Profiles of the ability to optimally use the limbs muscle strength of combat sports athletes, racket sports athletes and drummer as validation of the accuracy of the recommended methods of measuring this phenomenon

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

Background and Study Aim: The phenomenon of ability to optimally use the muscle strength (AOUMS) has not been explored in either human motor science or other specialized sports science. The aim of this study is to find out whether athletes and musician, who differ in many ways, but whose essence of motor activity is the use of the upper and lower extremities, differ in their individual AOUMS profile.

Material and Methods: The eldest of the research subjects (age 59 years; 161 cm; 64 kg) is a combat sports and martial arts practitioner and coach (aikido, boxing, judo, karate kyokushin, taekwondo ITF), with total 37 years of experience; younger research subjects are: a tennis player and coach (49 years; 172 cm; 79 kg) 34 years of experience; karate athlete (22 years; 186 cm; 87.5 kg) 9 years of experience; box athlete (21 years; 175 cm; 78 kg) 4.5 years of experience; table tennis player (20 years; 178 cm; 80.5 kg) 10 years of experience; drummer (19 years; 203 cm; 120 kg) almost 3 years of percussion play experience. The methods used were those recommended by Kalina (2021): 'diagnostic exercise systems.' Diagnosing of upper limbs AOUMS (quasi-apparatus version): baseball throw (dominant hand first) in a relatively isolated posture (heels, buttocks and back pressed against the wall), alternatively with eyes open and covered with goggles. Diagnosis of lower limb AOUMS (non-apparatus version): long jump from standing posture. Identical patterns of force use in diagnosing upper and lower limbs were used (the first exercise with eyes open, the second exercise eyes covered) and then alternated: 50%, 25%, 75%, 50% , 35%, 85%. The series of six exercises ended with three trials with eyes open, each at 100% (the farthest throw/jump was the frame of reference for measuring the conformity of each score to the model expressed in %). The subjects had no prior knowledge of the methods.

Results: The young table tennis player showed the most accurate use of force (according to the model) - lower extremities: five times errors less than 3% and only once 7.14% (total 15.51%). A much older tennis expert twice less than 3.5%, four times from 6.56 to 12.34% (total 43.5%). The hand profiles of dominant racket sports players are similarly varied: table tennis player five errors less than 4 (once 8.83% with eyes open; total of 18.78%); tennis expert twice less than 5%, four times from 14.57 to 22.03% (total 80.79%). The sum of combat sports expert errors was: legs 32%:, dominant hand 37.5%, while drummer: legs 54.36%:, dominant hand 72.72%.

Conclusions: Individual AOUMS profiles varied significantly with a clear representation of either the favourable impact of years of practice (young table tennis player and combat sports expert results) or the low effectiveness when trained too briefly (drummer profile). Innovative methods of measuring the AOUMS phenomenon meet the criteria of relevance of the tools according to the purpose they are intended to serve. Although 'diagnostic exercise systems' are not tests that could be subjected to a standardization procedure, however, used, according to the author's assumption, in a flexible manner, they can be widely applied in sports, military training, physical education or rehabilitation (a very good example of adapted physical activity).

Key words: kinaesthetic differentiation ability • motor kinesthetic sensation • proprioception

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Kinaesthetic differentiation ability – is the total coordination of motor abilities. This ability allows for the perception and control of body movements.

Motor kinesthetic sensation – ability to sense the position and movement of our limbs and trunk.

Proprioception – body ability to sense movement, action, and location. It's present in every muscle movement.

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 [29].

Quasi-apparatus test – can be conducted with simple instruments (a stopwatch, a ruler, a measuring tape, etc.) [29].

INTRODUCTION

The phenomenon of ability to optimally use the muscle strength (AOUMS) has not been explored in either human motor science or other specialized sports science. However, the phenomenon so specifically named only broadens the perception of the possibility of measuring kinaesthetic differentiation [e.g. 1-4]. The most important issue in methodological terms is the way in which the AOUMS phenomenon is studied in comparison to existing methods of measuring kinaesthetic differentiation in a comprehensive rather than selective approach.

Kalina's [5, 6] proposals boil down to simple, easy-to-use sets of exercises adapted separately for the examination of lower limbs and upper limbs, and, what is real, differing due to the separate motor functions of the arms and legs. Particularly cognitively important is the possible variant of using open and covered eyes alternately in the course of the experiment. An important methodological element is also the use of simple tools (sheets of paper) to control the stability of the vertical posture of the examined person in the case of measuring AOUMS upper limbs, without the need to use complicated apparatus. When throwing a baseball at a distance resulting from the adopted model of using force in relation to the perceived maximum force at the time of the tests, these sheets of paper must be pressed against the wall with the muscles of the back and buttocks for the attempt to be considered valid. Furthermore (again an important methodological aspect), the measurement of the maximum muscle strength of the tested limb (limbs) is made with eyes open only during three exercises that end a given set of exercises.

Kalina, however, did not make a complete assessment of the accuracy of the proposed, more of a method than specific tools for measuring AOUMS. In general, he based the validation on arguments regarding: criterion oriented validity – concurrent validity and predictive validity; content validity; construct validity. However, he put forward two hypotheses, whose positive verification would mean that the method and the proposed tools for measuring the AOUMS phenomenon (which can be created by the researcher himself for the purpose of the specificity of the analysed motor skills) would be the final proof of the accuracy of these unique tools, enriching the equally unique, new applied science – innovative agonology [7, 8], which is related to many aspects of also a new sub-discipline, namely the science of martial arts [9-17].

Your hypotheses. H1: If the results of the measurement of the phenomenon of the ability to optimally use the muscle strength of people differentiated in many respects (especially many years of experience of specialized motor skills) were very similar under conditions when the other evaluation circumstances are identical (the same measurement model, due to the method and tools used time of day, health condition of the examined person, etc.), which means that neither the method nor the tools (test, exercise, set of exercises, etc.) meet the required validity. H2: Any similarity discovered when measuring the ability to optimally use the muscle strength of people who differ in many respects, especially long-term experience of specialized motor skills, does not negate the accuracy of the method and measurement tool used (if the condition of basing the evaluation on these criteria has been met), but it is indirect evidence of the existence of a common neurophysiological factor that determines the stated state of affairs [5, 6].

The compilation of sets of exercises for lower and upper limbs used in our validation studies, as one coherent measurement system, is the closest to the model of randomized research of the "power precision" phenomenon of combat sports athletes (n = 202 and control group n = 67 physical education students) conducted by Stefaniak [4] and based on highly specialized measuring equipment. Among the remaining fundamental differences between the two research models is that Stefaniak first determined the maximum values of force (F_{max}), then in various experimental conditions (before warm-up, after warm-up, after training) the recovery of 50% of F_{max}. Stefaniak did not distinguish between the dominant hand, only the right and left. The best results were scored after warm-up, the worst before physical effort. The total of committed faults and diversity in precision between the limbs after training, especially as far as the results before and after warm-up are concerned may characterize the range of athletes' movements symmetry. The evaluation of the results regarding dimorphism in the interdisciplinary approach, reveals that men manifest a higher level of precision use of limb muscle strength than the women. He also discovered that the combat sports athletes of both sexes, regardless of their sports levels, characterized by of significantly greater this precision than those who do not take martial arts [4].

The aim of this study is to find out whether athletes and musician, who differ in many ways, but whose essence of motor activity is the use of the upper and lower extremities, differ in their individual AOUMS profile.

MATERIAL AND METHODS

Participants

The eldest of the research subjects (age 59 years; 161 cm; 64 kg) is a combat sports and martial arts practitioner and coach (aikido, boxing, judo, karate kyokushin, taekwondo ITF), with total 37 years of experience; younger research subjects are: a tennis player and coach (49 years; 172 cm; 79 kg) 34 years of experience; karate athlete (22 years; 186 cm; 87.5 kg) 9 years of experience; box athlete (21 years; 175 cm; 78 kg) 4.5 years of experience; table tennis player (20 years; 178 cm; 80.5 kg) 10 years of experience; drummer (19 years; 203 cm; 120 kg) almost 3 years of percussion play experience.

Study design

The methods used were those recommended by Kalina [5, 6]: 'diagnostic exercise systems': model-execution "2 × 160 UMS", i.e. using 160% of muscle strength in total, 6 with eyes open, 6 with eyes covered (in total, alternately, 12 exercises).

Diagnosing of upper limbs AOUMS (quasi-apparatus version): baseball throw (dominant hand first) in a relatively isolated posture (heels, buttocks and back pressed against the wall), alternatively with eyes open and covered with goggles. The quality of isolated posture was controlled in such a way that the tested subject had to press 4 sheets of paper against the wall with the muscles of the back and buttocks. The attempt was considered valid if the card or cards did not fall during the throw of the ball. The throw distance was determined using a measuring tape with an accuracy of 1 cm [6].

Diagnosis of lower limb AOUMS (non-apparatus version): long jump from standing posture. After making a jump from the set line, the tested person made a turn on the heel of the foot closer to the starting line, and the measure of the distance was the number of feet (if the last foot either crossed the starting line or had no contact with it, then the distance was subjectively estimated with an accuracy of 0.1 of the length of that foot; the result was saved, e.g. 6.4) Individual results were recorded in the AOUMS test documentation cards recommended by Kalina [5].

Identical patterns of force use in diagnosing upper and lower limbs were used (the first exercise with eyes open, the second exercise eyes covered) and then alternated: 50%, 25%, 75%, 50%, 35%, 85%. The series of six exercises ended with three trials with eyes open, each at 100% (the farthest throw/jump was the frame of reference for measuring the conformity of each score to the model expressed in %). The subjects had no prior knowledge of the methods.

The ordinal variable and AOUMS profile evaluation criteria

The ordinal variable when determining the ranking positions (RP) of the subjects was always the smaller value of the estimated error or the sum of the errors of the analysed indicator (conformity of the result to the model). The main ordinal variable (sum of Index AOUMS) was the value of the sum of Index AOUMS for lower limbs, dominant hand and non-dominant hand.

The muscle strength indicator (UMS) in relation to the model value is the proportion of exercises whose error in relation to the model value is not greater than 5% to the number of exercises of a given diagnostic system. In the model used, there are 12 of these exercises (6 for open eyes and 6 for covered eyes). Index UMS for 12 exercises (in brackets for 6): very high 1 and also 0.916 and 0.83 (1 and 0.83); high 0.75 and 0.667 (0.667); average 0.58, 0.50, 0.416 (0.50); low 0.33 (0.33); very low 0.167 and 0.08 (0.167); insufficient (0.00). The absolute compliance of the performed exercises with the model or with errors of less than one percent would mean an outstanding level of AOUMS [5, 6].

RESULTS

The leader of the most general ranking of results (sum of Index AOUMS) turned out to be the table tennis player (81.5% of the sum of errors in relation to the model), while the tennis player closing the list made these errors more than three times more (203.24%). Representing racket sports players differed in the profiles of the use of muscle strength (UMS). The leader revealed a tendency to overuse lower limbs muscle strength, and a deficiency when using upper limbs muscle strength. The profile of a tennis player is a testimony to the overuse of the muscular strength of all limbs, with almost three times more non-dominant hand than lower limbs. A similar profile was found only in the case of the boxer, but with smaller disproportions of individual limbs. The fact is that there is a separation between the first and second positions of the Index AOUMS for limbs among the respondents. Although the sum of these indicators is the most favourable for the boxer (2+1+4), the leader is the table tennis player (1+2+5) due to the smaller sum of all mistakes made (Table 1).

The table tennis player is also the leader in the ranking of the lower limbs UMS indicators with the dominant hand indicators (Table 2).

Among combat sports athletes, the leader is the boxer. AOUMS profiles of boxer and karate (last RP in this group) athletes indicate a tendency to use excessive muscle strength. Multi combat

Table 1. Ranking position (RP) of the surveyed people according to the ordinal variable: from the lowest total (sum) value of the Index AOUMS.

Ranking position		Person	Difference model-execution "2 × 160 UMS"				
			sum of Index AOUMS	the use of muscle strength (UMS)	Index AOUMS for:		
sum Index	profile limbs				lower limbs	dominant hand	non dominant hand
1	1+2+5	table tennis player	**81.05**	UMS quality modified by circumstances	**8.57+**	**18.17–**	**54.31–**
2	2+1+4	boxer	**84.23**	UMS excessive	**22.64+**	**10.34+**	**51.25+**
3	3+4+1	multi combat sports athlete	**91.47**	UMS quality modified by circumstances	**30+&–**	**38.82–**	**22.65+&–**
4	4+3+3	karate athlete	**111.95**	UMS excessive	**34.79+**	**29.69+**	**47.47+**
5	6+5+2	drummer	**134.28**	UMS quality modified by circumstances	**54.66+**	**46.82+**	**32.8+&–**
6	5+6+6	tennis player	**203.24**	UMS excessive	**37.14+**	**75.88+**	**90.22+**

Table 2. Ranking position (RP) of the lower limbs UMS indicators with the dominant hand indicators.

Open eyes				Cover eyes			
RP	**below x%**	**50%**	**over x%**	**RP**	**below x%**	**50%**	**over x%**
1	Table tennis 2.14 + 1.67	Table tennis 2.86 + 0.3	Table tennis 0.71 + 3.6	1	Table tennis 2.14 + 1.67	Boxer 0.00 + 3.01	Karate 0.07 + 3.48
2	Karate 3.36 + 6.27	Boxer 4.41 + 6.37	Tennis 1.62 + 4.64	2	Multi CS 0.00 + 6.07	Table tennis 7.14 + 1.52	Table tennis 0.71 + 2.85
3	Boxer 4.71 + 6.03	Karate 7.53 + 7.94	Karate 4.45 + 4.21	3	Boxer 2.94 + 4.52	Multi CS 5 + 4.6	Tennis 3.18 + 2.46

sports athlete is the most labile in this regard. The sum of combat sports athletes errors was: legs 32%:, dominant hand 37.5%, while drummer: legs 54.36%:, dominant hand 72.72% (Table 3).

The young table tennis player showed the most accurate use of force (according to the model) - lower extremities: five times errors less than 3% and only once 7.14% (total 15.51%) (Table 4). A much older tennis expert twice less than 3.5%, four times from 6.56 to 12.34% (total 43.5%). The hand profiles of dominant racket sports players are similarly varied: table tennis player five errors less than 4 (once 8.83% with eyes open; total of 18.78%); tennis expert twice less than 5%, four times from 14.57 to 22.03% (total 80.79%) (Table 4).

The individual profiles of the tested athletes (Table 3 and 4) and the drummer (Table 5) positively verify both of Kalina's hypotheses. Therefore, they are empirical evidence (also Figures 1 to 4) that the method recommended by him, including unique tools (exercises and set of exercises, as well as criteria for evaluating the results) meet the expected criteria of relevance.

Table 3. The results of combat sports athletes listed by ordinal variable: from the lowest total value of Index AOUMS (see Table 1).

Body part	**Eyes standard & sum**	**Criteria for the use of force: model and differences (%) and sum**				**Difference model-execution "2 × 160 UMS"**	**AOUMS profile**
		below x%	**50%**	**over x%**	**sum**		
Boxer: age 21 years, training experience years 4.5 (total value of Index AOUMS 84.23)							
lower limbs	open	**4.71*+**	**4.41*+**	8.82+	17.94+	17.94+	very high (0.83 Index) AOUMS; tendency to UMS abuse
	covered	**2.94*+**	**0.0****	**1.76*+**	**4.7*+**	4.7+	
	sum	7.65+	**4.41*+**	10.58+	22.64+	**22.64+**	
dominant hand	open	6.03+	6.37+	5.62–	18.02+&–	6.78+	average (0.50 Index) AOUMS; tendency to UMS abuse
	covered	**4.52*+**	**3.01*+**	**3.97*–**	11.5+&–	3.56+	
	sum	10.55+	9.38+	9.59–	29.52+&–	10.34+	
non dominant hand	open	13.05+	16.92+	8.38+	38.35+	**38.35+**	low (0.33 Index) AOUMS; tendency to UMS abuse
	covered	**4.72*+**	8.46+	**0.27**–**	13.45+&–	12.9+	
	sum	17.77+	25.38+	9.1+&–	52.25+&–	**51.25+**	

Body part	Eyes standard & sum	Criteria for the use of force: model and differences (%) and sum				Difference model-execution "2 × 160 UMS"	AOUMS profile
		below x%	50%	over x%	sum		
	Multi combat sports athlete: age 59 years, training experience years 37 (total value of Index AOUMS 91.47)						
lower limbs	open	**5*+**	10+	0.00	15 +	15+	very high (0.83 Index) AOUMS; tendency to excessive UMS
	covered	0.00	**5*–**	10–	15–	15–	
	sum	**5*+**	15+&–	10–	30+&–	**30+&–**	
dominant hand	open	**0.33**+**	8.64–	11.55–	20.52+&–	19.85–	low (0.33 Index) AOUMS; tendency to UMS deficiency
	covered	6.07–	**4.6*+**	17.5–	28.17+&–	18.97–	
	sum	6.4+&–	13.24+&–	29.05–	48.69+&–	**38.82–**	
non dominant hand	open	10+	**4.54*+**	2.15*–	16.69+&–	12.4+	high (0.667 Index) AOUMS; UMS quality modified by circumstances
	covered	**2.23*+**	**2.69*–**	9.79–	14.71+&–	10.25–	
	sum	12.23+	7.23+&–	11.94–	31.4+&–	**22.65+&–**	
	Karate athlete: age 22 years, training experience years 9 (total value of Index AOUMS 111.95)						
lower limbs	open	**3.36*+**	7.53+	**4.45*+**	15.34+	15.34+	average (0.50 Index) AOUMS; tendency to UMS abuse
	covered	6.51+	13.01+	**0.07**–**	19.59+&–	19.45+	
	sum	9.87+	20.54+	**4.52***+&–	34.93+&–	**34.79+**	
dominant hand	open	6.27+	7.94+	**4.21*+**	18.42+	18.42+	low (0.33 Index) AOUMS; tendency to UMS abuse
	covered	6.21+	8.55+	**3.48*–**	18.24+&–	11.27+	
	sum	12.48+	16.49+	7.69+&–	36.66+&–	**29.69+**	
non dominant hand	open	11.21+	15.04+	**4.07*–**	30.32+&–	22.18+	very low (0.167 Index) AOUMS; tendency to UMS abuse
	covered	6.5+	13.28+	5.51+	25.29+	25.29+	
	sum	17.71+	28.32+	9.58+&–	55.61+&–	**47.47+**	

Table 4. The results of racket sports players listed by ordinal variable: from the lowest total value of Index AOUMS (see Table 1).

Body part	Eyes standard & sum	Criteria for the use of force: model and differences (%) and sum				Difference model-execution "2 × 160 UMS"	AOUMS profile
		below x%	50%	over x%	sum		
	Table tennis player: age 20 years, training experience years 10 (total value of Index AOUMS 81.05)						
lower limbs	open	**2.14*–**	**2.86*+**	**0.71**–**	5.71 +&–	0.00	very high (0.83 Index) AOUMS; slight tendency to UMS abuse
	covered	**2.14*+**	7.14+	**0.71**–**	9.99 +&–	8.57+	
	sum	**4.28***+&–	10.00+	**1.42*–**	15.7 +&–	**8.57+**	

Body part	Eyes standard & sum	Criteria for the use of force: model and differences (%) and sum				Difference model-execution "2 × 160 UMS"	AOUMS profile
		below x%	50%	over x%	sum		
dominant hand	open	8.83–	0.3**+	**3.6*–**	12.73+&–	12.13–	very high (0.83 Index) AOUMS; slight tendency to UMS deficiency
	covered	**1.67*–**	**1.52*–**	**2.85*–**	6.04–	6.04–	
	sum	10.5+&–	**1.82***+&–	6.45–	18.77+&–	**18.17–**	
non dominant hand	open	8.92–	9.8–	12.84–	31.56–	31.56–	very low (0.167 Index) AOUMS; tendency to UMS deficiency
	covered	**0.49*+**	7.25–	15.98–	23.72+&–	22.75–	
	sum	9.41+&–	17.05–	28.82–	55.28+&–	**54.31–**	
Tennis player: age 49 years, training experience years 34 (total value of Index AOUMS 203.24)							
lower limbs	open	6.56+	9.74+	**1.62*+**	17.92+	17.92+	low (0.33 Index) AOUMS; tendency to UMS abuse
	covered	10.06+	12.34+	**3.18*–**	25.58+&–	19.22+	
	sum	16.62+	22.08+	**4.8***+&–	43.5+&–	**37.14+**	
dominant hand	open	14.57+	18.84+	**4.64*+**	38.05+	38.05+	low (0.33 Index) AOUMS; tendency to UMS abuse
	covered	22.03+	18.26+	**2.46*–**	42.75+&–	37.83+	
	sum	36.6+	37.1+	7.1+&–	80.8+&–	**75.88+**	
non dominant hand	open	24.95+	24.83+	5.7+	55.48+	55.48+	very low (0.167 Index) AOUMS; tendency to UMS abuse
	covered	13.44+	16.67+	**4.63*+**	34.74+	34.74+	
	sum	38.39+	41.5+	10.33+	90.22+	**90.22+**	

Table 5. The results of musician (drummer).

Body part	Eyes standard & sum	Criteria for the use of force: model and differences (%) and sum				Difference model-execution "2 × 160 UMS"	AOUMS profile
		below x%	50%	over x%	sum		
Drummer: age 19 years, training experience years 3 (total value of Index AOUMS 134.28)							
lower limbs	open	18.33+	4.67*+	6.33+	29.33+	29.33+	very low (0.167 Index) AOUMS; tendency to UMS abuse
	covered	12.33+	7.33+	5.67+	25.33+	25.33+	
	sum	30.66+	12.0+	12.0+	54.66+	**54.66+**	
dominant hand	open	11.14+	21.36+	**3.86*–**	36.36+&–	28.64+	very low (0.167 Index) AOUMS; tendency to UMS abuse
	covered	14.77+	12.5+	9.09–	36.36+&–	18.18+	
	sum	25.91+	33.86+	12.95+&–	72.72+&–	**46.82+**	
non dominant hand	open	1.0*+	3.2*–	17.0+	21.2+&–	14.8+	average (0.500 Index) AOUMS; UMS quality modified by circumstances
	covered	9.0+	2.0*–	25.0–	36+&–	18.0–	
	sum	10.0+	5.2–	42.0+&–	57.2+&–	**32.8+&–**	

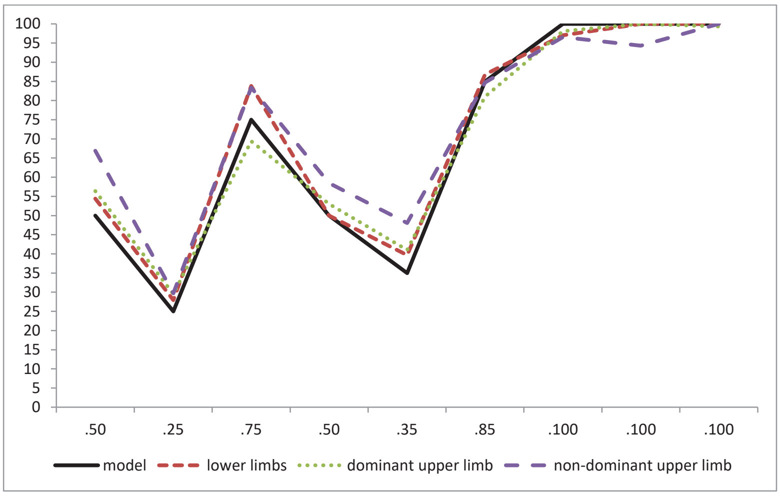

Figure 1. Profile AOUMS of box athlete.

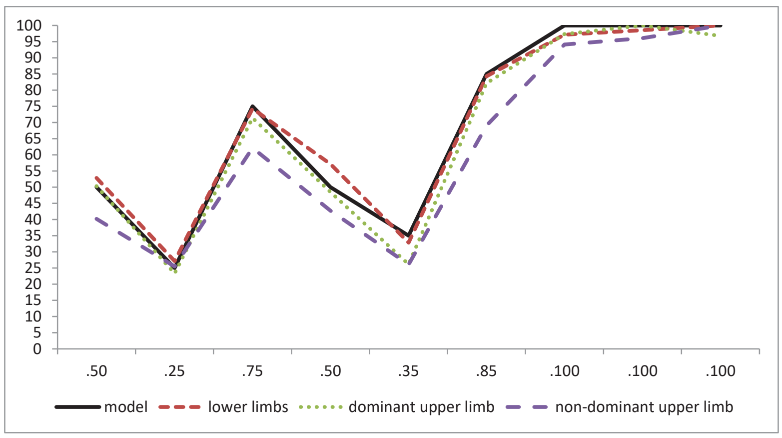

Figure 2. Profile AOUMS of table tennis player.

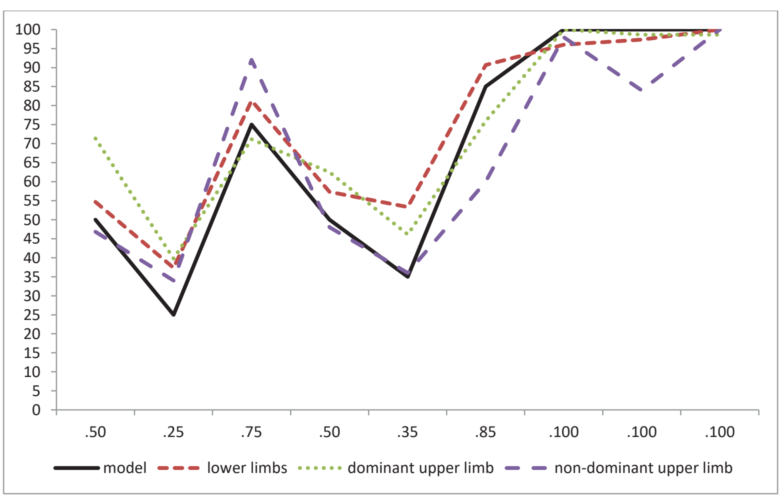

Figure 3. Profile AOUMS of musician (drummer).

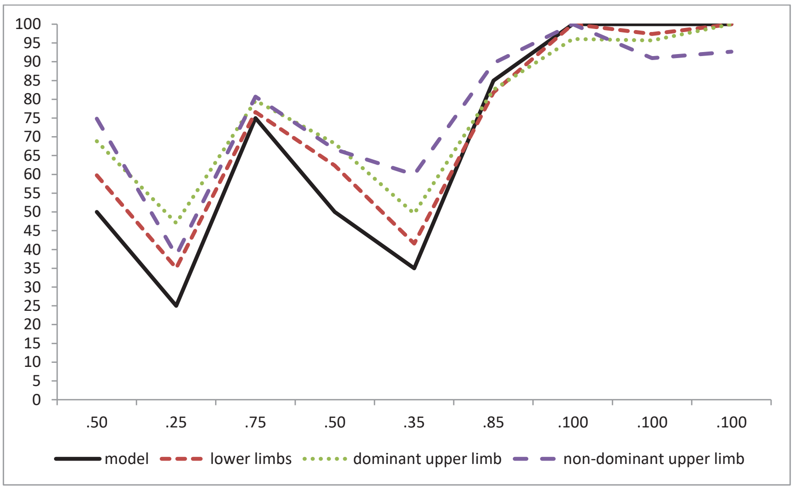

Figure 4. Profile AOUMS of tennis player.

DISCUSSION

The research results provide a lot of evidence that the proposed, original tool for diagnosing a very important property of the human body, i.e. AUOMS (the ability to optimally use muscle strength), meets the methodological criteria for the accuracy of diagnosing this phenomenon [5, 6]. The author of the AUOMS concept clearly emphasised that he is not proposing a test that measures the AUOMS phenomenon, but only puts forward sets of exercises that, if certain methodological criteria are met, can provide valuable information about the ability to use the neurophysiological potential of the human being in a wide range of motor functioning (daily physical activity, rehabilitation, preventive kinesis, sport, music education, military, rescue and police training, etc.). In these circumstances, the classic test-retest procedure (after all, sets of exercises are not tests) based on the "test-retest" method loses its importance. Therefore, the validation procedure had to be primarily based on verifying on hypotheses put forward by Kalina. In accordance with the custom of respecting scientific correctness, the author of this unique, innovative methodological proposal was not involved in this validation procedure.

We included few athletes and only one musician in our study, which may raise some concerns and criticism. However, there are enough similarities and especially enough diversity between them to prove that, for the purposes of this validity procedure, the criteria for methodological correctness have been met.

The element that connects all the examined people is the use of both lower and upper limbs in their specific motor activity. The first imposing differentiating factors are the different proportions of use of lower limbs relative to the upper limbs by the drummer and by the athletes studied. In the racket sports group, the need to differentiate the use of upper limbs (measured, e.g., by the number of steps taken during a match) is determined by the difference in the size of the tennis court or the size and specificity of table tennis. However, the similarity may apply to the number of actions performed with the dominant hand by tennis and table tennis players.

In combat sports (in the case of the tests included in the category of hitting the opponent), the differentiating factor is another acceptable way of using upper limbs during a sports fight (disproportionately more often during training). A karate athlete also uses lower limbs directly for offensive and defensive actions. A boxer uses them for preparatory activities only and when he defends himself by jumping backwards or sideways.

Our research provides evidence that the impact of all of the listed factors (apart from those not mentioned) is to some extent mapped in very different results between individuals as well as in cases of high convergence of results (and thus documented identity of adaptive effects regardless of the differences in specialized motor activity or the great similarity of the organic background of the compared individuals).

Therefore, the suggestion of the author of the concept of measuring the AUOMS phenomenon to combine the analysis of indicators concerning the lower limb UMS with dominant hand indicators turned out to be accurate. The ranking of the leaders of this compilation of results based on 12 sub-indices (Table 1) provides evidence that the results of high UMS compliance with the model suggest a high neurophysiological potential, rather than the impact of adaptive factors (training, participation in sports competitions, concert activity in the case of musicians, etc.). The leader of this ranking, a table tennis player, made a mistake below 5% eleven times (so in 91.66% of the trials), but only once did he make a slightly larger error (7.14% during the 50% UMS lower limbs trial). The boxer, second in this ranking, made errors below 5% three times, so he met the criterion of optimal use of muscle strength (OUMS) in 75%.

We are by no means diminishing the importance of the training impact factor. The leader of both separate rankings, i.e. the table tennis player, is penultimate on the list of Index AOUMS for non-dominant upper limbs. In his sports motor activity, the main manipulations are performed with the dominant hand, so there are no grounds to claim that a very high level of AUOMS found in him is mainly the effect of the neurophysiological potential and other organic components. It is also, to a large extent, the effect of the modifying environmental impact. This line of reasoning is confirmed by the results obtained for the drummer. He is second to last in the main ranking (Table 1). Moreover, he is the only respondent who was not listed in the ranking of the leaders of the combination of UMS lower limbs results with dominant hand indicators. However, the analysis of the UMS non-dominant upper limbs phenomenon (based on six different tasks, and therefore also on six indicators) shows an average Index AOUMS (0.50). The higher one (0.667) belongs only to the multi combat sport athlete, i.e. the oldest of the surveyed persons.

For example, the observation results quoted above allow for many implications as well as many important questions to be asked. Therefore, in our opinion, they are sufficient presumptions to recommend sets of exercises based on the methodological findings of Kalina [5, 6] for the use of current diagnostics of the AOUMS phenomenon in each of the possible areas of human physical activity – as long as there are no medical contraindications. The real diagnostic value of this category of non-apparatus and/or quasi apparatus (or compilation as in these studies), sets of exercises will only be confirmed by comparing empirical data with parallel research using high-quality modern equipment.

Similar phenomena for mapping joint position and feeling force (in active reproductive mode, where study participants actively made joint movement stopping at a point where they felt they had reached the target position or recognized the mapping of a remembered level of strength, and passive reproductive, where joint movement performed passively with a device moving at a constant speed) are measured, for example, using a Biodex System 4 Pro dynamometer (Biodex Medical Systems, Inc. Shirley, NY, USA). It is hypothesized that the reason for the increased proprioceptive efficiency in athletes may be the selection of people with innate predispositions or the improvement of motor control induced by training. It may include peripheral changes (e.g. increased sensitivity of muscle and tendon receptors) as well as central changes (in terms of information processing and facilitation) [18-22].

From the available results of research carried out with the use of the identical model of sets of exercises, but only based on measuring the OUMS lower limbs, an identical non apparatus version tool is the publication on the impact of a week-long, intensive alpine skiing training of physical education students on the AOUMS [23]. The leaders of this study, identified with Index AOUMS for lower limbs 10.55+; 10.6+&−; 11.67+&−; 16.11+ are behind the leader of our research (table tennis player: 8.57+). However, they are significantly ahead of the second one (boxer: 22.64+) in terms of quality. The student of physical education with the Index AOUMS score of 63.07− (closing the list) is clearly inferior to the drummer we studied (54.66+). Only as a side note, we emphasize that the effects of intensive training in alpine skiing with the use of another qusi-apparatus tool were previously measured by Litwiniuk et al. [24] or by Gasieica-Walczk et al. [25] in various phases of intense physical effort, differing in content and motor experience of athletes (professional ice hockey player and amateur mountain biking).

The only results of case studies concerning the measurement of the AOUMS upper limbs phenomenon using identical quasi apparatus tools, but with a different set of exercises model are available, as an example, in the publication recommending this tool, which is also a method of measuring, documenting and interpreting the results [6]. The violin teacher, with nearly fifty years of professional experience, did not make a single error exceeding the 5% criterion when performing individual tasks (exercises) – the AOUMS index was therefore equal to 1.0. In addition, she flawlessly controlled a stable body posture, which means that during the exercises, a sheet of paper pressed against the wall by the muscles of the violinist's back and buttocks never fell out. Personality, experience [26] and postural stability [27, 28] can make the difference when performance this set of exercises.

In this study, we omitted two aspects of diagnostics, which are an immanent part of the method, whose most important elements, however, are the models of sets of exercises and the unique measurement formula (compilation of non apparatus and quasi apparatus – about those unique tools see more in Kalina and Jagiełło 2018 [29]). We did not measure heart rate (HR) or motivation on a scale of 1 to 10 before, during and after sets of exercises, as recommended by the creator of the method of measuring AOUMS in general and specific methods [5, 6]. We share the view that the measurement of HR and motivation makes sense in circumstances where the models described in this paper or similar will be used either as a form of warm-up before a training session, therapy, etc. or in the course of a given motor activity lasting at least 30 minutes, and especially longer. Regardless of respecting the adopted assumption, we observed a high level of involvement of all surveyed individuals and a growing interest in the results of the measurements.

The above-quoted study of students after the end of the alpine skiing course provides evidence of the validity of such reasoning. The fourth-ranked student before the alpine skiing course Index AOUMS for lower limbs was 16.11+, and under the influence of specific measures and new motor experiences related to learning skiing, it decreased to 5.72+&− (she became the leader of the results at the end of the course) .The phenomenon turned out to be bipolar: the leader from before the course (10.55+) with the result of alpine skiing 63.58+ moved to the penultimate RP after the course. This, in a way, paradox of results migration is not isolated and divides students into two groups in this respect. However, the researchers (as they clearly emphasize) did not control other variables that could have such a radical impact on the migration of results, so we will not speculate, either. However, this is proof of the high sensitivity of these original research tools, and, therefore, they are useful in recording the short-term influences of the internal (concerning the human body) and external environment, in conditions of limited access to precise diagnostic equipment.

CONCLUSIONS

Studying the AOUMS phenomenon in the population of athletes and instrumental musicians has the advantage that in most cases it is easy to define the range of motor activity of these people. Also, the usefulness of these simple tools in diagnosing lower and upper limbs in these areas of human motor activity is not questioned. However, we see a wide application of this method of measuring the AOUMS phenomenon, especially in preventive and therapeutic practice, but also in clinical diagnostics, and even as an element of self-assessment of one's own neurophysiological potential. In particular, matching the results of clinical trials based on the latest measurement technology may become the best method of verifying the usefulness of these simple tools, which do not require expensive equipment, in the above-mentioned areas of diagnostics. Precisely defining the motor activity of people, even in popular professions (firefighter, miner, driver, agricultural worker, policeman, etc.) is not easy, unlike the simple possibility of diagnosing AOUMS, i.e. the neurophysiological potential in general terms. The found deviations from the published results of repeated models can be the basis for investigating the causes. Therefore, we recommend the method of measuring the AOUMS phenomenon as safe, easy to use and available to virtually anyone who can read with comprehension and is motivated enough to use the available tools based on scientific knowledge.

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