

## Analysis of martial arts athletes' goniometric indicators

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### Abstract

**Purpose:** comparative analysis of limbs' joints goniometric indicators of martial arts athletes; study of sportsmanship level influence on kick boxers' movements' amplitude.

**Material:** martial arts athletes – students and senior pupils (n=29) participated in the research. The participants were divided into two groups. 1<sup>st</sup> group consisted of 18 kick boxers of age 17.44±0.34 years. 2<sup>nd</sup> group included 11 wrestlers of age 18.45±0.39 years. The first group was divided into two sub-groups: sub group 1a – 9 athletes of age 18.22±0.52 years and sportsmanship level: candidates and masters of sports. Sub group 1b consisted of 9 athletes, age (16.67±0.24) years and sportsmanship level from beginners to 1<sup>st</sup> sport category. We registered movements' amplitude in wrist, shoulder, elbow, hip, knee and ankle joints.

**Results:** we confirmed the distinctions of goniometric indicators of martial arts athletes' limbs joints. It was found that sportsmanship level of kick-boxers influences to certain extent on movements' amplitude. The found distinctions reflect clearly specific of kind of sports. Wrestlers have higher amplitude of movements in wrist joints that determines reliable grip in a fight. Kick boxers have better amplitude of movements in elbow and shoulder joints. It permits to punch with higher strength. The closeness of goniometric indicators of different sportsmanship kick-boxers proves equal orientation of their training. Need in constant keeping combat stance conditions reduction of in-movement amplitude in right wrist joint and outside movement in left shoulder joint of experienced athletes.

**Conclusions:** increase of abduction in hip joint and reduction of bending in left knee joint illustrate specificities of punching/kicking, optimization of their technique in experienced athletes. The higher is training experience, the more working asymmetry of joints' movements is.

**Keywords:** martial arts, goniometric, indicators, successfulness, asymmetry.

### Introduction

Intensive physical trainings facilitate harmony of physical condition and optimization of athletes' functional state [3]. Rising of athletes' efficiency is ensured by study of special aspects of special qualities' formation and their level's optimization. In the complex of successfulness factors important place is taken by condition of muscular skeletal apparatus. Its condition can be assessed with the help of special method – goniometry.

In review of Atwater Anne E. [2] there is a conclusion about goniometric studies' prospects in sports and physical culture. Results of goniometry increase effectiveness of researches, devoted to kinesiology and bio-mechanics. Lees Adrian [20] analyses possibilities of bio-mechanical and goniometry methods' application in study movements' technique. Achievement of results is possible only with complex application of qualitative, quantitative and prognostic methods.

Application of goniometry in analysis of exercises with weights has been proved [6]. Goniometric researches of knee joint permit to assess the complex of movements' kinematic. In its turn, it permits to optimize mastering of this technique by athletes. Ribeiro A. & Pascoal A. [32] analyzed active and passive movements of athletes and people, who do not practice sports, shoulder joints. Application of goniometry permitted to find high amplitude of outside rotation in discus throwers. Norris Beth S. & Olson Sharon L. [24] confirmed the validity of goniometry and researches with the help of 2D video analysis for studying of hip and knee joints' movements. Rogers Kate & Gibson Ann L. [33] used goniometry as the method for assessment of Pilates trainings. They proved significant flexibility improvement resulted from

8 weeks' training program.

Goniometric analysis of ballet movements was fulfilled by Quanbeck Amy E. et al. [31]. They found higher angle value of rotation in comparison with available results.

Goniometry is used rather widely in sport games. Morozova E.V. [23] used goniometry for study muscular skeletal apparatus's functional state of football players. Low flexibility, by results of goniometry, witnesses about non-elasticity of shortening of muscles and ligaments. It is one of signs of muscular skeletal apparatus's chronic over-tension.

Udochkina L.A. et al. [38] used goniometry for assessment of first maturity men – football players and those, who do not practice sports, anthropometric characteristics. They found that angle of active bending in knee joint of football players is less than in their peers. Fajzulin D.E. & Orlov A.V. [11] proved importance of elite goal keepers in mini-football special flexibility with the help of goniometry.

Mel'nichuk K.N. [21] used goniometry for assessment of functional state of junior tennis players' muscular-ligament apparatus (upper limbs). High informative value of this method for mobility in elbow joint determination was confirmed. Panasiuk T.V. & Raspopova E.A. [25] studied functional aspects of muscular-skeletal apparatus, formed under influence of diving. They found hypertrophy of the most loaded muscular groups, high mobility in joints and changes of posture. It is caused by specificities of divers' muscular activity. воду.

Zebzeev V.V. [41] offered goniometric research as a tool of control over biathlon skiers' functional fitness. Similar results were obtained by Pozhidaev S.N. [29]. The author substantiated application of goniometry for testing in gymnastic. Jonsson Per et al. [17] found that different speed of thumb's movements can be a risk factor of traumatizing. Usage of electronic goniometer for study

of fingers' movements permitted to substantially reduce errors, comparing with mechanical device.

Podrigo L.V. et al. [26] analyzed results of goniometry of arm wrestlers' and amateurs' arm joints. They proved high movements' amplitude in athletes, especially in wrist joints. The data were interpreted as proof of hand's importance for efficiency in arm wrestling.

In other works the laws of bio-kinematic links of martial arts athletes were found:

- Maximal speed (result and value in every plane) of lower limbs' segments (thigh, shin and foot) was found as well as time of reaching this speed in fulfillment of kicks in Thae-quan do. The measurements for kinematic analysis were fulfilled with the help of two three dimensional power plates and eight chambers' motion system [9].
- Initial position of athlete as factor, influencing on Thae-quan-do technique, was determined. For measuring angle shifting of pelvis and thigh the motion system [10];
- Positions of boxers' torso and legs, which influence on successfulness of punching, were found. For obtaining kinematic data motion system Vicon 3D was used [12];
- Parameters, which, to large extent, conditioned maximal speed of foot movement in kicking, were determined. 3D kinematic of kicks of 22 Thae-quan do athletes was recorded with the help of motion system (Vicon Motion Systems Limited, Oxford, Great Britain) [30];
- For different kinds of analysis bio-mechanical parameters, connected with range of movements, strength of punch/kick and time of punch/kick, were used. 3D technology of motion system was used [39];
- Quantitative indicators of karatekas' movements, characterizing balance in competitions, were measured. Step width and angle articulation of athlete's body bio-links were registered [40];

The following are important aspects in perfection of martial arts athletes' training:

- Theoretical-methodic substantiation of sport wrestling means' usage in physical training of cadets of lyceum with advanced military-physical training [4];
- Special aspects of special workability of elite wrestlers [37].
- Optimization of physical load in Judo wrestlers' training [1, 13];
- Formation of Judo-wrestlers' active attitude to sports [5];
- Increase of different kinds of Judo wrestlers' muscular strength for formation of technical skills [8];
- Differentiation of body composition in athletes' training for Thae-quan do competitions [16];
- Finding of criteria of athletes' talent in combat kinds of sports and self-defense [18];
- Finding of individual aptitude of elite wrestlers to work in different regimes [36].

Analysis of researches points at possibilities to

use goniometry indicators for perfection of martial arts athletes' trainings. With such approach it is recommended to combine goniometry indicators with other characteristics of athletes' actions.

*The purpose of the research* is comparative analysis of limbs' joints goniometric indicators of martial arts athletes; study of sportsmanship level influence on kick boxers' movements' amplitude.

### Material and methods

*Participants:* martial arts athletes – students and senior pupils (n=29) participated in the research. The participants were divided into two groups. 1<sup>st</sup> group consisted of 18 kick boxers of age  $17.44 \pm 0.34$  years. 2<sup>nd</sup> group included 11 wrestlers of age  $18.45 \pm 0.39$  years. The first group was divided into two sub-groups: sub group 1a – 9 athletes of age  $18.22 \pm 0.52$  years and sportsmanship level: candidates and masters of sports. Sub group 1b consisted of 9 athletes, age  $(16.67 \pm 0.24)$  years and sportsmanship level from beginners to 1<sup>st</sup> sport category.

*Organization of the research:* with the help of goniometer, produced by firm IGaging® we registered movements' amplitude in wrist, shoulder, elbow, hip, knee and ankle joints. We fulfilled 2-3 registrations of one and the same movement, fixing maximal indicators. In wrist, shoulder and hip joints we assessed: bending (flexio), unbending (extensio), abduction (abductio), adduction (adductio). In elbow, knee and ankle joints we assessed bending and unbending.

*Statistical analysis* was fulfilled with the help of licensed electronic tables Excel. We determined indicators of descriptive statistics: mean arithmetic, standard deviation and error of mean arithmetic. Confidence of differences in groups was assessed with the help of parametric Student's t-test and non-parametric tests of Wilcoxon – Manna – Whitney (U) and Wald – Wolfowitz (r).

### Results

The received data are presented in tables 1-3.

We found that movements' amplitude in wrist joints was higher in wrestlers. It is confirmed with Student's test for abduction of both hands. Wilcoxon – Manna – Whitney test proved substantial differences between bending of right hand ( $U=29$ ,  $p<0.05$ ) and left hand ( $U=31$ ,  $p<0.05$ ), unbending of right joint ( $U=33$ ,  $p<0.05$ ), abduction of right ( $U=29$ ,  $p<0.05$ ) and left joints ( $U=32$ ,  $p<0.05$ ).

Bending amplitude in elbow joints also had significant differences. In right elbow joints the values were higher in kick boxers. It was proved by Student's t-test ( $t=2.33$ ) and Wilcoxon – Manna – Whitney test ( $U=15$ ,  $p<0.05$ ).

Movement amplitudes in shoulder joints were higher in kick boxers. For right shoulder joint, by all kinds of movements we confirmed significant difference by three movements (with Student's t-test). For left shoulder joint we confirmed significant difference by three movements (except unbending) (with Student's t-test). Usage of non-parametric tests confirmed the made conclusions. By three kinds of movements we confirmed significant

exceeding of amplitude in boxers. For right shoulder joint we confirmed significant difference by bending ( $r=2$ ,  $p<0.05$ ), отведению ( $U=2$ ,  $p<0.05$ ) and adduction ( $U=32$ ,  $p<0.05$ ). For left shoulder joint the picture is (by the same three movements) (accordingly:  $r=4$ ,  $p<0.05$ ;  $U=30$ ,  $p<0.05$  and  $U=25$ ,  $p<0.05$ ).

Analysis of joint movements' asymmetry also proved the presence of certain distinctions. In boxers we found noticeably higher abduction of left wrist joint, bending and abduction of right shoulder joint (by Student's test). Wrestlers, by the same criterion) had higher amplitude of

left shoulder joint bending.

Results (see table 2) witness about closeness of results of different sportsmanship kick boxers. It is confirmed by the presence of differences between groups (by Student's test). At the same time usage of non parametrical criteria confirmed the presence of certain differences.

The adduction amplitude in right wrist joint of experienced athletes was less by Wald – Wolfowitz criterion ( $r=3$ ,  $p<0.05$ ). In the same group abduction amplitude in left shoulder joint was noticeably less as per criterion of Wilcoxon-Manna-Whitney ( $U=19$ ,  $p<0.05$ ).

**Table 1.** Movements' amplitudes in arms' joints of martial arts wrestlers

Joint movement (degrees)		The tested groups	
		1 group	2 group
Wrist (right)	Bending	72.65±3.26	82.43±5.34
	Unbending	58.65±3.95	60.35±2.50
	Abduction	36.71±1.76 <sup>1,2</sup>	42.82±3.94
Wrist (left)	Adduction	51.12±2.43	50.70±4.21
	Bending	70.21±3.33	79.90±3.12
	Unbending	62.17±2.80	67.08±3.74
Elbow (right)	Abduction	43.82±1.99 <sup>1</sup>	50.35±3.85
	Adduction	47.12±1.92	45.72±3.96
	Bending	120.69±1.65 <sup>1,2</sup>	109.42±2.12 <sup>2</sup>
Elbow (left)	Unbending	27.27±1.48 <sup>2</sup>	25.15±2.74
	Bending	114.58±1.71 <sup>1</sup>	125.02±3.13
	Unbending	23.29±1.17	22.73±0.74
Shoulder (right)	Bending	190.22±3.15 <sup>1,2</sup>	112.45±3.67
	Unbending	72.94±3.42 <sup>1</sup>	67.10±5.58
	Abduction	194.22±3.37 <sup>1,2</sup>	157.03±6.58
Shoulder (left)	Adduction	30.39±1.72 <sup>1</sup>	25.47±2.21
	Bending	178.21±4.07 <sup>1</sup>	135.58±7.76
	Unbending	66.74±4.38	68.30±6.31
	Abduction	174.67±7.02 <sup>1</sup>	160.63±7.90
	Adduction	32.69±1.86 <sup>1</sup>	27.40±0.85

Notes: 1 – difference from wrestlers is confident ( $p<0.05$ ). 2 – Difference from left arm is confident ( $p<0.05$ ).

**Table 2.** Movements' amplitudes in arms' joints of kick boxers

Joint movement (degrees)		The tested groups	
		1a group	2b group
Wrist (right)	Bending	72.56±5.96	72.76±2.42
	Unbending	60.93±3.88	56.09±7.40
	Abduction	38.49±2.29	34.70±2.69
Wrist (left)	Adduction	49.89±4.46	52.50±1.62
	Bending	71.49±5.41	68.76±3.96
	Unbending	58.92±4.47	65.83±2.96
Elbow (right)	Abduction	44.60±3.14	42.94±2.54
	Adduction	47.01±3.01	47.24±2.49
	Bending	119.58±1.87 <sup>1</sup>	121.95±2.87
Elbow (left)	Unbending	28.50±1.63 <sup>1</sup>	25.89±2.59
	Bending	112.72±2.17	116.66±2.63
	Unbending	23.19±1.40	23.40±2.02
Shoulder (right)	Bending	191.80±4.43	188.44±4.69
	Unbending	70.16±4.60	76.08±5.18
	Abduction	190.66±3.90 <sup>1</sup>	198.23±5.60
Shoulder (left)	Adduction	29.64±1.77	31.23±3.18
	Bending	178.10±6.19	178.34±5.57
	Unbending	67.16±5.28	66.26±7.56
	Abduction	164.50±11.53	186.11±5.79
	Adduction	31.63±1.80	33.89±3.50

Note: difference from left hand is confident ( $p<0.05$ ).

Usage of Student's test permitted to confirm asymmetry of flexibility's development. More experienced athletes have higher amplitude of movement in right elbow joint by bending and unbending. The similar dependence was found for abduction in shoulder joint. In younger athletes we did not find movements' asymmetry in joints.

Analysis of movements in legs' joints confirmed made earlier assumptions about closeness of kick boxers' flexibility indicators. We found significant increase of abduction in right hip joint in 1a sub group (by criterion of Wald – Wolfowitz:  $r=4$ ,  $p<0.05$ ). Bending in left knee joint was noticeably higher in 1b sub group (by Wilcoxon-Manna-Whitney criterion:  $U=14$ ,  $p<0.05$ ). In this case Student's t-test permitted to find only tendency to confident increase ( $p<0.1$ ).

Higher asymmetry in 1a sub group was determined. We confirmed higher adduction amplitude in left hip joint and higher bending amplitude in right ankle joint (by Student's t-test). In young athletes we found no significant differences.

### Discussion

Efficiency of athletes' condition analysis directly depends on informative value of the used methodic and tests. The main criterion for their selection is consideration of kind of sports' specificity. Mirzaei B. et al. [22] determined that perfection of physical training and functional state in martial arts facilitates successfulness in fight. The authors confirmed that in junior wrestlers these factors influence on trainability.

Jafari R.A. et al. [15] studied interconnections between the following: motor activity and somatic type; anthropometric profile, body composition and physiological/physical profile of junior wrestlers. Consideration of wrestlers' profile permits to raise their competition successfulness.

Successfulness in martial arts is in direct proportion to victory in duels. It is determined by complex of factors, which includes athlete's physical and technical fitness. Athlete's technical fitness to large extent depends on movements' amplitude of limbs' joints.

Rukosuev D.A. [34] offered include complex of tests for special flexibility in U-shu athletes (10-12 yrs age) in goniometric study. On the base of the received results the author found joints, whose mobility is always insufficient and requires additional training.

Kim T.K. & Podlesnykh A.A. [19] used goniometric researches in analysis of Judo wrestlers' motor profile. He proved effectiveness of the methodic for rising athletes' competitiveness.

Comparison of wrestlers and impact martial arts athletes permits to consider the specificity of these kinds of sport. The similar conclusions were made by Podrigalo L.V. & Volodchenko O.A. [28] when they used bio-mechanical approaches in martial arts. Results of wrestlers and other martial arts athletes illustrate the presence of certain distinctions, depending on different techniques in wrestling and impact martial arts. The found closeness of impact martial arts' results reflects specific aspects of these kinds of sports.

The presence of certain distinctions in wrestlers' and impact martial arts athletes' body constitution has been proved [14]. Increase of wrestlers' shoulder and forearm's circumferences as well as strength of grip in dynamic and static regimes reflects specificity of wrestling and importance of reliable grip for success.

The found differences between goniometric indicators of wrestlers and kick boxers clearly reflect specificity of kinds of sports. In wrestlers just grip takes important place in duel, as the base of effective technique's fulfillment. Reliable grip is determined by strength of hand and movement's amplitude in wrist joint. That is

**Table 3.** Movements' amplitudes in legs' joints of kick boxers

Joint movement (degrees)		The tested groups	
		1a group	2b group
Hip joint (right)	Bending	33.89±9.47	102.64±5.31
	Unbending	75.06±8.45	71.48±5.04
	Abduction	97.69±7.16	86.50±6.25
	Adduction	40.42±2.29 <sup>1</sup>	48.14±6.15
Hip joint (left)	Bending	99.01±8.33	90.16±5.52
	Unbending	83.54±5.41	80.48±4.98
	Abduction	86.50±10.30	71.03±5.58
	Adduction	51.03±4.13	56.36±5.69
Knee joint (right)	Bending	79.20±6.26	85.63±1.54
	Unbending	49.11±4.67	44.81±3.41
Knee joint (left)	Bending	77.17±5.26	87.81±1.31 <sup>2</sup>
	Unbending	50.74±3.76	47.93±1.83
Ankle joint (right)	Bending	30.26±2.05 <sup>1</sup>	28.81±1.94
	Unbending	43.38±2.91	48.96±3.63
Ankle joint (left)	Bending	23.83±2.30	21.78±3.52
	Unbending	44.58±3.86	42.70±3.82

Notes: 1 – difference from left leg is confident ( $p<0.05$ ). 2 – Tendency to confidence of differences between groups ( $p<0.1$ ).

why movement's amplitude in wrist joint is noticeably higher in wrestlers.

Podrigalo L.V. et al. [26] confirmed importance of goniometric indicators in respect to wrist joint for successfulness in arm-wrestling.

For victory, in kick boxing min importance has kicking/punching that pre-conditioned the distinctions of goniometric indicators. Just it pre-determined increase of amplitude of right elbow joint's bending and practically all movements in shoulder joints of kick boxers. Just they are determining in effective punching. Higher amplitude of wrestlers' left joint's bending reflects available in them asymmetry of development. May be it is conditioned by technical peculiarities of wrestling.

The determined asymmetry of kick boxers reflects specificity of duel. In stance left hand is in frontal position. Increase of wrist joint's amplitude permits to expand the defended area. Increase of right shoulder joint's abduction amplitude permits to punch with greater strength.

Analysis of different sportsmanship kick boxers' goniometric indicators confirms similar orientation of their training. It is witnessed by closeness of the received results and absence of significant differences by most of indicators.

At the same time, the found distinctions illustrate specificity of kick boxing training. Reduction of adduction amplitude in right wrist joint and abduction in left shoulder joint in experienced athletes reflects need in sustaining of combat stance, which requires certain fixing of arms' position. This causes joints' mobility.

Increase of training experience results in joint movements' asymmetry. It is absent in young athletes. In kick boxing right arm's punches are very strong. It conditions higher bending/unbending amplitude in elbow joint and abduction in shoulder joint.

Chernicyna N.V. & Sozailov U.A. [7] studied joints' mobility of sambo and Judo wrestlers' lower limbs joints. They found tendency to increasing mobility in hip joint of sambo and Judo wrestlers. But they did not found confident differences between these kinds of sports' indicators.

Saenko V.G. [35] used parameters of flexibility training for analyzing karate kicking. Interconnection between results of knee kick and ann flexibility indicators was found.

Analysis of movements' amplitude in legs' joints confirms made earlier conclusions about influence of specificity of kind of sport on goniometric indicators. Increase of hip joint's abduction and reduction of left knee joint's bending illustrate specific features of kicking and their technique's optimizing in experienced athletes. The similar dependence is confirmed by rising of goniometric indicators' asymmetry in athletes of 1a sub group.

### **Conclusions**

The fulfilled researches confirmed the following: distinctions in goniometric indicators of martial arts athletes' limbs' joints; certain influence of sportsmanship on kick boxers' movements' amplitude. The found differences between indicators of wrestlers and kick boxers clearly reflect specificity of kind of sports. For wrestlers reliable grip is very important. To large extent it depends on amplitude of wrist joint's movements. These indicators were higher in 2<sup>nd</sup> group athletes. In impact martial arts success is determined by quality and strength of punching/kicking. It pre-conditioned increase of right elbow joint's bending amplitude and movements in shoulder joints of kick boxers. The found kick boxers' asymmetry reflects specificity of duel.

The closeness of different sportsmanship kick boxers' goniometric indicators confirms equal orientation of their training. The found differences illustrate specificity of training in this kind of sports. Need in combat stance constant sustaining conditions reduction of adduction amplitude in right wrist joint and abduction in left shoulder joint of experienced athletes. Increase of right hip joint's abduction and reduction of bending in left knee joint illustrate the following: specificities of punching/kicking, optimizing of their technique in experienced athletes. Increase of training experience results in growth of working asymmetry of movements in joints. Goniometry is a simple, informative and objective tool for control and monitoring of martial arts athletes' functional state. It can be recommended for monitoring of athletes state.

### **Conflict of interests**

The authors declare that there is no conflict of interests.

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