	25.29	19.000	75.000
6. Static balance right leg	Sec.	32	7.181	5.857	81.56	1.800	21.700
7. Static balance left leg	Sec.	32	7.877	12.185	154.68	1.400	68.800
8. BMI	points	32	21.764	2.330	10.70	16.652	27.774

Table 2. Statistical data for the results in the junior category

	Unit	N	Arithmetic average	Standard deviation	Coefficient of variation	Minimum	Maximum
1. Age	Years	24	18.042	0.859	4.76	17.000	19.000
2. Body weight	Kg	24	84.375	17.194	20.38	60.000	141.000
3. Body height	M	24	1.804	0.071	3.91	1.650	1.920
4. Years of training	Years	24	7.854	3.063	38.99	0.500	13.000
5. Dynamic balance	Points	24	63.833	11.754	18.41	34.000	75.000
6. Static balance right leg	Sec.	24	6.229	2.656	42.63	2.700	11.400
7. Static balance left leg	Sec.	24	6.625	5.050	76.22	2.100	26.600
8. BMI	points	24	25.802	4.334	16.80	20.911	38.249

Table 3. Statistical data for the results in the senior category

	Unit	N	Arithmetic average	Standard deviation	Coefficient of variation	Minimum	Maximum
1. Age	Years	28	24.929	5.062	20.31	20.000	42.000
2. Body weight	Kg	28	83.750	15.104	18.03	64.000	118.000
3. Body height	M	28	1.768	0.081	4.59	1.620	1.980
4. Years of training	Years	28	13.286	4.837	36.41	6.000	29.000
5. Dynamic balance	Points	28	69.107	9.354	13.54	40.000	75.000
6. Static balance right leg	Sec.	28	10.900	9.968	91.45	1.800	52.200
7. Static balance left leg	Sec.	28	10.021	11.664	116.39	2.000	63.000
8. BMI	points	28	26.643	3.320	12.46	20.988	34.108

Table 4. Student's t-test for two groups (lower junior and junior categories)

	Value of Student's t-test	Probability linked to type I error (P)
Age	-13.720	-0.0000***
Body weight	-4.609	0,0001***
Body height	-3.570	0,0008***
Years of training	-4.359	0,0001***
Dynamic balance	-2.925	0.0051**
Static balance right leg	0.804	0.4284
Static balance left leg	0.518	0.6089
BMI	-4.126	0.0004***

Table 5. Student's t-test for two groups (lower junior and senior categories)

	Value of Student's t-test	Probability linked to type I error (P)
Age	-9.966	0.0000***
Body weight	-5.167	0.0000***
Body height	-1.694	0.0957
Years of training	-8.550	0.0000***
Dynamic balance	-5.136	0.0000***
Static balance right leg	-1.724	0.0962
Static balance left leg	-0.689	0.4938
BMI	-6.469	0.0000***

Table 6. Student's t-test for two groups (junior and senior categories)

	Value of Student's t-test	Probability linked to type I error (P)
Age	-7.081	0.0000***
Body weight	0.140	0.8896
Body height	1.706	0.0942
Years of training	-4.905	0.0000***
Dynamic balance	-1.801	0.0777
Static balance right leg	-2.383	0.0245*
Static balance left leg	-1.396	0.1742
BMI	-0.792	0.4324

Table 2 contains the results for the junior category and Table 3 – for the oldest age group (senior judokas). In the junior category (Table 2) the arithmetic average for dynamic balance was 63.833 points. This score is higher than in the lower junior category. In the static balance test for the right leg the average result in the junior category was 6.229 sec. and for the left leg – 6.625 sec. Significantly, these results were lower than those in the lower junior category.

Table 3 demonstrates that in the oldest group – senior category – the arithmetic average in the dynamic balance test was 69.107 points, i.e. higher than in the two other groups. When it comes to static balance, the experimenters observed quite considerable differences in comparison with the previous groups. For the right leg the arithmetic average was 10.900 sec. and for the left leg – 10.021 sec. These results, too, were higher than in the two other groups.

The results of the various tests were analysed further. Tables 4-6 present comparisons of the results of tests for the various groups of judokas. The results unequivocally point to the differences in the levels of dynamic and static balance among judokas, taking into account their calendar age and training experience. To verify their hypothesis, the researchers used the Student's t-test to demonstrate statistically significant differences of 0.05; 0.01; 0.001.

Table 4 shows that dynamic balance is statistically significantly different between the lower junior and junior categories. Interestingly, there were no statistically significant differences in the static balance test. The results in both groups were similar. As we compare the lower junior category with the senior category, we see a statistically significant difference in dynamic balance. There is no such difference in static balance. Table 6 includes comparisons between the junior and the senior categories, but the results are completely different from the earlier comparisons; there are no statistically significant differences in dynamic balance. They do appear, however, when it comes to static balance in the right leg.

As we analyse these results, we can answer the questions presented earlier. When it comes to dynamic balance the biggest differences can be seen when we compare the lower junior category with the junior category, and the lower junior category with the senior category. Differences in static balance can be observed only in the comparison between the junior and senior categories, and concern the right leg. As we analyse calendar age and training experience, we can see a growing level of dynamic balance. When it comes to static balance, here, too, we can notice differences in its levels, but they are not linear. Judo is a discipline forcing the athletes to become versatile in terms of their motor abilities. Efficient and highly effective mechanisms for controlling balance are some of the criteria determining success at sports.

When it comes to the BMI, we can see (Fig. 3) that it begins at 20 in the first group and slowly rises with age to reach the value of over 26 in the oldest group. However, the values are still within the ranges for the subjects' age groups. The study has shown that dynamic balance improves with calendar age and training experience. This is well illustrated by Fig. 4, which shows the changes in dynamic balance in the various age groups.

Static balance measured by the time the subjects were able to stand on one leg in the "flamingo position" differed for the right and left leg in all studied groups. However, the results demonstrate that the level of static balance does not rise

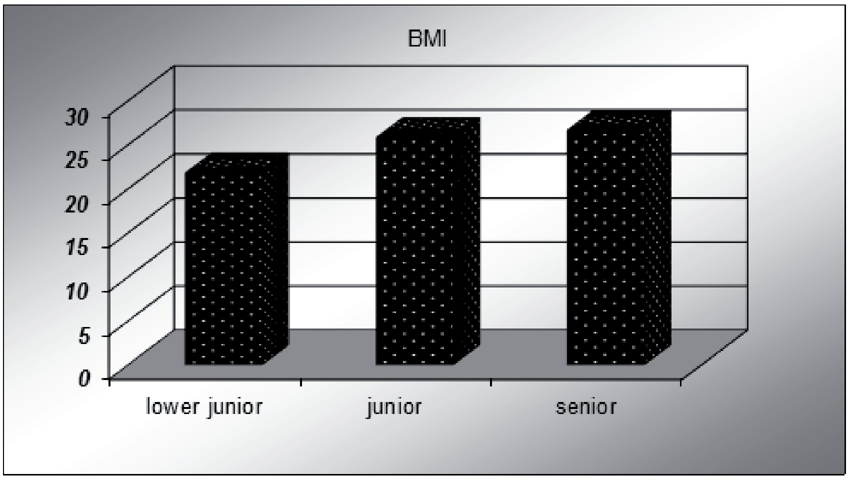

Fig. 3. Average BMI values of the studied groups

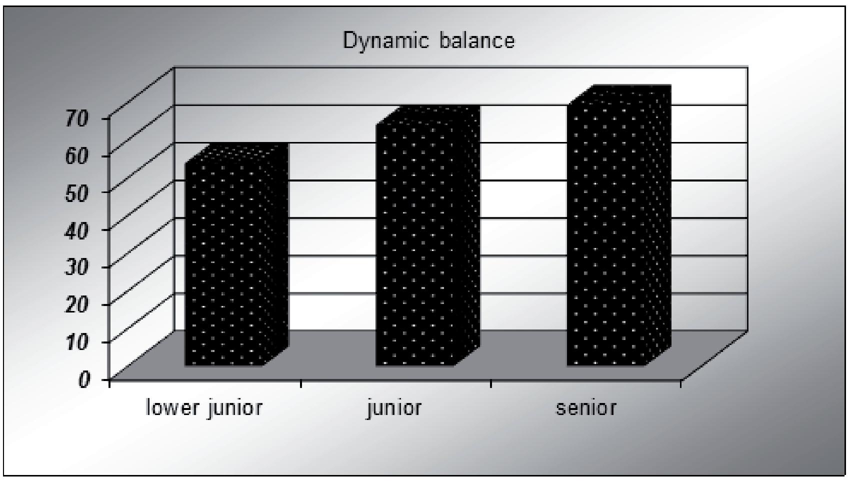

Fig. 4. Average values of dynamic balance in the three studied groups

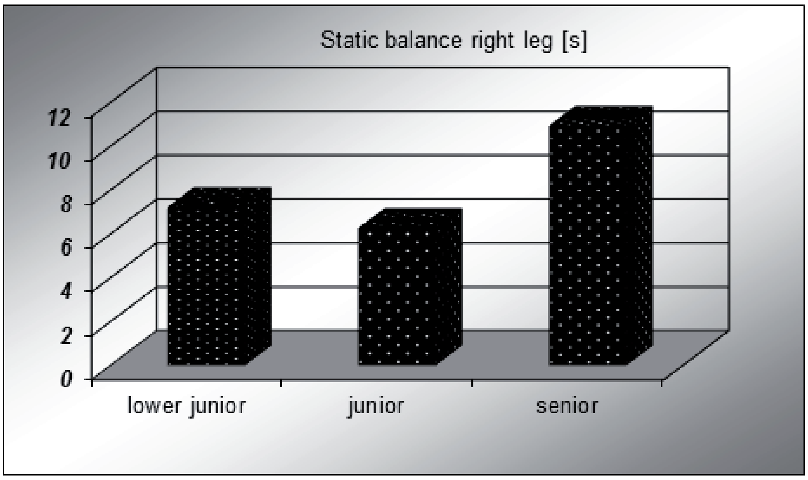

Fig. 5. Average values of static balance for the right leg in the three studied groups

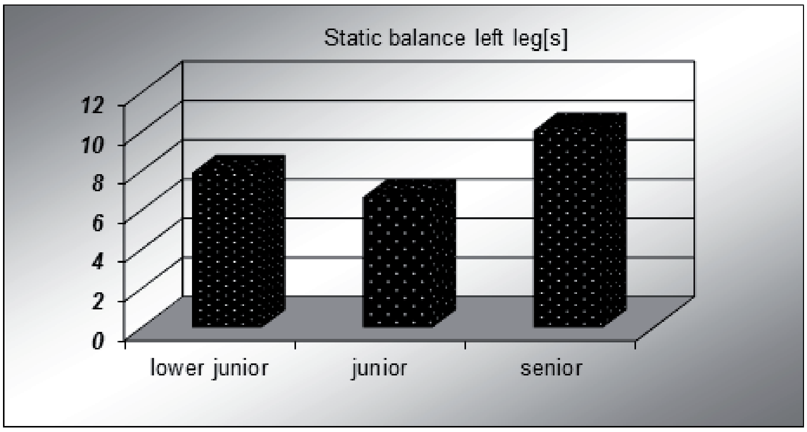

Fig. 6. Average values of static balance for the left leg in the three studied groups

with calendar age. The researchers have even noted a regression in the junior category, which may be linked to a rapid growth in body height, changes in body proportions (Fig. 5 and 6).

Discussion

According to Meinel [20], when it comes to motor abilities in sports, there might occur some interferences, which are revealed in the following circumstances: in difficult acyclical movements (e.g. apparatus exercises); in complex movements; when learning new movements; in posture during movements and involuntary movements, primarily within body parts that are of little significance to the ultimate result of an activity; in movements requiring exceptional accuracy and precision. Today we know that these interferences certainly do not concern everyone during puberty and certainly not everyone in equal measure. Stagnation is temporary and disappears towards the end of puberty. Puberty is marked by violent transformations in the whole body. Obviously, these processes also affect motor abilities and skills. They are reflected in individuals' rich emotional life, maturations of inhibition and activation processes in the nervous system, changes in the physiological equilibrium, intense morphological growth and changes in the proportions of the whole body. The concurrent phenomenon of pubertal spurt and sudden upward shift in the centre of gravity cause significant qualitative changes in motor abilities. These abilities undergo extraordinary changes in that period: while some develop at a rate similar to that in the previous period, the dynamics of change in others are huge and unique; finally, some qualities gradually cease to develop or even noticeably regress [21]. A rapid growth in the static form of balance has been observed in boys aged between 7 and 12. A clear regression occurs at the age of 14. This must be caused by the pubertal spurt in the growth of body height in boys, the upward shift in the centre of gravity associated with it and, consequently, poorer static balance. They reach the maximum values between the ages of 15 and 17 [22]. When it comes to dynamic balance, it develops rapidly until the age of 13 and clearly regresses at the age of 14. Boys reach their peak in this respect between the ages of 15 and 17. After that the level of balance gradually decreases with age [22].

In the present study the subjects from the lower junior category achieved similar results in terms of average dynamic and static balance values as in other studies by Witkowski et al. [23, 24]. Denisiuk et al. [25] noted clear motor fluctuations and movement disruptions during puberty among adolescents with a higher rate of somatic growth. Schnabel [10], on the other hand, wrote that periodic coordination disturbances were more frequent in boys.

In the present study the authors observed a decrease in the level static balance in the junior category in comparison with the lower junior category, which in some way confirms the findings presented in earlier publications [10,23]. Interestingly, the level of dynamic balance increased in this group.

The authors also analysed the BMIs of their subjects. In comparison with other indices the BMI correlates with body height the least, which is why it is more useful in the assessment of body mass, largely independent as it is of body height. The average value was within the normal range for all three studied groups. The lowest value was noted in the lower junior group, rising further with age.

Conclusions

1. Dynamic balance improves with calendar age and training experience.
2. The results demonstrate that the level of static balance does not rise with calendar age.
3. A regression in the level of static balance in the junior category has been observed, which may be linked to the rapid growth in body height in this age group.
4. The biggest differences have been observed in dynamic balance, which may be linked to the nature of the discipline, which involves being constantly in motion, changing the position of the body and loosing balance during contests.
5. Judo training influences the body build. The researchers have observed that judokas with longer training experience have higher BMIs (Body Mass Index).
6. The results achieved by the judokas show that judo is a discipline developing human motor abilities and coordination abilities in a variety of ways.

References

1. Erdman W. Badanie siły obronnej podczas zachowania równowagi w judo, [in:] Konferencja naukowo-metodyczna. Halin 16-18.05.1973. Warsaw; 1976.
2. Witkowski K, Stefaniak T, Kuźmiński J. Ocena równowagi ciała u osób trenujących judo. Biomechanika 2004; 455-60.
3. Raczek J, Mynarski W, Ljach. W. Kształtowanie i diagnozowanie koordynacyjnych zdolności motorycznych Podręcznik dla nauczycieli, trenerów i studentów Katowice: Wydawnictwo AWF; 2002. p. 26-64, 69-95.
4. Raczek J. Koncepcja strukturalizacji i klasyfikacji motoryczności człowieka, [in:] Motoryczność człowieka – jej struktura, zmienności i uwarunkowania (W. Osiński- ed.). Poznań: Wydawnictwo AWF; 1994. Monografia: 310, 65.
5. Szopa J. Uwarunkowania, przejawy i struktura motoryczności, [in:] Podstawy antropomotoryki (J. Szopa et al.) Kraków: PWN; 1996. p. 42-3.
6. Guilford JP. A system of the psychomotor abilities. American Journal Psychology 1958; 67: 411-26.
7. Gundlach H. Systembeziehungen korperlicher Fahigkeiten und Fertigkeiten. Theorie und Praxis der Korperkultur 1968; 2: 198-205.
8. Gundlach H. O systemie zależności pomiędzy zdolnościami i umiejętnościami fizycznymi, [in:] Sympozjum techniki sportowej. Warszawa: Sport i Turystyka; 1970. p. 185-94.
9. Schnabel G. Die koordinativen Fahigkeiten und das Problem der Gewandtheit, Theorie und Praxis der Korperkultur, 1973; 3: 263-269.
10. Schnabel G. Koordinative Fahigkeiten im Sport – ihre Erfassung und zielgerichtete Ausbildung. Theorie und Praxis der Korperkultur 1974; 7: 627-32.
11. Hirtz P. Schwerpunkte der koordinativ – motorischen Vervollkommnung im Sport-unterricht der Klassen 1 bis 10, Korperziehung 1978; 1: 340-3.
12. Hirtz P. Koordinative Fahigkeiten im Schulsport. Berlin: Volk und Wissen; 1985.
13. Golema M. Utrzymywanie równowagi ciała w postawie stojącej w ujęciu biomechanicznym, [in:] T. Bober (ed.), Potencjał ruchowy człowieka (badania w aspekcie biomechanicznym i uczenia się). Z warsztatów badawczych (Warszawa AWF) 1986: 75-110.
14. Samołyk A, Wierzbicka- Damska I, Witkowski K. Porównanie procesu utrzymania stabilnej postawy podczas stania swobodnego zawodników dżudo i studentów, AWF Wrocław. Zbornik referatov z medzinarodonej vedeckiej konferencie, Brarislava 13-14.11.2003.
15. Raczek J. Motoryczność człowieka – nowe poglądy oraz ich znaczenie dla praktyki treningu. Sport wyczynowy 1998; 5: 17-26.
16. Sikorski W. Nauka praktyce judo. Warszawa: Polski Związek Judo; 2010.
17. Witkowski K. Z historii systemów walk dalekiego wschodu. Wrocław: Wydawnictwo AWF; 1993. p. 79-89.
18. Witkowski K, Maśliński J, Kubacki R. Kompendium Judo – t1, podstawy tachi-waza. Wrocław: AWF; 2009.
19. Pawluk J. JUDO sportowe. Wydawnictwo Sport i Turystyka 1988: 103-10.
20. Meinel K. Motoryczność ludzka: zarys teorii cynności sportowych i działań ruchowych z punktu widzenia pedagogicznego. Sport i Turystyka (Warszawa) 1967; 16: 445.
21. Kalina RM, Bouchard C. Growth, Maturation, and Physical Activity. Champaign, Illinois: Human Kinetics Books; 1991.
22. Mynarski W, Raczek J. Zmienność ontogenetyczna wybranych koordynacyjnych zdolności motorycznych u dzieci i młodzieży w wieku 7-18 lat. Antropomotoryka 1992; 6: 7-11.
23. Witkowski K, Maśliński J, Remiarz A. Static and dynamic balance in 14-15 year old boys training judo and in their non-active peers. Arch Budo 2014; 10: 323-31.
24. Witkowski K, Cieśliński W. Sport rank and body stability in judoists, [in:] International Congress on Judo "Contemporery Problems of Training and Judo Contest". Spała, Poland; 9-11 November, 1987. p. 164-173.
25. Denisiuk L, Pilicz S, Sadowska J. O sprawności fizycznej młodzieży zasadniczych szkół zawodowych, Warszawa Państwowe Wydawnictwo szkolnictwa zawodowego, 1968: 215

Address for correspondence:
Jarosław Maśliński
Department of Sport Teaching, Academy of Physical Education, Wrocław,
ul. Paderewskiego 35, 51-612 Wrocław, phone: +48 71 347 33 79, e-mail: katedra.ds@awf.wroc.pl

Received: 22.02.2016
Accepted: 11.05.2016