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Conditioning and coordination motor abilities of combat sports athletes

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: Conditioning and coordination motor abilities (CMA) play a very important role in the process of sports training in learning a complex technique. Particularly in combat sports, including taekwondo, strikes and kicks performed in place, in a jump or in rotation, as well as combinations, allow you to create effective technical and tactical actions. Both of them have a significant impact on the sports results achieved in competitions. The aim of this study is the knowledge about level of conditioning and coordination motor abilities of combat sports athletes.

Material & Methods: The study was conducted on 30 person who have been taekwondo athletes for at least 5 years. Conditioning motor abilities (general physical fitness) was measured using the method recommended by the Polish Sports Association International Physical Fitness Test (IPFT) includes the following eight tests: 50 m dash, standing broad jump, long run 1000 m, hand grip; pull ups, 4x10 m shuttle run, sit ups, and bend trunk. Coordination motor abilities was measured using the Starosta Test. Body composition was measured device Tanita 545N. Statistical analysis was based on a Statistica software ver. 13.5.

Results: The taekwondo athletes differed in the level of physical fitness as well as somatic and body composition variables such as BMI, body weight, fat content, lean body mass, water content in the body and visceral fat. A relationship was found between the value of coordination motor abilities, the level of somatic features and general physical fitness.

Conclusions: In this research the positive influence of many years of training in the combat sport of taekwondo on the selected features of general physical fitness of athletes diagnosed by IPFT was observed. Similarly, this training influenced the level of global coordination, which should will contribute to the increase in special technical skills and indirectly to the results achieved in competitions. Both research using IPFT and Starosta's (coordination measure) turned out to be valuable research tools.

Keywords: body composition • CMA • combat sports • physical fitness

Conflict of interest: Author has declared that no competing interest exists

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Combat sports – *noun* a sport in which one person fights another, e.g. wrestling, boxing, taekwondo, and the martial arts [69].

Physical fitness – the ability of a person to function efficiently and effectively [70].

Coordination motor abilities (**CMA**) – psychomotor properties that define the readiness to control and regulate motor activities in an optimal way [18].

Body composition – body composition of the body provides important information about nutritional status of the organism and assessed by the simplest method of electrical bioimpedance (BIA), using i.e. Tanita, SECA, In Body devices, etc. [69].

INNOAGON – acronym 'innovative agonology' [62].

Innovative agonology – is an applied science dedicated to promotion, prevention and therapy related to all dimensions of health and regarding the optimization of activities that increase the ability to survive from micro to macro scales [60, p. 274].

INTRODUCTION

Modern training not only sports, is a complex process and its effectiveness is influenced by many factors, the knowledge of which constitutes the basis of the entire training activity, training management requires more and more extensive knowledge and all the threads of controlling the athletes development are concentrated in the competences of the trainer [1-3].

Knowledge about sports and training is constantly developing. We know more and more about the functioning of the human system, we are able to manage the complex processes of exercise adaptation more and more wisely and more effectively, and the result will be a high level of sports performance during competitions. Comprehensive training stimulates the development of physical fitness only up to a certain point, gradually limiting the strength of shaping influences [4].

The field of the physical condition skills is well investigated both theoretically and practically because of its simpler structure. On the other hand, the structure of the coordination skills is more complex and from the point of view of its development (expected positive changes) more demanding [5].

Many specialists prove that, especially in combat sports, physical fitness, including coordination motor abilities (CMA), as well as mental predispositions, are largely related to body structure and body composition, which determines technical and tactical activities, depending on the type of sport [6-13].

There are also few longitudinal studies concerning the dynamics of the development of coordination motor abilities which is probably due to the difficulty of organizing such studies. The scientific investigations have shown that such CMA as the force of spatial movement indicators, time of reaction, vestibular stability and the reaction to a moving object show a large stability in time [14].

Hirtz [15] considers the coordination abilities to be the complex and relatively independent presumptions of the performance regulations of the locomotive activities bases on the dominantly inherited, still they can be influenced by the neurophysiological function mechanisms and thus they are trainable. They are present at different levels of the specific locomotive activities, in the pace, speed and accuracy of acquiring the new activities and skills, in updates of the locomotive programs in accordance with the conditions, in the adequate application of the skills, in the level of using the locomotive skills, in the economic use of the energetic potential, in the purposeful, functional and aesthetic movements. They make higher demands on CNS and the functions of analysers (especially visual and vestibular). Considering the position of the coordination skills in the system of the human beings' motor we can conclude that CNS controls and coordinates of the body as a unit and at the same time comes up the coordination between the different functional systems that frequently operate autonomously.

In this regard much more attention is now paid to the matters of coordination-motor perfection in the programs of physical education and sport training of many countries. Many famous scientists have devoted their treatises to the study of the place, significance, notion, structure, ontogenesis, and training of CMA. Currently trainers apply conditioning training more often, thus neglecting the development of movement coordination motor abilities. It is known that the greatest adaptability of coordination abilities occurs between 7 and 12 as well as between 14 and 18 years of age and even though sensitive periods do not overlap in the findings of various authors, everybody is unanimous that developing coordination motor abilities in a period other than the sensitive one will be more laborious and less effective [16-18].

Both fitness and coordination (CMA) skills are currently perceived as integrated psychomotor properties determined dominantly by the functions of the muscular system and the central nervous system. Recently, there has been an increase in interest in research on metric coordination skills in combat sports, including taekwondo, wrestling and karate, as the improvement of already learned and teaching new elements depends on them, as they significantly influence the economy of movements and the proper use of players' energy resources during training and competitions [19-26].

As an Olympic and non-Olympic sport, taekwondo is a combat sport involving scientific and technological aspects. Taekwondo is mixes mental and physical training [27-30].

The aim of this study is the knowledge about level of conditioning and coordination motor abilities of combat sports athletes.

MATERIAL AND METHODS

Participants

The study was conducted on 30 person who have been taekwondo athletes for at least 5 years. Body height 182.07 ±5.61 cm, body weight 79.53 ±9.52 kg, BMI 23.87 ±1.996. Almost all taekwondo athletes had a normal body build.

Informed consent was obtained from all participants involved in the study.

The Ethics Committee of the Latvian Academy of Sport Education in Riga (Latvia) approved the study protocol, and all procedures followed the ethical standards of the Declaration of Helsinki.

Procedure

Body composition

We based the characteristics of the body composition on the recommended indicators: body height (cm), body weight (kg), BMI (body mass index) [31, 32]. Body composition was measured device Tanita 545N.

Diagnostics of general physical fitness

To evaluate of general physical fitness the International Physical Fitness Test was used (IPFT). The following sequence of test is recommended: on the first day fitness should be evaluated in the first three tests. On the second day the remaining tests are to be performed, i.e. from 4 to 8 (Figure 1). It is also possible to carry out

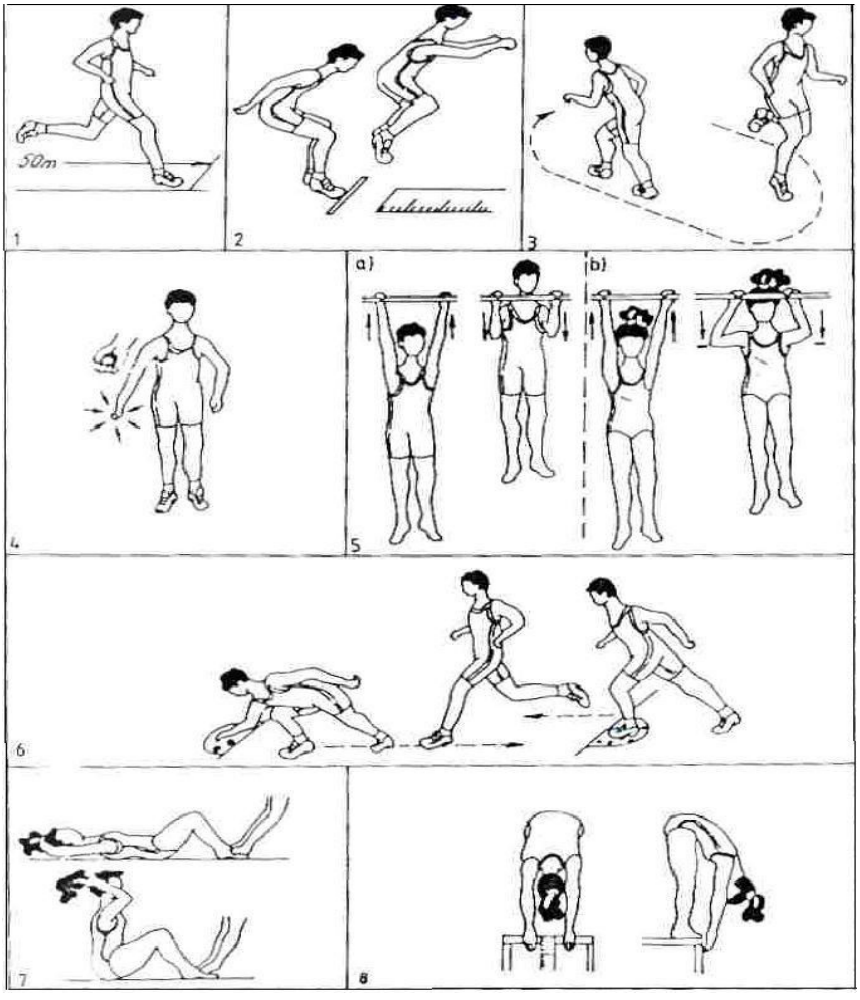

Figure 1. The International Physical Fitness Test (IPFT) [33].

all the tests on the same day according to the indicated sequence, however, the third exercise (long run) should be done at the end. The physical fitness trial includes the following eight tests: (1) 50 m dash; (2) standing broad jump; (3) long run 1000 m; (4) hand grip; (5) pull-ups on a bar and over; (6) 4x10 m shuttle run; (7) sit ups done within 30 s; (8) bend trunk.

Interpretation of results based on the recommendations of Tadeusz Ulatowski [34] addressed to athletes: outstanding level 641 and more points, high level 561 to 620-; medium level 481 to 560-; low level 401 to 480-; very low level 400 and less points. For individual trials they are in line with Ulatowski's recommendation: outstanding level 81 and more points, high level 71 to 80-; medium 61 to 80-; low level 51 to 60-; very low level 50 and less points.

Coordination motor abilities

To determine the level of motor coordination, the Starosta's global coordination test was used [35]. The test consisted in making a maximum turn in a jump with both legs to the right and left with the help of the hands. The measurements were carried out on a coordination meter, i.e. on a wooden platform with dimensions of 100 × 100 cm, on which a circle was drawn with a diameter 80 cm. There is a scale with degrees on the circumference of this wheel, separate for right and left turns. The task was started from a precisely determined position of the feet. After performing the rotation, the subject should 'land' within the circle, maintaining balance. By making appropriate determinations, the turnover rate was read. A higher numerical score indicates better global coordination (Figure 2).

Statistical analysis

The estimation of the results is based on the following indicators: frequency (N, n); mean (M); minimum (Min); maximum (Max); standard deviation (SD or ±). In the studies, the level of at least $p<0.05$ (also for a directional test) and higher was shown as statistically significant differences. Because of lack normal distribution for majority of the variables statistical analysis was based on a non-parametric test (Spearman correlation coefficient). The interpretation of the correlation coefficient (r) is based on the Guilford's classification. Calculus was performed using STATISTICA software ver. 13.5.

As the results of physical fitness tests are expressed in different units, scale T was used for their comparison and the results of Investigation expressed as points are compared.

RESULTS

In the study group, all subjects achieved a level of general physical fitness (GF) classified as high M = 567.3 ±22.8 points (Table 1). On the other hand, analysing individual elements of the physical

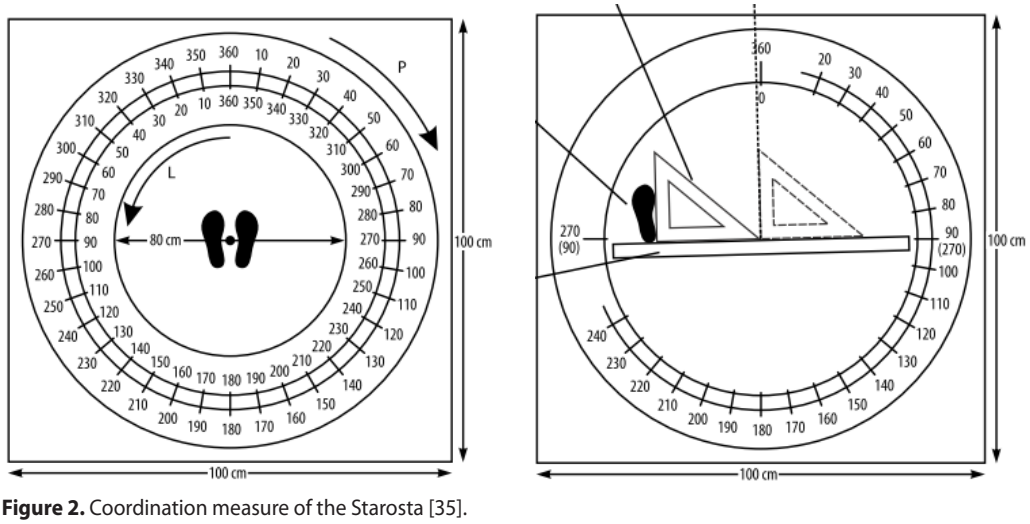

Figure 2. Coordination measure of the Starosta [35].

Table 1. Descriptive statistics for taekwondo athletes (n = 30) – ordinal variable: from the highest arithmetic mean of the result (points).

Variable	Mean	SD	SE	−95%CI	+95%CI	Min	Max	LQ	UQ
BT [cm]	**80.6**	6.0	1.1	78.3	82.9	71	92	76.0	85.0
SBJ [cm]	**73.5**	6.5	1.2	71.0	76.1	64	87	68.0	78.0
D 50 [s]	**73.1**	6.3	1.2	70.6	75.5	62	88	68.0	77.0
ShRu [s]	**71.7**	5.9	1.1	69.4	73.9	62	86	66.5	76.5
SU [n]	**70.6**	3.8	0.7	69.2	72.1	64	78	68.0	73.5
PU [n]	**67.6**	3.9	0.7	66.1	69.1	59	74	64.5	71.0
HGS [kg]	**67.3**	4.6	0.9	65.5	69.1	56	77	64.5	69.0
R1000 [s]	**62.9**	4.4	0.8	61.2	64.6	54	72	60.0	65.5
GF [point]	**567.3**	22.8	4.3	558.4	576.1	533	628	548.5	583.0
RL [degree]	**586.6**	66.1	12.5	561.0	612.3	485	740	527.5	630.0
RR [degree]	**578.4**	64.9	12.3	553.2	603.0	475	730	527.5	620.0

CI Confident Interval; **LQ** Lower Quantile; **UQ** Upper Quantile; **SE** Standard Error

Note: **D 50** 50 m dash; **SBJ** standing broad jump; **R1000** long run 1000 m; **HGS** hand grip; **PU** pull-ups on a bar and over; **ShRu** 4x10 m shuttle run; **SU** sit ups done within 30 s; **BT** bend trunk; **GF** general fitness; **RL** rotation to the left; **RR** rotation to the right

fitness of the studied taekwondo athletes studied to further analysis in the case of speed (D 50) M = 73.1 ±6.3; leg muscle strength (SBJ) M = 73.5 ±6.5; endurance (R1000) M = 62.9 ±4.4; hand grip (HGS) M = 67.3 ±4.6; arms muscle strength (PU) M = 67.6 ±3.9; agility (ShRu) M = 71.7 ±5.9; abdominal muscle strength (SU) M = 70.6 ±3.8 and flexibility (BT); M = 80.6 ±6.0. However, when analysing global coordination, it was noticed (RL) M = 586.6 ±66.1 and (RL) M = 578.4 ±64.9.

The tested taekwondo athletes were characterized by a high and medium level of general physical fitness (M = 567.3 ±22.8 points, Min 533-, Max 628 points).

As the results of physical fitness tests are expressed in different units, scale T was used for their comparison and the results of Investigation expressed as points are compared.

There is a strong positive correlation between speed (D 50) and leg muscle strength (SBJ) agility (ShRu), general physical fitness (GF), rotation to the left (RL) and rotation to the right (RR). Additionally also observed strong positive correlation between leg muscle strength (SBJ) and agility (ShRu), general physical fitness (GF), rotation to the left (RL) and rotation to the right (RR), also agility (ShRu) or abdominal muscle strength (SU) and general physical fitness (GF), also general physical fitness (GF) and rotation to the left (RL) and rotation to the right (RR). Average and weak correlation in other cases. Any correlations were observed between somatic features (BM, BH and BMI) only between the individual components of fitness and global coordination (Table 2).

DISCUSSION

Problems of physical condition and coordination motor abilities training and monitoring in sports, many of its theoretical and practical aspects have found recently further development (expected positive changes). In particular, attempts to determine place, tasks and content of condition and coordination training within the long-term preparation of athletes engaged in combat sports have been undertaken [1, 14, 4].

Table 2. Spearman correlation matrix of elements of physical fitness and global coordination – significant correlation are marked in bold print (n = 30).

Variable	R50	SBJ	R1000	HGS	PU	ShRu	SU	BT	GF	RL	RR
D 50	-	**0.721**	0.222	0.115	–0.058	**0.505**	0.345	0.299	**0.803**	**0.717**	**0.691**
SBJ		-	0.261	–0.172	0.112	**0.555**	0.487	0.039	**0.755**	**0.694**	**0.732**
R1000			-	0.207	–0.120	0.244	0.381	–0.025	0.469	0.253	0.206
HGS				-	0.188	0.158	0.052	–0.124	0.272	0.204	0.096
PU					-	–0.127	0.178	–0.006	0.197	0.176	0.216
ShRu						-	0.447	–0.055	**0.672**	0.384	0.363
SU							-	0.265	**0.704**	0.306	0.348
BT								-	0.358	0.153	0.140
GF									-	**0.705**	**0.683**
RL										-	**0.976**

Note: **D 50** 50 m dash; **SBJ** standing broad jump; **R1000** long run 1000 m; **HGS** hand grip; **PU** pull-ups on a bar and over; **ShRu** 4x10 m shuttle run; **SU** sit ups done within 30 s; **BT** bend trunk; **GF** general fitness; **RL** rotation to the left; **RR** rotation to the right

The results of these investigations concerning physical condition and selected coordination motor abilities taekwondo athletes confirm the known dependence the number of years and quality of training and the level of training. The causes of this regularity are seen in the positive and multifaceted role play professional competences of the trainer [36].

Whereas states [37] effective work in this profession cannot be schematic when many different roles have to be reconciled at the same time. For instance, a trainer has to adequately motivate the competitors in order to shape their attitudes, and at the same time, he must act as a teacher, scientific observer, manager etc.

Similar research was conducted [38] only regarding body composition but also the special abilities of female ju-jitsu athletes. They stated that it is related to their weight category but does not affect the results in special fitness tests. In turn, profile analysis enabled group and individual diagnosis of fitness preparation. The authors revealed that such a diagnosis can be used to compare athletes at the time of measurement, as well as in the process of monitoring changes occurring in the training cycle. While the established structure of special fitness among female top ju-jitsu contestants can be used for comparisons with male representatives.

Another research [39] observed that senior judoists expressed better balance ability compared to both juniors and cadets. The balance training may lead to task specific neural adaptation at the spinal and supra-spinal levels, such as muscle stretch reflex during postural task, which leads to less destabilizing movements and improved balance ability [40].

Authors of numerous studies on wrestlers regarding the role of coordination motor abilities in increasing the effectiveness of the sports training process. They claim that coordination motor abilities significantly contribute to the quality of motor learning and the stabilization of sports technical and tactical skills and their adequate use during competitions [41-48]. In turn, mainly on karate athletes, both general and special physical fitness tests were carried out by other Polish and foreign researcher [49-54].

Studies aimed at optimizing and experimental testing of the methods for diagnosis and control of condition and coordination skills have

been conducted, their structure and the leading components of combat sports have been determined depending on age, sex, skill level, stage of preparation and other factors. More and more empirical data concerning relationship between different coordination and conditioning capacities, as well as between technical and tactical skills with account for the abovementioned factors have appeared.

Research was conducted on combat sports athletes aimed at developing and experimentally testing methods for diagnosing and controlling fitness and coordination skills, their structure and leading elements of combat sports were determined depending on age, gender, skill level, stage of preparation and other factors to also avoid injuries [55, 56]. There is more and more empirical data on the relationship between various coordination and fitness abilities as well as technical and tactical skills, taking into account the above factors.

To sum up, it should be said that sports results depend on many factors, both innate and acquired. In combat sports, the effectiveness of performing complex techniques is influenced by genetic factors, such as the ability to rhythmist movements, maintain balance, relax muscles, differentiate the amount of force or spatial orientation, as well as the level of acquired skills, which include technical elements obtained through heavy, systematic work training. In the tests and trials performed, we deal with both acquired and genetic factors.

In the text, I added 'expected positive changes' several times in brackets after the word 'development' to emphasize the positive connotation of this word as a key term 'innovative agonology' (acronym INNOAGON – see glossary and basic publications [57-65]). The inspiration is the ground-breaking discovery of Kalina et al. [66] questioning the validity of the 'toddlerhood and pre-school motor development' paradigm. Researchers have provided empirical evidence that four-year-old children support themselves with their hand(s) during each unintentional fall (in controlled, safe laboratory conditions), and some of them even collide with their heads on the ground. Meanwhile, approximately 65% of the population of two-year-olds in identical circumstances unconsciously protects their hands and heads during a collision with the ground. The authors of the discovery proposed the following name for this period of ontogenesis: 'the first period of positive and negative changes in human motor skills already at toddlerhood and pre-school age' [66, p. 222].

This discovery is related to factors that may interfere with the process of stimulating coordination abilities (in the broadest possible sense) already in the period of ontogenesis when the child is not yet subject to school education. However, there is evidence that children are taught sports motor activities as early as four years of age (tennis, skiing, gymnastics, etc.) and this phenomenon should therefore be carefully studied. The optimal solution is a complementary approach – the basic INNOAGON method [67, 68].

CONCLUSIONS

In this research the positive influence of many years of training in the combat sport of taekwondo on the selected features of general physical fitness of athletes diagnosed by IPFT was observed. Similarly, this training influenced the level of global coordination, which should will contribute to the increase in special technical skills and indirectly to the results achieved in competitions. Both research using IPFT and Starosta's (coordination measure) turned out to be valuable research tools.

These results may suggest that monitoring concerning physical conditions and selected coordination motor abilities is very useful when creating annual training plans and selecting optimal training loads.

Limitations

The study has several limitations, such as having no control group. Thus, we suggest that future studies should be conducted on larger samples, preferably selected by random sampling groups.

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REFERENCES

1. Naglak Z. Trening sportowy: teoria i praktyka. Warszawa-Wrocław: Państwowe Wydawnictwo Naukowe; 1977 [in Polish]
2. Litwiniuk A, Grants J, Waldzinski T. Professional competences of personal trainers. Arch Budo Sci Martial Art Extreme Sport 2020; 16: 79-84
3. Kruszewski A, Litwiniuk A. The importance of the quality of education of personal trainers from the perspective of personal security. Arch Budo Sci Martial Art Extreme Sport 2021; 17: 197-202
4. Sozański H, Czerwiński J, Sadowski J, editors. Podstawy teorii i technologii treningu sportowego. Biała Podlaska: Akademia Wychowania Fizycznego Józefa Piłsudskiego w Warszawie, Zamiejscowy Wydział Wychowania Fizycznego; 2013 [in Polish]
5. Sertić H, Baić M, Segedi I. Metric characteristics of chosen acrobatic tests for advanced wrestlers. In: Sadowski J, editor. Coordination Motor Abilities in Scientific Research. Vol 20. Warsaw: Jozef Pilsudski University of Physical Education in Warsaw, Faculty of Physical Education in Biala Podlaska; 2005: 247-252
6. Starosta W. Znaczenie badań koordynacji ruchowej dla doskonalenia sportowego zaawansowanych zawodników. Kult Fiz 1987; 34: 33-40 [in Polish]
7. Szopa J. Genetyczne uwarunkowania zdolności motorycznych – przegląd zagadnienia. Antropomotoryka 1992; 8: 141-155 [in Polish]
8. Kalina RM. Teoria sportów walki. Warszawa: Centralny Ośrodek Sportu; 2000 [in Polish]
9. Sieber L, Cynarski WJ, Litwiniuk A. Spheres of fight in martial arts. Arch Budo 2007; 3: 42-48
10. Litwiniuk A, Daniluk A, Cynarski WJ et al. Structure of personality of person training jujitsu and wrestling. Arch Budo 2009; 5: 139-141
11. Raczek J. Antropomotoryka: teoria motoryczności w zarysie. Warszawa: Wydawnictwo Lekarskie PZWL; 2010 [in Polish]
12. Kuśnierz C, Cynarski WJ, Litwiniuk A. Comparison of aggressiveness levels in combat sports and martial arts male athletes to non-practising peers. Arch Budo 2014; 10: 253-260
13. Litwiniuk A, Grants J, Kravalis et al. Personality traits of athletes practicing eastern martial arts. Arch Budo 2019; 15: 195-201
14. Raczek J, Mynarski W. Koordynacyjne zdolności motoryczne dzieci i młodzieży: struktura wewnętrzna i zmienność osobnicza. Katowice: Akademia Wychowania Fizycznego; 1992 [in Polish]
15. Hirtz P. Koordinačné schopnosti – charakteristika, dynamika vývinu a možnosti ovplyvnenia. Tréner; 1982 [in Slovak]
16. Ljach W. Kształtowanie zdolności motorycznych dzieci i młodzieży: podręcznik dla nauczycieli, trenerów i studentów. Warszawa: Centralny Ośrodek Sportu; 2003 [in Polish]
17. Osiński W. Antropomotoryka. Poznań: Akademia Wychowania Fizycznego; 2003 [in Polish]
18. Starosta W. Globalna i lokalna koordynacja ruchowa w wychowaniu fizycznym i w sporcie. Warszawa: Międzynarodowe Stowarzyszenie Motoryki Sportowej; 2006 [in Polish]
19. Cynarski WJ, Obodyński K, Litwiniuk A. The technical advancement and a level of chosen coordination motor abilities of people practicing karate. In: Sadowski J, editor. Coordination Motor Abilities in Scientific Research. Vol 20. Warsaw: Jozef Pilsudski University of Physical Education in Warsaw, Faculty of Physical Education in Biala Podlaska; 2005: 428-433
20. Litwiniuk A, Cynarski WJ, Blach W. The level of coordination motor abilities in persons practicing taekwon-do depending on the training experience. In: Sadowski J, editor. Coordination Motor Abilities in Scientific Research. Vol 20. Warsaw: Jozef Pilsudski University of Physical Education in Warsaw, Faculty of Physical Education in Biala Podlaska; 2005: 434-440
21. Kruszewski A, Szczęsna K, Litwiniuk A et al. The ability of keeping the state of body balance by people practising karate. In: Sadowski J, editor. Coordination Motor Abilities in Scientific Research. Vol 24. Warsaw: Jozef Pilsudski University of Physical Education in Warsaw, Faculty of Physical Education in Biala Podlaska; 2008: 209-215
22. Kruszewski A, Wiktorek P, Litwiniuk A et al. The ability level of keeping body balance and fighting in a man-to-man clash. In: Sadowski J, editor. Coordination Motor Abilities in Scientific Research. Vol 24. Warsaw: Jozef Pilsudski University of Physical Education in Warsaw, Faculty of Physical Education in Biala Podlaska; 2008: 216-222
23. Litwiniuk A, Wieleba A, Cynarski WJ. The structure of coordination motor abilities of the Polish team traditional karate athletes. In: Sadowski J, editor. Coordination Motor Abilities in Scientific Research. Vol 24. Warsaw: Jozef Pilsudski University of Physical Education in Warsaw, Faculty of Physical Education in Biala Podlaska; 2008: 228-231
24. Litwiniuk A, Bujak Z, Mastalerz A et al. Comparison of Maintaining of Body Balance in Combat Sports Between Experts and Non-Experts. J Kinesiol Exerc Sci 2023; 102(33): 21-27
25. Witkowski K, Superson M, Piepiora P. Body composition and motor potential of judo athletes in selected weight categories. Arch Budo 2021; 17: 161-175
26. Boguszewski D, Falkowska M, Adamczyk JG. Effect of 10-Week Progressive Stretching Exercise Programme on Functional Limitations of Musculoskeletal System. Pol J Sport Tour 2023; 30(1): 22-26
27. Choi HH. Encyclopedia of taekwon-do. Vol 1. Mississauga: International Taekwon-Do Federation; 1983
28. Kim YK. TaeKwon-Do: Philosophy History Technique. Orlando: World Martial Art Research Institute; 1985
29. Choi JH, Bryl A. Taekwon-do: koreańska sztuka samoobrony. Wrocław: Iglica; 1990 [in Polish]
30. Burdick D. People & Events in Taekwondo's Formative Years. J Asian Martial Arts 1997; 6(1): 30-49
31. Wattanapenpaiboon N, Lukito W, Strauss BJG et al. Agreement of skinfold measurement and bioelectrical impedance analysis (BIA) methods with dual energy X-ray absorptiometry (DEXA) in estimating total body fat in Anglo-Celtic Australians. Int J Obes 1998; 22: 854-860
32. Kyle UG, Bosaeus I, De Lorenzo AD et al. Bioelectrical impedance analysis—part I: review of principles and methods. Clin Nutr 2004; 23(5): 1226-1243
33. Pilicz S, Przewęda R, Dobosz J et al. Punktacja sprawności fizycznej młodzieży polskiej wg Międzynarodowego Testu Sprawności Fizycznej: kryteria pomiaru wydolności organizmu testem Coopera. Studia i Monografie. Warszawa: Akademia Wychowania Fizycznego; 2002 [in Polish]
34. Ulatowski T. Wszechstronna sprawność fizyczna – podstawa mistrzostwa, konieczność testowania. In: Śledziewski D, Karwacki A, editors. Szkolenie uzdolnionej sportowo młodzieży w polskim systemie edukacyjnym. Warszawa: Estrella; 2003: 88-114 [in Polish]
35. Starosta W. Nowy sposób pomiaru i oceny koordynacji ruchowej. In: Materiały I Konferencji Metody Badawcze w Wychowaniu Fizycznym i Sporcie; 1976 Nov 12-13; Poznan, Poland. Poznan: Akademia Wychowania Fizycznego; 1978: 365-369 [in Polish]
36. Sterkowicz S, Garcià Garcià JM, Lerma FS. The importance of judo trainers' professional activities. Arch Budo 2007; 3: 57-61
37. Murphy M, Houlston D, Cooke G. The Coach in Action: The National Coaching Foundation: Introductory Study Pack. Leeds: Coachwise Ltd; 1984
38. Sterkowicz-Przybycień K, Ambroży T, Jasiński M et al. Body build, body composition and special fitness of female top ju-jitsu contestants. Arch Budo 2014; 10: 117-125
39. Sterkowicz S, Lech G, Jaworski J et al. Coordination motor abilities of judo contestants at different age. Abstract book of the 12th International Scientific Conference of Sport Kinetics; 2011 Sep 22-24; Krakow, Poland. Krakow: University School of Physical Education in Krakow, International Association of Sport Kinetics; 2011: 199-200
40. Hrysomallis C. Balance ability and athletic performance. Sports Med 2011; 41(3): 221-232

41. Starosta W. Sprawność ogólna i specjalna zaawansowanych zapaśników (styl klasyczny i wolny) w świetle badań prowadzonych w latach 1981-1984. Warszawa: Instytut Sportu; 1984 [in Polish]
42. Gierczuk D. Level of selected indicators of coordination motor abilities in Greco-Roman and freestyle wrestlers aged 13-14. Pol J Sport Tour 2008; 15(4): 192-199
43. Sadowski J, Gierczuk D. Correlations between selected coordination motor abilities and technical skills of Greco-Roman wrestlers aged 14-15. Arch Budo 2009; 5: 35-39
44. Gierczuk D, Sadowski J. Effectiveness of coordination training in technical preparation of freestyle wrestlers at various levels of sports advancement. Arch Budo 2010; 6(3): 143-148
45. Gierczuk D, Lyakh V, Gierczuk A. Changes in the level of coordination motor abilities in Greco-Roman wrestlers aged 12-19. Antropomotoryka 2012; 22(58): 75-85
46. Sadowski J, Gierczuk D, Miller J et al. Success factors in elite WTF taekwondo competitors. Arch Budo 2012; 8(3): 141-146
47. Gierczuk D, Sadowski J. Dynamics of the development of coordination motor abilities in freestyle wrestlers aged 16-20. Arch Budo 2015; 11: 79-85
48. Starosta W, Baić M. Battery of tests for evaluation level of motor abilities in high advanced wrestlers from perspective of 32 years of using in practice. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 213-220
49. Story G. Testing fitness for karate. Sports Coach 1989; 35-38
50. Sterkowicz S. Charakterystyka wybranych wskaźników określających stan przygotowania zawodników karate. Kraków: Akademia Wychowania Fizycznego imienia Bronisława Czecha; 1992: 47 [in Polish]
51. Sterkowicz S. Sprawność fizyczna karateków. Wych Fiz Sport 1992; 1-2: 59-67 [in Polish]
52. Sterkowicz S. Test specjalnej sprawności ruchowej w judo. Antropomotoryka 1995; 12-13: 29-44 [in Polish]
53. Sterkowicz S. Zdolności koordynacyjne a sprawność specjalna karateków. Antropomotoryka 1998; 18: 65-77 [in Polish]
54. Sterkowicz S, Franchini E. Testing motor fitness in karate. Arch Budo 2009; 5: 29-34
55. Błach W, Dobosz D, Gasienica-Walczak B et al. Falls Are the Leading Cause of Injuries among Farmers—Limitations of Practicing Judo in Preventing These Incidents. Appl Sci 2021; 11(16): 7324
56. Litwiniuk A, Knas M, Grants J. The diagnostic value of the 'Rotational Test' in preclinical studies – an example of combat and non-combat sports athletes research before and after an alpine skiing course. Arch Budo 2021; 17: 357-370
57. Kalina RM. Agonology – the unknown science. Arch Budo 2016; 12: 231-237
58. Kalina RM. Innovative agonology as a synonym for prophylactic and therapeutic agonology – the final impulse. Arch Budo 2016; 12: 329-344
59. Kalina RM. Language and methods of innovative agonology as a guide in interdisciplinary research on interpersonal relationships and people with the environment – from micro to macro scale. Arch Budo 2020; 16: 271-280
60. Kalina RM. Innovative Agonology – Its Definition, Detailed Theories, General Rule of Struggle, and Laws. Proceedings of the 14th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences (AHFE 2023); 2023 Jul 20-24; San Francisco, USA. Healthcare and Medical Devices 2023; 79: 272-279
61. Kalina RM, Bagińska J. Language of Innovative Agonology: A Guide in Combining Micro and Macro Scales of Preventive, Therapeutic and Defensive Actions. Proceedings of the 14th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences (AHFE 2023); 2023 Jul 20-24; San Francisco, USA. Healthcare and Medical Devices 2023; 79: 307-315
62. Kalina RM, Kruszewski A. INNOAGON is an acronym for 'innovative agonology', but is not synonymous with 'science of martial arts'. Arch Budo 2023; 19: 193-204
63. Kruszewski A, Gąsienica Walczak B. Although "self-defence" is an individual case of human defensive struggle and the object of research of the specific sciences dedicated to struggle, it also is a term borrowed by other categories of sciences classified by WoS. Arch Budo 2023; 19: 61-75
64. Waszkiewicz E. Multidimensional Educational Models Recommended by Innovative Agonology – Examples of Physical Education and Music Education. Proceedings of the 14th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences (AHFE 2023); 2023 Jul 20-24; San Francisco, USA. Healthcare and Medical Devices 2023; 79: 290-298
65. Witkowski K. Kalina RM. Struggle: The Most Frequently Used Word in the Public Sphere Since the Beginning of the COVID-19 Pandemic. Proceedings of the 14th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences (AHFE 2023); 2023 Jul 20-24; San Francisco, USA. Healthcare and Medical Devices 2023; 79: 299-306
66. Kalina RM, Dłubacz N, Zachwieja J et al. Innovative method of diagnosing the susceptibility to the body injuries during the fall of children from 2 to 6 years. Arch Budo Sci Martial Art Extreme Sport 2022; 18: 211-228
67. Kalina RM. Complementary Medicine – An Example of the Application of the Basic Research Method of Innovative Agonology. Proceedings of the 14th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences (AHFE 2023); 2023 Jul 20-24; San Francisco, USA. Healthcare and Medical Devices 2023; 79: 316-324
68. Kalina RM. Methodology of complementary research as the basis for integrating science in fulfilling its social mission in the future. Arch Budo 2023; 19: 77-82
69. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006
70. Kent M. The Oxford dictionary of sports science and medicine. Oxford-New York-Tokyo: Oxford University Press; 1994

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