ORIGINAL ARTICLE

Success factors in elite WTF taekwondo competitors

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B Data Collection
C Statistical Analysis
D Manuscript Preparation
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Abstract

Background and Study Aim: The aim of the study was to identify selected success factors of elite Olympic taekwondo competitors in the context of medals that they have or have not won during Polish Senior Championships (PSCs).

Material/Methods: Sixty-four elite male taekwondo competitors took part in the study. The competitors were divided into two groups on the basis of their achievements: PSC medallists and non-medallists. Factors determining sports success were modelled with the use of a general linear model (GLM). The procedure lasted until the minimum of the quality criterion, i.e., the Akaike information criterion (AIC), was reached.

Results: Successful competitors (medallists) demonstrated significantly better technique, conditioning and flexibility parameters. Technical skills (e.g., strikes and side and roundhouse kicks), speed, dynamic strength and endurance were the factors that contributed to the achievement of excellent results in taekwondo.

Conclusions: The research results revealed groups of success factors in taekwondo at a national level. Variables concerning kicks exerted the greatest influence on point scores (*360° dollyo chagi montong* – 41% and *dollyo chagi* – 31%).

Key words: WTF taekwondo • regression model • 360° dollyo chagi montong • dollyo chagi

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Background

The most important success factors in sports include body build, conditioning, technical and tactical skills, mental abilities and the experience of a competitor [1]. Since WTF (World Taekwondo Federation) taekwondo was approved for the Sydney 2000 Olympic Games, it has been the subject of extensive research, where one of the areas of interest is the identification of success factors. Training effectiveness in sport is measured with the best possible performance (result) in the most important competitions. Therefore, many researchers have been interested in establishing success factors in taekwondo.

The majority of studies have sought to determine correlations between different indicators and performance in taekwondo, including morphological [2–10], biomechanical [7,11], conditioning, physiological and psychological indicators [6,8,12–14] and indicators related to coordination [15]. The aforementioned researchers have found that taekwondo competitors with mesomorphic body build, high levels of speed, strength, endurance and flexibility, as well as shorter reaction times and proper technique have achieved excellent results.

Rarely have several success factors in elite taekwondo competitors been analysed simultaneously (in terms of medals they have or have not won at the highest levels of competition). In the above-mentioned studies, researchers focused entirely on single factors that were somatic or physiological.

The aim of this study was to identify selected success factors of elite Olympic taekwondo competitors within the context of medals that they have or have not won during Polish Senior Championships (PSCs).

Material and Methods

Sixty-four elite male taekwondo competitors took part in the study. The competitors were 19.7±2.5 years old,

and their training experience was 7.5±3.3 years. The subjects were assigned to two groups. The first group consisted of competitors (n=28) who had won medals (MW) at PSCs, while the other included competitors (n=36) who had finished 4th–8th (NMW) at PSCs.

The number of points scored in the 2010–2011 PSC qualifying tournaments and at the 2010–2011 PSCs constituted the results. The grading scale of the Polish Taekwondo Federation was employed [16].

The research included measurements of structure (A1–12), conditioning (B1–5) and flexibility (B6, 7) as well as technical (C1–3), coordination (D1–5) and energetic (E1–5) measurements.

The variables of body build assessment included body height and mass; the Quetelet index II; length of upper and lower limbs; shoulder and pelvis width; arm, forearm, thigh and shank circumference; and the thickness of five skinfolds (calf, supraspinal, triceps, subscapular, abdominal).

Conditioning was assessed using the following tests: overhead medicine ball throw (2 kg), standing broad jump, 30 s sit-ups, flying 30 m run, 20 m shuttle run (beep test) [17,18].

Flexibility was measured with the length of front and side splits [15].

Technical skills were assessed with the time needed to perform 10 repetitions of *dollyo chagi, jirugii momtong*, and *360° dollyo chagi momtong* [16].

Simple and complex reactions were measured using RT (version S1) and DT (version S1) of the Vienna Test System [19].

The anaerobic muscle capacity of the lower limbs was measured using a 30 s Wingate test [20]. The following indicators were determined: workload ($J \cdot kg^{-1}$), peak power ($W \cdot kg^{-1}$), anaerobic fatigue (%) and the time of achieving and maintaining peak power (s).

Regression model – functions describing correlations between a scalar variable and explanatory variables.

At first, the correspondence of the distribution of particular variables with a normal distribution was analysed. The Shapiro-Wilk test was employed. Then, specific variables were standardised into means and standard deviations of the NMW group. The success factors were modelled using two methods. In the first – variance analysis – the scalar variable was the dichotomy of "has won/has not won a medal". The other method incorporated modelling with the use of the general linear model (GLM) – multinomial logistic regression analysis – where the scalar variable was the number of points scored at PSCs and two qualifying tournaments.

The Akaike information criterion (AIC) was adopted as the main criterion. All the available models of multinomial logistic regression (4095) were analysed, and the one for which the AIC achieved minimal values was selected. Moreover, odds ratios (ORs) were calculated for particular (significant) variables incorporated in the model. The significance of the model was verified using the Wald test. The script defining an algorithm was created and was based on the P. Bieck programme [21], which was activated and performed on the R platform [22].

Results

The differences between the MW and NMW groups were noted in the techniques of kicks and strikes, in conditioning and flexibility and in certain structural and energetic factors ($p<0.05$).

The comparison of body build between the MW and NMW groups revealed that the subjects from the former group were much slimmer than those from the latter (Table 1). The largest differences were found in the BMI (A3: 8.5%), upper limb circumferences (A8: 8.8%, A9: 5.1%) and adiposity – the sum of skinfolds (A12: 30.6%) ($p<0.05$).

The MW group performed better in the speed-strength (B2: 7.2%; B4: 4.1%), endurance-strength (B3: 13.0%) and endurance (B5: 23.6%) tests. A significant difference was also observed in the front split (B7: 9.3%) ($p<0.01$).

The subjects from the MW group also excelled in technical skills (Figure 1). The differences ranged from 8.8% to 16% (C1: 11.3%; C2: 16%; C3: 8.8%) ($p<0.05$–0.01). In turn, the analysis of simple and complex reaction times did not reveal the dominance of either group, which may indicate that this factor did not play a key role in achieving success.

The Wingate test results show that the medal winners worked more and obtained higher values of peak power (E1: 6.0% and E2: 6.1%) than did the other subjects.

The aim of defining the **regression model** was to select significant success variables. The following variables were identified: standing broad jump ($p<0.05$), sit-ups ($p<0.001$), front split ($p<0.001$), 20 m shuttle run ($p<0.001$), *dollyo chagi* ($p<0.001$), and *360° dollyo chagi momtong* ($p<0.001$). ORs were then calculated for those variables. ORs define the influence of unitary changes in the value of particular variables on the chances of scoring a point (Table 2).

Table 1. Differences in the levels of selected groups of factors in WTF taekwondo competitors (n=64) who have or have not won medals *(mean ±SD)*.

Group of factors (indicator)		MW group (n = 28)	NMW group (n = 36)	Differences p
Structural	A1 – body height (cm)	176.6±9.3	177.0±7.3	
	A2 – body mass (kg)	67.0±10.4	72.9±15.4	
	A3 – BMI (kg/m^2)	21.3±1.93	23.1±3.62	*
	A4 – lower limb length (cm)	91.4±6.0	91.6±4.8	
	A5 – upper limb length (cm)	81.3±5.0	81.1±4.2	
	A6 – shoulder width (cm)	30.9±1.8	31.7±2.5	
	A7 – pelvis width (cm)	26.2±1.1	26.4±2.0	
	A8 – arm circumference (cm)	26.2±1.9	28.5±3.9	*
	A9 – forearm circumference (cm)	23.5±1.4	24.7±2.7	*
	A10 – thigh circumference (cm)	52.8±3.6	55.0±6.4	
	A11 – shank circumference (cm)	36.1±1.9	37.4±3.3	
	A12 – sum of skinfolds (mm)	34.6±7.14	45.2±20.8	*
Conditioning And flexibility	B1 – overhead medicine ball throw (m)	11.5±2.1	10.7±1.5	
	B2 – standing broad jump (cm)	244.4±17.9	226.7±26.1	**
	B3 – sit-ups (number)	34.5±4.1	30.0±2.9	***
	B4 – 30 m run (s)	4.62±0.41	4.81±0.51	*
	B5 – 20 m shuttle run (number)	72.2±10.0	55.2±9.0	***
	B6 – side split (cm)	77.3±7.6	77.3±9.3	
	B7 – front split (cm)	90.4±8.8	82.0±7.6	***
Technical	C1 - dollyo chagi (s)	4.24±0.71	4.72±0.62	*
	C2 – jirugi momtong (s)	2.62±0.52	3.04±0.43	**
	C3 – 360° dollyo chagi momtong (s)	10.2±0.71	11.1±0.82	***
Coordination	D1 – reaction time (ms)	238.4±26.7	247.0±31.7	
	D2 – time of single movement (ms)	104.5±29.6	108.2±22.4	
	D3 – proper reactions (number)	245.1±39.2	234.9±32.4	
	D4 – improper reactions (number)	25.6±14.5	23.6±10.9	
	D5 – median of reaction time (s)	0.74±0.05	0.75±0.05	
Energetic	E1 – workload (J·kg±)	231.0±20.8	217.1±17.6	**
	E2 – peak power (W·kg±)	9.93±1.05	9.32±1.11	*
	E3 – anaerobic fatigue (%)	19.5±4.70	21.2±7.00	
	E4 – time of achieving peak power (s)	6.56±2.03	7.23±2.31	
	E5 – time of maintaining peak power (s)	4.02±1.57	3.72±1.40	

* p<0.05; ** p<0.01; *** p<0.001.

Of all the identified variables, the ones regarding kicks had the largest influence on the number of points scored (***360° dollyo chagi montong*** – 41% and ***dollyo chagi*** – 31%). Abdominal muscle strength (30 s sit-ups), flexibility (front split) and aerobic endurance (20 m shuttle run) were less significant. The hypothesis of model

360° dollyo chagi montong – spinning back kick.

Dollyo chagi – roundhouse kick.

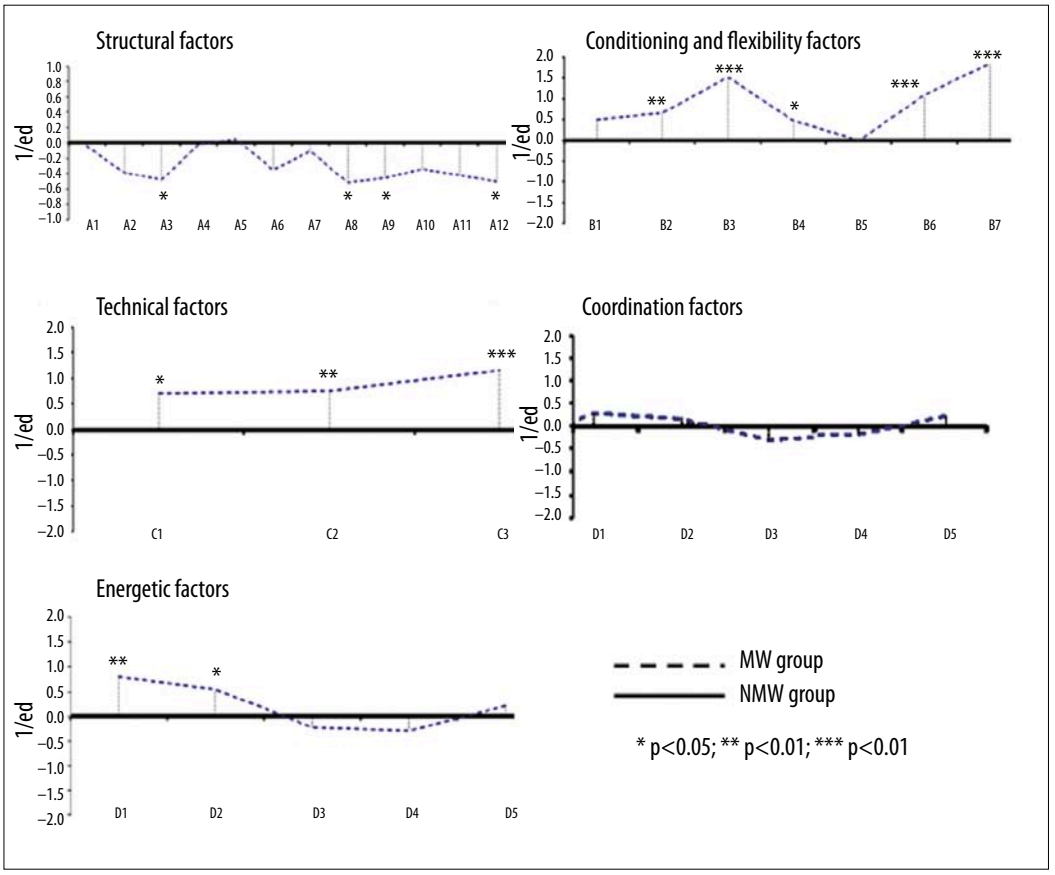

Figure 1. Normalised values of results for particular parameters in groups of taekwondo competitors.

Table 2. Results of the process of seeking an optimal model.

Variable	Value of estimated parameter	Standard estimation error	Significance level	OR (%)
Standing broad jump	0.006	1.20	p<0.05	0.6
Sit-ups	0.09	0.01	p<0.001	10
Front split	0.02	0.005	p<0.001	2
20 m shuttle run	0.03	0.004	p<0.001	3
Dollyo chagi	–0.36	0.06	p<0.001	31
360° dollyo chagi momtong	–0.51	0.08	p<0.001	41

AIC=570.52.

incommutability as a whole was rejected at the level of p<0.001. Therefore, it may be assumed that the model properly describes the investigated correlation.

Discussion

The aim of the study was to identify selected success factors of elite Olympic taekwondo competitors within the context of medals that they have or have not won during PSCs.

The elite taekwondo competitors from the MW and NMW groups differed significantly in body build, conditioning, flexibility, technique, coordination and energetic parameters. The MW group excelled in most tests.

To date, the majority of authors have focused on defining single factors, e.g., structure [6–10], biomechanics [7,11], physiology [13,23], coordination [13,24–26] and conditioning [8,12–14], and the correlations of these with competition results. In our research, we tried to identify success factors while simultaneously considering what the competition result is conditioned by.

The analysis of somatic factors revealed that in **WTF taekwondo** competitors, a slim body build and low levels of adiposity were conducive to achieving success. Medal winners demonstrated higher levels of BMI and lower levels of adiposity, which indicates that the mesomorphic body type was dominant. Taaffe, Pieter [2], Pieter [3], Gao [5], Marković et al. [7], Kazemi et al. [8], Fritzsche, Raschka [9], and Pieter [27] share this opinion, as they claim that the monomorphic type is the most promising in terms of achieving successful results.

Moreover, it was observed that the competitors from the MW group manifested higher levels of speed, dynamic strength, strength endurance and flexibility. These results are in line with other researchers' findings, which claim that taekwondo belongs to the group of sports in which speed plays a key role in achieving success [6–8,12,28–31]. In addition, the medallists performed better in the 20 m shuttle run (B5). According to McArdle et al. [32], Toskovic et al. [6], Marković [7], Cetin et al. [33], and Thompson et al. [34], this factor does not affect performance directly but rather exerts greater influence on the effectiveness and speed of energetic recovery, which may contribute to obtaining a better result and may be why our research uncovered these results.

The greatest differences were observed in technical skills. The medallists demonstrated considerably higher levels of skill than did the non-medallists, which shows how important technical skills are in terms of results. Our findings are in line with the data gathered by other researchers [8,25,30,35].

It is worth highlighting that in the case of coordination, i.e., simple and complex reactions, no significant differences were noted between groups, contrary to previous studies. Most researchers have found high correlations between time of reaction and competition results [12,13,24,25,36]. The lack of differences between the groups may have been the cause of the different results of our study.

Workload and peak power differentiated both groups. These parameters account for the efficiency and kinetics of phosphagen substrate metabolism (ATP and phosphocreatine), which may have exerted some influence on speed and the strength of kicks and strikes performed by the MW competitors [13,23,35].

The procedure of searching all acceptable models of regression revealed that the most substantial variables in terms of success (winning PSC medals) are technical skills, followed by conditioning, speed, dynamic strength and endurance.

The high levels of technical skills manifested by kick and strike performance probably resulted from an integrated manifestation of higher levels of motor and coordination abilities in the MW group.

WTF Taekwondo – Olympic sport where two competitors are engaged in direct combat.

Conclusions

Our findings enabled us to identify success factors in taekwondo at a national level. However, these results have certain limitations. Only Polish competitors participated in the study, which did not allow us to generalise the data. Future research should focus on seeking success factors in athletes at different levels of competition, particularly in those who achieve success at an international level, e.g., during Olympic Games.

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