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Electric activity of selected agonists and antagonists registered during the measurements of different kinds of muscle strength and technical skills of 17 to 19 years old judo athletes

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
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Marcin Dornowski[ABCDE], **Władysław Jagiełło**[ACDE], **Beata Wolska**[CDE]

University of Physical Education and Sport in Gdansk , Poland

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Abstract

Background & Study Aim: There is only few reports which could give answers for combining both technical skills and strength ability with electrical control of muscle activity. The main objective of this study is knowledge about relations between bioelectric muscle activity, registered during the muscle strength activity measurement at 17 to 19 years old judo athletes and the level of their technical skills (throws). Application purpose was to define the topography of electrical activity of chosen agonists and antagonists, registered during the measurements of muscle strength, depending on technical skills of 17 to19 years old judo athletes.

Material & Methods: Age of examined 30 judo athletes: average 17.83 ±0.64 years; body weight 69.66 ±12.33kg. During the research following methods of measurements was used: electrical muscle activity EMG, muscle strength in different conditions of its realisation.

Results: Fifteen technical skills in judo (throws) have revealed their correlation with electric activity of agonist and antagonists in measuring muscle strength in three out of four strength manifestations: in isotonic strength, in power and jumping rate, and static strength. Among these: 5 belonged to leg throws; 4 to hip throws and 4 to "dedication throws" and 2 to the hand throws.

Conclusions: Value of muscle electric activity defined in the measurement of strength endurance stayed without any statistically significant correlations with technical skills. On the basis of the studies of muscle electric activity, registered during the measurement of various muscle strength manifestation and based on the practical experience, the results of above researches can be used in the process of training of young judo athletes.

Key words: bioelectric muscle activity, combat sports, fight technique, judo throwing techniques

Author's address: Władysław Jagiełło, Department of Combat Sports, Faculty of Physical Education, Academy of Physical Education and Sport, Kazimierza Górskiego 1, 80-336 Gdańsk, Poland; e-mail: wjagiello1@wp.pl

Tokui-waza – "favourite" or "best" technique. It's the throw that fits naturally to athlete body type

Throwing techniques:

Hand techniques (sub classification: ***te waza***):

kibisu-gaeshi – single leg take down (one-hand reversal)

kuchiki-taoshi – dead-tree drop

morote-gari – two-arm clip

seoi-otoshi – kneeling shoulder drop

sukui-nage – double leg takedown (scoop throw)

tai-otoshi – body drop

uchi-mata-sukashi – inner thigh void throw

Hip techniques (sub classification: ***goshi waza***):

koshi-guruma – hip whirl

o-goshi – hip roll

osoto-makikomi – big outer wraparound

sode-tsurikomi-goshi – hip throw with a rising sleeve pull

tsuri-goshi – lifting hip throw

uki-goshi – rising-hip throw

ushiro-goshi – back-lift throw

utsuri-goshi – hip shift

Leg techniques (sub classification: ***ashi waza***):

deashi-barai – forward outside clip

kouchi-gari – small inside clip

okuri-ashi-barai – assist foot sweep

osoto-gari – big outside clip

osoto-otoshi – big outer drop

sasae-tsurikomi-ashi – lifting-pull throw with supporting foot

uchi-mata – thigh throw (inner-thigh throw)

INTRODUCTION

Efficiency of solving the motor exercise/task, as practical situation is dependent from physical work (muscular), meaning its biological and intellectual potential [1-3]. Judo is high-speed and strength sport with coordination compound structure. It requires from the athletes plastic motor habits, proper energy potential and high level of motor skills [4-8]. Physical fitness and its aspects in judo is often a subject of the research. Judoists' appropriate strength preparation is one of the elements having influence on the technical training level, which gives possibility of high sport achievements [9, 10]. Significant importance of strength and various manifestations of achieving high results in most sport disciplines, confirm numerous theoretical and practical [11-17].

Fight technique is defined for the purpose of theory and practice of combat sports as „used such sport technique, which facilitates achieving fight aims as to acquired motor habits or in other words use of such, even earlier not practiced motor solution, which fighting person considers in particular moment as the best one" [1, p. 58].

In the literature we observe publications showing influence also of chosen elements of strength preparation for technical skills level in judo [16-20]. However there are only few reports/news which would give answers regarding link between technical and strength skills and electric activity of judoists' muscles. The scientific exploration of complex links of realization measurements of various manifestations of muscular strength judoists and their technical preparation is very important and necessary matter for empirical defining.

The **main objective** of this study is knowledge about relations between bioelectric muscle activity, registered during the muscle strength activity measurement at 17 to 19 years old judo athletes and the level of their technical skills (throws).

The **application aim** was to develop the topography of electric al activity of selected agonists and antagonists, registered during the measurements of muscular strength depending on technical skills of 17 to19 years old judo athletes.

MATERIAL AND METHODS

Participants

In the studies took part 30 athletes training judo: age 17 to 19 years old, average17.83 ±0.64; body weight 69.66 ±12.33kg. They were students from the classes with judo profile in Sports Group of Secondary School and athletes training in clubs in Pomerania voivodship and Warmia and Mazury voivodship. Examined athletes have trained on average for 7.05 ±2,46 years, and have improved their sport skills during the training process. The first sport class had 4 athletes during the research, second class 12 athletes and third 14. Two from 30 examined judoists were members of the Younger Junior National Team, 8 were in the Junior Voivodship Team.

Bioethical Commission at Local Medical Chamber in Gdansk has accepted information about the research and has not raised objections against research mentioned above. The research has no signs of medical experiment on human.

Protocol

To assess the level of electrical muscle activity in every manifestation of muscle strength (isotonic strength, static strength, strength endurance, power and jumping rate) method of skin reading summary of electrical muscle bio-potential on the Electromyography AMT – 8 CDN Bortec Biomedical equipment using ACQ software and surface electrodes (Sorimex EK – S50WPSG), was used. There were analyzed the activity of main muscle groups responsible respectively for flexion and extension in joints in upper and lower limbs.

Regarding the upper limbs, EMG signal was collected from following muscles: *biceps brachii caput longum* (right and left) and *triceps brachii caput lateralis* (right and left); as for lower limbs from: *quadriceps femoris caput longum* (right and left) and *biceps femoris caput longum* (right and left).

Electrodes were placed at the appropriate muscle after proper preparation of the skin (ungreased skin and shaved, if necessary). Electrodes with diameter up to 1cm (active surface) were placed over the muscle belly in the central position. Additionally, every examined was equipped with reference electrode, placed over electrically inactive areas such as joints, bones being close to the examined area.

The study of muscle electrical activity (mean amplitude value) has allowed to define participation level of particular muscle during the exercise or work done by the muscle at the completion of the task or exercise. Muscle strength was defined in four of its manifestations.

Ergometric measurement equipment ,,Concept 2 Dyno" was used to estimate the level of isotonic strength. This equipment measures the isotonic strength of upper and lower limbs. The ergometr's main element is the flywheel with different load levels. The judo athletes were subjected to strength examination of upper and lower limbs.

Ergometric measurement equipment ,,Concept 2 Dyno" was used to estimate the level of strength endurance. This equipment measures strength endurance of upper and lower limbs The ergometr's main element is the flywheel with different load levels. The tested athletes had to make 10 repulses of the bar with upper limbs from the position with bent elbow joints to extension. In case of lower limbs tested athletes made repulses with foots from the position of the lower limbs bent at the knees to extension.

The studies to assess the level of power and jumping rate were made on the Kistler tensometric platform (Quatro Jump Bosco Protocol). In the measurement of lower limbs participants performed 10 to 12 continuous jumps with straight legs with upper limbs swing. During the measurement of upper limbs participants performed 10 to 12 bounces in front support, where hands of tested judoist aimed in the centre of the platform (athlete has minimally weigh down in elbow joints).

The electronic device dynamometer Ergo Meter was used to assess the level of static strength. The tested athlete had to do 6 test tasks. 3 tasks were for upper limbs and 3 tasks for lower limbs.

In the work the measurements results from years 2006-2008 conducted in the Laboratory of Physical Effort in Gdansk Academy of Physical Education and Sport.

For the purpose of defining basic technical skills (throws) for 17 to 19 years old judo athletes, source materials analysis (research reports and Olympic Games and protocols World Cup) and diagnostics survey using a questionnaire filled by 30 judo coaches with master class and first class were used.

To assess the level of technical skills expert evaluation method (trainers assessment) was used. Every technique (throw), indicated by coaches in previously conducted diagnostic survey, was rated 1 to 10 (with point divided into tenths). Each error and discrepancy from the model had adequate sanction in given points, given in especially prepared evaluation protocol. Three experts who made assessment of conformity of demonstrated skills (throws from 4 groups) with the model one. Each tested athlete had to demonstrate with partner (equal in terms of height and weight) all commanded throws from right-sided pose. Then evaluation of all experts were averaged.

Statistical analysis

Software package Statistica 8 was used. Statistical significance of above correlations was defined by using linear Pearson's correlation (for variables which presented normal distribution) and Spearman correlation (for variables which didn't present normal distribution). Additionally percentage level of these correlations has been defined using multiple stepwise regression that allowed to separate this correlations which explained in the strongest way influence of the independent variables for dependent variables.

RESULTS

Hand techniques (sub classification: te waza): kibisu-gaeshi; kuchiki-taoshi; morote-gari; seoi-otoshi; sukui-nage; tai-otoshi; uchi-mata-sukashi

The performance level of *kibisu-gaeshi* throw is explained accordingly to multiple backward regression, in 36.9% by independent variable: electric activity of right thigh *quadriceps* muscle in measuring the isotonic strength in the exercise involving upper and lower limbs together. The *kuchiki-taoshi* throw is explained accordingly to multiple regression, in 48.8% by independent variable: electric activity of right arm *biceps* muscle in measuring the isotonic strength in the exercise involving upper limbs together in 31.8%. The second independent variable affecting the level of this throw performance is electrical activity of left arm *triceps* muscle in measuring static strength in the exercise involving left upper limb. The performance level of *morote-gari* throw is explained accordingly to multiple regression, in 32.6% by independent variables: electric activity of right thigh *quadriceps* muscle in measuring strength rate and jumping rate in the exercise involving lower limbs together, electric activity of left thigh *quadriceps* muscle in measuring isotonic strength in exercise involving lower limbs together and electric activity of left thigh *biceps* muscle in measuring isotonic strength in exercise involving lower limbs together. The *seoi-otoshi* throw is explained accordingly to multiple backward regression, in 61.94% by independent variable: electric activity of right thigh

Rear-fall and side-fall judo throws, synonym: "dedication throws" (sub classification: ***sutemi-waza***):

soto-makikomi – outside wrap-around throw (outer wraparound)

tani-otoshi – valley drop

uchi-mata-makikomi – inner-thigh wrap-around Inner thigh wraparound

yoko-otoshi – side drop

quadriceps muscle in measuring the isotonic strength in the exercise involving upper and lower limbs together. The performance level of *sukui-nage* throw is explained accordingly to multiple backward regression, in 32.7% by independent variable: electric activity of right thigh *quadriceps* muscle in measuring the isotonic strength in the exercise involving upper and lower limbs together. The performance level of *tai-otoshi* throw is explained, accordingly to multiple forward regression, in 41.09% by independent variable: electric activity of right thigh *quadriceps* muscle in measuring the isotonic strength in the exercise involving upper and lower limbs together. The *uchi-mata-sukashi* throw is explained accordingly to multiple backward regression, in 32.17% by independent variable: electric activity of right thigh *quadriceps* muscle in measuring isotonic strength in the exercise involving upper and lower limbs together.

Hip techniques (sub classification: goshi waza): koshi-guruma; *o-goshi; osoto-makikomi; sode-tsurikomi-goshi; tsuri-goshi; uki-goshi; ushiro-goshi; utsuri-goshi*

The performance level of *koshi-guruma* throw is explained accordingly to multiple backward regression, in 37.4% by independent variable: electrical activity of right thigh *quadriceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together. The *sode-tsurikomi-goshi* throw is explained accordingly to multiple backward regression, in 33.2% by independent variable: electric activity of right arm *biceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together. The performance level of *o-goshi* throw is explained accordingly to multiple regression, in 32.8% by independent variables: electric activity of right arm *biceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together and electric activity of right thigh *quadriceps* muscle in exercise involving upper and lower limbs together. The *osoto-makikomi* throw is explained accordingly to multiple backward regression, in 40.07% by independent variable: electric activity of right thigh *quadriceps* muscle in exercise involving upper and lower limbs together in measuring the isotonic strength. The *uki-goshi* throw is explained accordingly to multiple forward regression, in 46.9% by independent variables: electric activity of left thigh *quadriceps* muscle in measuring isotonic strength in exercise involving lower limbs together, electric activity of right thigh *biceps* muscle in measuring isotonic strength in exercise involving lower limbs together. The independent variables are crucial in this group. The performance level of *tsuri-goshi* throw is explained accordingly to multiple forward regression, in 60.01% by independent variable: electric activity of right thigh *quadriceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together. The *utsuri-goshi* throw is explained accordingly to multiple regression, in 49.19% by independent variable: electric activity of right thigh *quadriceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together. The performance level of *ushiro-goshi* throw is explained accordingly to multiple regression, in 47.85% by independent variables: electric activity of left arm *biceps* muscle in measuring the static strength in exercise involving upper limbs together and electric activity of left arm *triceps* muscle in exercise involving left upper limb. Both independent variables are crucial in this couple/pair.

Leg techniques (sub classification: ashi waza): deashi-barai; kouchi-gari; okuri-ashi-barai; osoto-gari; osoto-otoshi; sasae-tsurikomi-ashi; uchi-mata

The performance level of *deashi-barai* throw is explained accordingly to multiple forward regression in 32.3% by independent variable: electric activity of left arm *triceps* muscle in measuring isotonic strength in exercise involving left upper limb. The *kouchi-gari* throw is explained accordingly to multiple forward regression, in 30.7% by independent variables: electric activity of left thigh *quadriceps* muscle in exercise involving lower limbs together and electric activity of left thigh biceps muscle in exercise involving lower limbs together. Both independent variables are crucial (important). The *okuri-ashi-barai* throw is explained accordingly to multiple regression, in 51.25% by independent variables: electric activity of right thigh *quadriceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together and electric activity of right arm biceps muscle in measuring the isotonic strength in exercise involving upper and lower limbs together. All independent variables are in this case of the same importance. The performance level of *osoto-gari* throw is explained accordingly to multiple regression, in 30.12% by independent variable: electric activity of left arm *biceps* muscle in measuring isotonic strength in exercise involving upper limbs together. The *osoto-otoshi* throw is explained accordingly to multiple regression, in 42.35% by independent variables: electric activity of left thigh *quadriceps* muscle in measuring isotonic strength in exercise involving lower limbs together and electric activity left

thigh *biceps* muscle in measuring isotonic strength in exercise involving lower limbs together. All independent variables are in this case of the same importance. The performance level of *sasae-tsurikomi-ashi* throw is explained accordingly to multiple regression, in 38.2% by independent variables: electric activity of right thigh *quadriceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together, electric activity of left arm *triceps* muscle in measuring isotonic strength in exercise involving left upper limb and electric activity of left arm *biceps* muscle in measuring isotonic strength in exercise involving upper limbs together. The last independent variable in this group is the key variable (most important). Independent variables from measurement of strength and jumping rate were: electric activity of left thigh *quadriceps* muscle in exercise involving lower limbs together and electric activity of left thigh *biceps* muscle in exercise involving lower limbs together, which explains the level of dependent variable in 44.83%. Both independent variables are crucial (important). The performance level of *uchi-mata* throw is explained accordingly to multiple backward regression, in 37,41% by independent variable: electric activity of right thigh *quadriceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together.

Rear-fall and side-fall judo throws (sub classification: sutemi-waza): soto-makikomi; tani-otoshi; uchi-mata-makikomi; yoko-otoshi

The performance level of *soto-makikomi* throw is explained accordingly to multiple regression, in 44.07% by independent variables: electric activity of right arm *biceps* muscle in measuring isotonic strength in exercise involving upper limbs together, electric activity of right arm *biceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together and electric activity of right thigh *quadriceps* in measuring isotonic strength in exercise involving upper and lower limbs together. The *tani-otoshi* throw is explained accordingly to multiple regression, in 44.5% by independent variables: electric activity of right thigh *quadriceps* muscle in measuring strength and jumping rate in exercise involving lower limbs together and electric activity of left thigh *biceps* muscle in measuring strength and jumping rate in exercise involving lower limbs together. The independent variables are crucial in this group The *uchi-mata-makikomi* throw is explained accordingly to multiple forward regression, in 53.59% by independent variables: electric activity of right thigh *quadriceps* muscle in measuring isotonic strength in exercise involving upper and

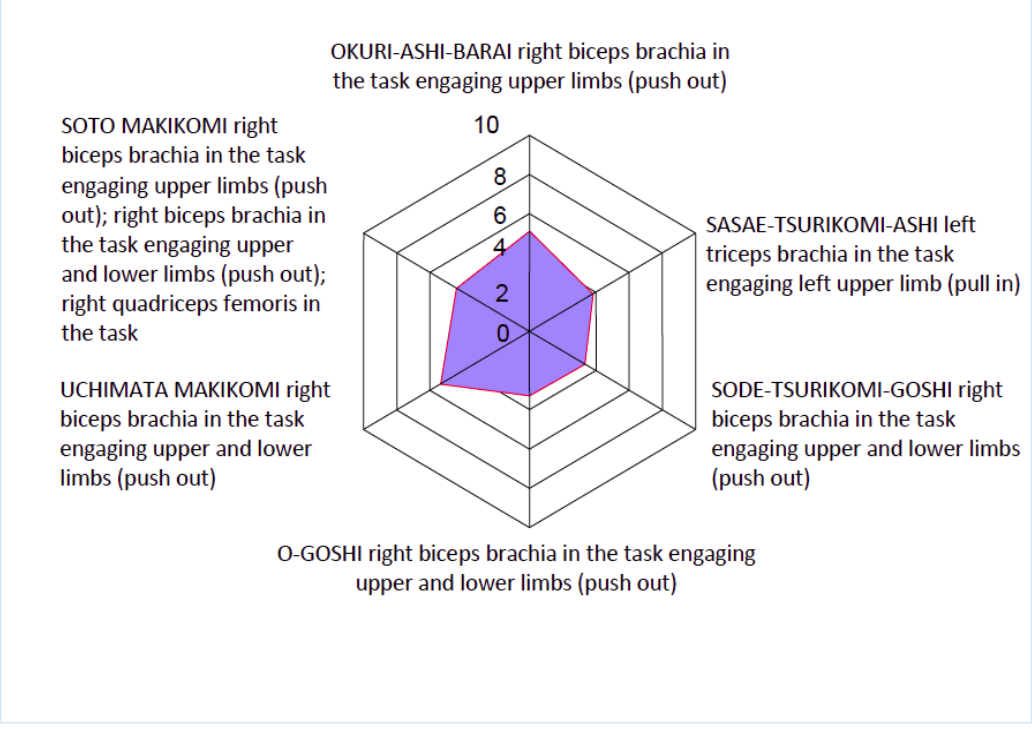

Figure 1. Topography of electrical muscle activity in the isokinetic strength measurement in dependence of 17 to19 years old judo athletes technical skills (throw sub classification: *goshi waza, ashi waza, sutemi waza*).

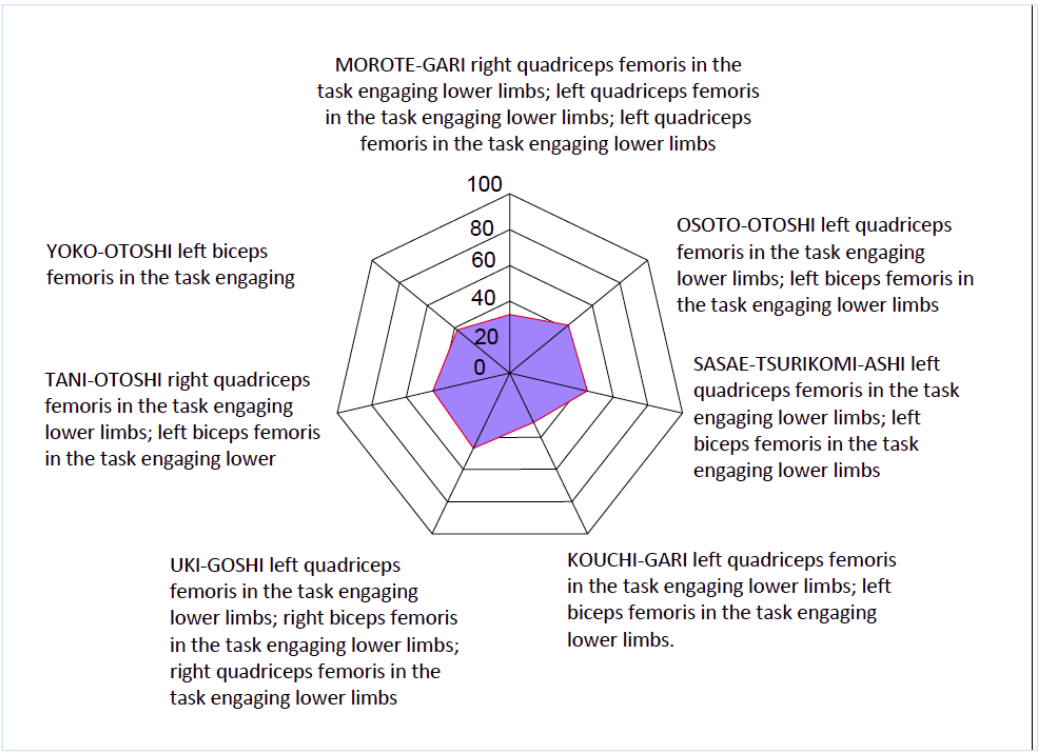

Figure 2. Topography of electrical muscle activity in the static strength measurement in dependence of 17 to 19 years old judo athletes technical skills (throw sub classification: *te* waza, *goshi waza, ashi waza, sutemi waza*).

lower limbs together and electric activity of right arm *biceps* muscle in measuring isotonic strength in exercise involving upper and lower limbs together. The *yoko-otoshi* throw is explained accordingly to multiple backward regression, in 38.08% by independent variables: electric activity of left thigh *biceps* in measuring power and jumping rate in exercise involving lower limbs together.

Using the information and data from correlation matrix of dependent and independent variables and based on multistep regression, which has revealed the most significant correlations between variables, shown as percentage, the topography of this correlations was created – separately for electrical activity of selected agonists and antagonists in measuring particular manifestations of muscular strength of 17-19 years old judo athletes. This information indicates elements of electric activity of muscle, which should be under particular attention during the training and interval measurements.

The aggregate values of electrical activity of chosen agonists and antagonists of measured manifestation of muscle strength and four groups of technical skills (17 to 19 years old judo athletes) with detailing these correlations which appeared among variables, were defined. Figures 1-3 show topography of correlations of dependent variables (movement skills – throws) and independent variables (muscle strength indicators).

DISCUSSION

The obtained results allowed to realise the main aim of the research, which define the correlation between electric activity of chosen agonists and antagonists, registered during measurements of various forms of muscular strength and technical skills of 17 to 19 years old judoists and application aim – developing the topography of muscle activity depending on technical skills of 17 to19 years old judo athletes.

In the literature we can observe few reports, where authors undertook the subject of relationship of electric muscle activity, registered during measurements of muscle strength and technical skills. Ahlstrom [21] in his studies provided comparison of the way how to do two different models of throw in judo in sport practice. In creating the standards of technical skills EMG signal analysis was used. Similar studies were provided by

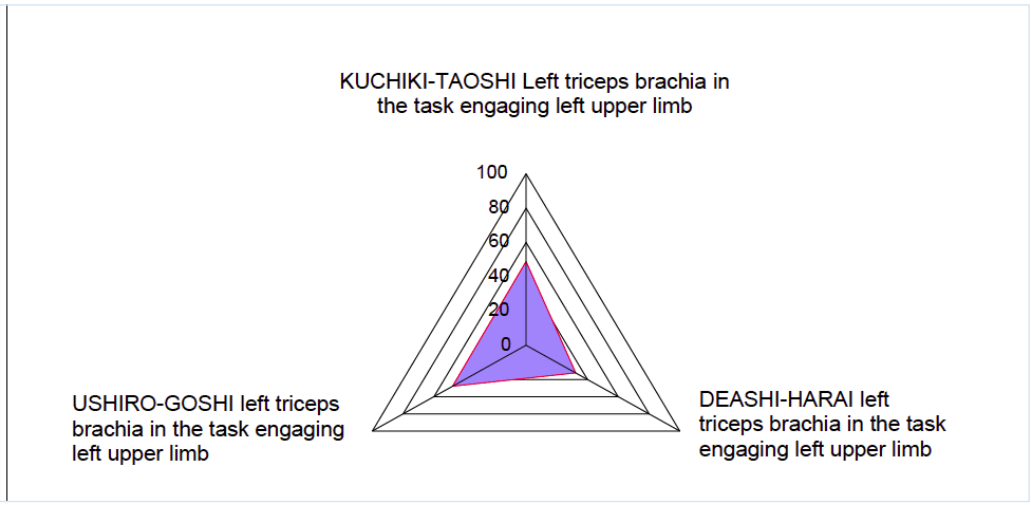

Figure 3. Topography of electrical muscle activity in the power and jumping rate measurement in dependence of 17to19 years old judo athletes technical skills (throw sub classification: *te waza, goshi waza, ashi waza*).

Houzan [22]. Number of throws were analyzed, where the aim was to determine the technical level and muscle activity during their implementation (EMG). The studies allowed to gain the model of electric activity of chosen muscle groups during the completing the motor exercise (motor ability – throw). Thierry and others [23] presented studies on the analysis of electrical activity of postural muscles (lower limbs) used in the favourite throw of examined judoists (*tokui-waza*). 23 judoists aged between 16 and 20 years with regional sport level were divided into two groups, which realised test task both in the position using one leg or two legs. The studies has shown that the manner of training the concrete throw (*tokui-waza*) has had major influence for the level of future performance. There was creating a specific scheme of postural muscle tension in both starting positions. Ribeiro et al. [24] have provided similar research to one presented in this paper. They have analyzed electric activity of selected muscle groups during performance of particular motor tasks. The authors have examined influence of specific character of physical activity in judo (sport fight 90s, 180s, 300s) on, inter alia, electric activity of muscles and on the level of disparity between activity before and after the exercise. Measurement of electric al activity was made during 5 dynamic contractions (90º) on the isokinetic dynamometer (Biodex System 3). Authors have concluded that stress 90s, 180s and 300s fights, although it cannot change the torque, it is sufficient stimulus to cause enzymatic changes and electric muscle activity, what can have negative effect on sport result.

Researches of 17 to 19 years old judo athletes have revealed statistically significant correlations between level of summary electric bio-potential of chosen agonists and antagonists in measuring muscle strength and performance level of technical elements of judo (4 groups of throws). There were characterised accordingly to the influence of summary electric bio-potential of chosen muscle groups, following technical judo skills (throws): *kuchiki-taoshi*, *morote-gari*, *okuri-ashi-harai*, *osoto-otoshi*, *deashi-harai*, sasae-tsurikomi-*ashi*, *kouchi-gari*, *uki-goshi*, *ushiro-goshi*, *sode-tsurikomi-goshi*, *o-goshi*, *tani-otoshi*, *uchi-mata-makikomi*, *yoko-otoshi*, *soto-makikomi*. The range of the correlations oscillated between 30.7% and 53.59%.

Out of 40 analysed technical judo skills (throws) 37.5% were characterised by electric activity of chosen agonists and antagonists, described by measurements methods used in this work. Technical skills (throws) 17 to 19 years old judo athletes describe specific model – scheme of muscle tensions determining the high correctness of their performance.

Fifteen technical skills in judo (throws) have revealed correlation with electric agonists and antagonists of 17 to 19 years old judoists in measuring muscle strength in 3 out of 4 measured strength manifestation: in isotonic strength, in power and jumping rate and static strength. These skills belong to the group of hand throws (*te waza*) **2**, hip throws (*goshi waza*) **4**, leg throws (*ashi waza*) **5**, "dedication throws" (*sutemi waza*) **4**. The values of defined muscle electric activity in measuring the strength endurance stayed without

any statistical correlation. Probably this motor ability is not the priority in realization of technical skills (throws) of 17 to 19 years old judo athletes. It is therefore necessary to concentrate on the electric activity control during the development of isotonic strength, power and jumping rate and static strength.

Hand throws (*te waza*) are mainly characterised by electric muscle activity from measuring static strength and power and jumping rate. Hip throws (*goshi waza*) – electric muscle activity from measuring isotonic strength, measuring power and jumping rate and static strength. Leg throws (*ashi waza*) – electric muscle activity from measuring isotonic strength, measuring power and jumping rate and static strength. "Dedication throws" (*sutemi waza*) – electric muscle activity from measuring isotonic strength, measuring power and jumping rate.

The technical skills in judo (throws) described in the work, characterise in asymmetric biomechanical structure of motion and muscle activity. The nature of movement in concrete throw causes in the given moment, for particular motion in joints, contraction of agonists and antagonists (muscle co-contraction) or exclusion of one of the limbs agonist at the expense of the other limb. The specific picture of electric activity of agonists and antagonists for concrete throw at 17 to 19 years old judo athletes is built.

Visual analysis of the judo throws not always ensures the certainty of activity of individual muscles. However thorough observation of the throw performance, would have allow to identify in more or less accurate way which muscles stop even if they should be active; which muscle could be active together although they are antagonistic to each other. The results of the studies allowed to distinguish the most important for the level of performance of the motor ability.

This type of image can allow for quick use of the electromyography method to determine adequate muscle tension with particular technical skill in judo (throws) in practice.

CONCLUSIONS

Fifteen technical skills in judo (throws) have revealed their correlation with electric activity of agonist and antagonists in measuring muscle strength in three out of four strength manifestations: in isotonic strength, in power and jumping rate, and static strength. Among these: 5 belonged to leg throws (*ashi waza*); 4 belonged to hip throws (*goshi waza*) and 4 to "dedication throws" (*sutemi waza*) and 2 belonged to the hand throws (*te waza*).

Value of muscle electric activity defined in the measurement of strength endurance stayed without any statistically significant correlations with technical skills.

On the basis of the studies of muscle electric activity, registered during the measurement of various muscle strength manifestation and based on the practical experience, the results of above researches can be used in the process of training of young judo athletes.

COMPETING INTERESTS

Authors declare no conflicts of interest.

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