TECHNICAL EFFICIENCY OF WRESTLERS IN RELATION TO SOME ANTHROPOMETRIC AND MOTOR VARIABLES

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Abstract:

Numerous previous studies have determined the influence of energy capacities and of motor and morphological characteristics on performance in wrestling. Research into the influence of various anthropological subspaces and motor abilities on wrestling techniques on the one hand, and the research into the interrelationship between these subspaces and abilities and wrestling techniques on the other produces valuable perceptions that can be applied in the training process both in wrestlers and in non-wrestlers (pupils, students, members of the police and army forces). The sample was comprised of 72 wrestlers (age 16-20yrs) tested at the same time at the beginning of sports preparations of young wrestlers for the European and World Championships. The measured variables encompassed two anthropometric tests (body height, body weight) and 15 motor tests. Multiple regression coefficients were used to determine the influence of those predictor variables on the following throws: *take-down, arm throw, hip headlock throw, throw* and a*rm lock and shoulder block.* The significant correlation between the set of predictor variables with three wrestling techniques was established. By employing the classical regression analysis it was possible to explain 36-41% of the variance of predictor variables in the three wrestling techniques (*hip headlock throw, take-down* and *throw*). The variables that were significant in prediction were *throwing the medicine ball from supine position*, *20-meter run from the standing start*, *double hand-tapping* and *push-ups on the floor.* It is also interesting to point out the negative influence of anthropometric measures on the execution of this throwing technique in wrestling. The obtained results allow the conclusion that technical efficiency in young top-level wrestlers depends on a large number of motor abilities as well as some morphological characteristics like body weight.

Key words*: wrestling techniques, anthropometric factors, motor ability, regression analysis*

TECHNISCHE EFFIZIENZ DER RINGER IN BEZUG AUF EINIGE ANTHROPOMETRISCHE UND MOTORISCHE VARIABLEN

Zusammenfassung:

Eine Reihe früheren Studien bewies den Einfluss sowohl von der aeroben und anaeroben Kapazität als auch von motorischen Fähigkeiten und morphologischen Eigenschaften auf das Ringen. Die Untersuchung der Auswirkungen verschiedener anthropologischen Teilräume und motorischer Fähigkeiten auf die Technik, sowie die Untersuchung des gegenseitigen Zusammenhangs dieser Teilräume, der Fähigkeiten und der Ringkampftechnik führte zu wertvollen Einsichten, die im Trainingsprozess sowohl den Ringern als auch den nicht-Ringern nützlich sein könnten (Schüler, Studenten, die Polizei, die Armee). 72 Ringer (im Alter 16-20) wurden gleichzeitig getestet am Anfang der Vorbereitungen von jungen Ringern für die Europa- und Weltmeisterschaft. Die gemessenen Variablen umfassten 2 anthropometrischen (die Körperhöhe, das Körpergewicht) und 15 motorischen Tests. Die multiplen Regressionskoeffizienten wurden angewandt, um den Einfluss dieser Prädiktorvariablen auf die folgenden Aktionen zu bestimmen: *Take-Down*, *Wurf mit Doppeltfassen eines Armes*, *Wurf über den Rücken*, *Wurf* und *Armschlüssel und Schulterblock*. Eine signifikante Korrelation zwischen der Gruppe von Prädiktorvariablen und drei Ringtechniken wurde festgestellt. Mittels einer klassischen Regressionsanalyse war es möglich, 36-41% der Varianz von Prädiktorvariablen in drei Ringtechniken (*Wurf über den Rücken*, *Take-Down* und *Wurf*) zu erklären. Die in der Prädiktion signifikanten Variablen waren *Medizinballwurf aus der Rückenlage*, *20-m Lauf aus dem Hochstart*, *doppeltes Hand--Tapping* und *Liegestütze auf dem Boden.* Der negative Einfluss anthropometrischer Messungen auf die Ausübung dieser Wurftechnik im Ringen ist bemerkenswert. Die gewonnenen Ergebnisse lassen darauf schließen, dass die technische Effizienz der jungen Spitzenringer nicht nur von einer Reihe motorischer Fähigkeiten, sondern auch von einigen morphologischen Eigenschaften, wie z.B. Körpergewicht, abhängig ist.

Schlüsselwörter: *Ringtechniken, anthropometrische Faktoren, motorische Fähigkeit, Regressionsanalyse*

Introduction

Since wrestling belongs to the group of sports characterized by polystructural acyclic movements and by very complex activities, it is affected by a large number of factors and dimensions at different levels, both in the execution of certain techniques and in competitive combat.

Previous studies have determined the influence of some segments of the motor and of the anthropological space on efficacy in executing wrestling techniques (Drobnjak, 1981; Marić, 1982; Kuleš & Marić, 1989). These studies were conducted on physical education students. Further analyses of the interrelationship between motor behaviour and anthropometry were carried out by employing the same criterion variables as in the studies mentioned previously and the subjects were junior wrestlers who could be characterized as quality athletes since most of them had had a wrestling 'career' longer than 4.5 years. Some studies in judo followed that were again conducted on physical education students (Cvetković & Marić, 1990), as well as some studies in free style wrestling (e.g., Marić, Kuleš, & Cvetković, 1990) (these studies employed some specific situational motor variables), together with a whole series of studies in free style, classical style wrestling and in judo (Stojić, 1984; Soršak, 1985; De Michele & Solomon, 1998; Marić, Gatovski, & Cvetković, 1989; Yoon, 2002; Wenhao, 2003; Turman, 2003). Stockbrugger and Haennel (2003) pointed to the fact that the interaction of upper- and lower-body strength and power in the performance of wrestlers appears complex, with the contributing factors differing for athletes with divergent skill sets and performance demands. According to Martin and Margherita (1999) weight control and weight loss distinguish wrestling from most other sports at the high school and collegiate levels.

The analysis of the results obtained in those studies makes it evident that a predictor set of situational motor and morphological variables may be employed to explain a much bigger portion of variance of techniques in all three combat styles than by employing the variables denoting general motor behaviour (the values of determination coefficients varied between 50 and 70%).

The aim of this study was to identify the structures, directions and the size of influence of the anthropometric (body height, body weight) and motor dimensions of young wrestlers on the successful execution of the elements of classical-style wrestling in the standing position.

Therefore, the aim of this paper was to determine the relation between some anthropometric and motor manifest variables with the efficiency of executing 5 wrestling techniques in the standing position in Greco-Roman or classical wrestling (*take-down* – DPPON, *arm throw* – RAMBAC, *hip headlock throw* – ZAHGL, *throw* – POJ, *arm lock and shoulder block* – OBA).

In accordance with the aim of the research the following hypothesis was formulated:

H0: There exists a statistically significant relationship between the set of anthropometric and motor dimensions, and the criterion variables denoting successful execution of some wrestling techniques.

Methods

The sample of subjects

This study was conducted on a sample of 72 wrestlers, aged 16 to 20 years, who were completely healthy and without any physical aberrations. The sample may be considered to be homogeneous, because the testing was done every year in the same sports centre, at the same time at the beginning of sports preparations of young wrestlers for the European and World Championships. The shortest wrestling career was the one of five years, and, apart from the young selection of wrestlers, quality wrestlers participated in the study as did the sparring partners. The sample consisting of 72 subjects enabled n-2 degrees of freedom so that each correlation coefficient equalling .21 may be considered as being significantly different from zero with the reliability of .95, and each correlation coefficient equalling .28 and more may be considered to be significantly different from zero with the reliability of .99.

The sample of variables

Predictor variables. Two anthropometric (body height, body weight – the measurements were carried out in accordance with the procedures prescribed in the international biological programme) and 15 motor variables (*throwing the medicine ball from supine position* – MFEBML, *horizontal jump* – MFEDSM, *20-meter run from the standing start* – MFE20V, *30-meter run from the crouch start* – MFE30N, *double hand-tapping* – MBFTA2, *assuming the bridge position in 15 seconds* – MBUM15, *sit-ups on the bench* – MRCDTK, *push-ups on the floor* – MRASKL, *straddling forward bend* – MFLPRR, *front split* – MFLCES, *wrestling bridge* – MFLMOS, *polygon backwards* – MREPOL, *crawling through and jumping over* – MKPOP, *side steps* – MAGKUS, *hang hold* – MSLIVS) were selected as predictor variables in this study.

The following throws were used as the wrestling-specific variables: *take-down* – DPPON (Fig. 1), *arm throw* – RAMBAC (Fig. 2), *hip headlock throw* – ZAHGL (Fig. 3), *throw* – POJ (Fig. 4) and a*rm lock and shoulder block* – OBA (Fig. 5).

Figure 1. Take-down – DPPON.

Figure 2. Arm throw – RAMBAC.

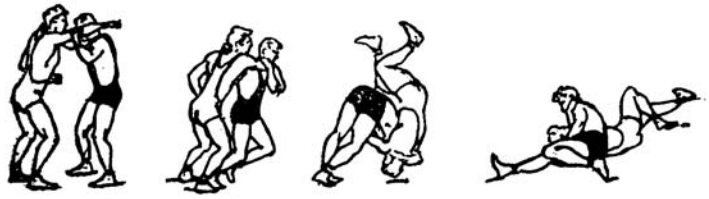


Figure 3. Hip headlock throw – ZAHGL.

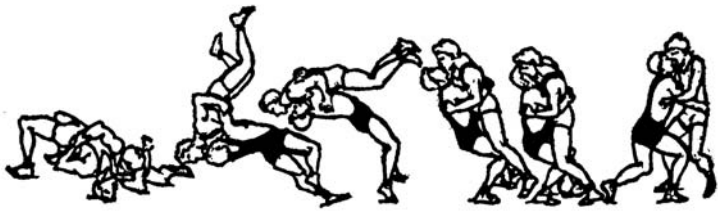


Figure 4. Throw – POJ.

Figure 5. Arm lock and shoulder block – OBA.

Criterion variables. To determine the quality of the execution of selected wrestling techniques in this study, the efficacy assessment executed by three competent referees, which, in fact, can be denoted as a quality 'objective' assessment tool, was used as the criterion variable. Each referee evaluated, by using marks from 1 – 5, each of the five wrestling techniques in each subject. The subjects executed each hold three times in a row. The following structures of each hold were evaluated:

1. correct basic combat position and the correct hold
   1 point
2. the phase of entering the hold
   1 point
3. operational phase (take-down, turning-over, throw)
   1 point
4. final phase
   1 point
5. general merit (coordinated execution of all phases without any interruptions)
   1 point

If a structure within one hold was not correctly executed then it was recorded as 0 points, so that the total mark varied from 0 – 5 points.

Data processing methods

The predictor variables, as well as the criterion variable were processed by means of the standard descriptive methods, namely, the central and the dispersion parameters for all variables were calculated. Further, the matrices of intercorrelations between the predictor variables and the criterion variable were calculated. Regression analysis was used to identify the influence of the anthropomteric and motor dimensions of wrestlers on efficacy in executing the Greco-Roman style techniques in the standing position.

The subjects were measured by two anthropometric and fifteen motor variables that served as the predictor system.

Results

Table 1 contains the data of descriptive statistics on the monitored predictor and criterion variables.

An inspection of Table 2, which displays the correlation between anthropometric and motor manifest variables, makes it possible to establish the relatively low correlations between predictor variables.

The results of the regression analysis of the technique *hip headlock throw* (ZAHGL) are presented in Table 3.

An inspection of Table 4 containing the results of the regression analysis of the technique *throw (POJ)* makes it evident that out of all the other analysed techniques this particular one is best explained by the employed system of manifest anthropometric and motor variables.

Discussion and conclusions

The descriptive statistics of variables (Table 1) may serve to emphasize the point that all anthropometric and motor variables had the normal distribution of results and could be presented by the Gaussian curve. Only the variable *crawling through and jumping over* (MBKPOP) had exceedingly condensed results in the zone of higher values, whereas several exceptionally tall and massive wrestlers of semi-heavy, heavy and super-heavy weight category were responsible for the skewness of the curve due to poorer results. This occurrence was logical because crawling through and jumping over the box is rather difficult for these three weight categories (due to their height and weight).

All the five employed wrestling-specific variables for the evaluation of technical skills also had a normal distribution of results. However, as for the range of marks given by the referees to each subject for each wrestling technique, Table 1 makes it obvious that three techniques (*arm throw* – RAMBAC, *hip headlock throw* – ZAHGL and *throw* – POJ) significantly exceeded the average values and approached the maximal possible mark, thus moving the results to the zone of higher values.

Table 2 makes it evident that out of the total of 138 calculated correlation coefficients, 66 had low and almost zero results which were, naturally, also statistically insignificant. If .23 of correlation coefficients are added that barely reach the minimal threshold of .21 at the level of significance p = .05, then it can be said that the selected anthropometric and motor variables represents an extremely heterogeneous structure.

Out of the remaining 49 correlation coefficients, 14 displayed significant and relatively high corre-

Table 1. Descriptive statistics of variables

Variables	AM	SD	Min.	Max.	Skew.	Kurt.
BODY HEIGHT	173.50	9.01	154.00	195.00	.25	2.60
BODY WEIGHT	69.30	14.93	47.00	116.30	.86	3.66
MFEBML	6.67	1.30	3.81	10.12	.32	3.32
MFEDSM	22.92	1.82	195.02	273.33	.31	2.49
MFE20V	3.48	.24	2.99	4.10	.19	2.50
MFE30N	4.90	.29	4.33	6.06	.82	5.13
MBFTA2	16.54	2.69	9.14	21.97	-.15	2.78
MBUM15	9.12	1.50	5.69	13.45	.05	3.30
MRCDTK	26.82	12.20	5.00	70.00	.70	3.67
MFLPRR	53.51	10.49	26.94	82.69	-.02	3.19
MFLCES	167.25	13.51	137.65	195.40	.14	2.47
MFLMOS	35.30	12.50	-.47	66.35	-.58	3.59
MREPOL	8.44	1.34	5.65	12.53	.70	3.32
MBKPOP	10.60	1.93	7.48	17.16	1.34	4.96
MAGKUS	9.22	0.73	7.50	10.97	.03	2.60
MRASKL	37.33	11.10	18.00	66.00	.48	2.94
MSLIVS	5.25	1.79	.00	9.00	-.26	3.15
DPPON	3.45	.92	1.36	5.26	-.32	2.46
RAMBAC	4.12	.83	1.14	5.12	-1.12	4.27
ZAHGL	4.33	.80	1.65	5.09	-1.21	3.95
POJ	4.25	.90	.71	5.05	-1.52	5.47
OBA	2.93	1.08	.76	5.18	-.20	2.38

Legend: Min. = minimal value; Max. = maximal value; AM = arithmetic mean; SD = standard deviation; Skew. = skewness; Kurt. = kurtosis

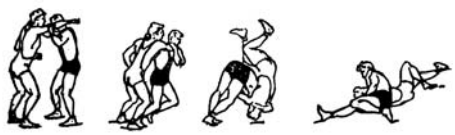
Table 2. Regression analysis of the technique take-down (DPPON)

Variables	r	beta	t	Q
BODY HEIGHT	.08	.32	1.22	.22
BODY WEIGHT	.09	.15	.54	.58
MFEBML	.16	-.09	.42	.67
MFEDSM	-.08	-.02	.10	.92
MFE20V	.27	.54	2.32	.02
MFE30N	.18	-.17	.64	.52
MBFTA2	-.05	-.06	.54	.58
MBUM15	.14	.16	1.10	.27
MRCDTK	.07	.16	1.25	.21
MFLPRR	-.04	-.27	1.81	.07
MFLCES	.09	.11	.70	.48
MFLMOS	.09	.07	.53	.59
MREPOL	.15	.32	1.61	.11
MBKPOP	-.06	-.54	2.55	.01
MAGKUS	-.20	-.10	.77	.44
MRASKL	.10	.24	1.73	.08
MSLIVS	-.02	-.12	.89	.37
DELTA = .35 RHO = .59 Err = .80 F = 1.76		Q=.05		

Legend: r – correlation coeffcient; beta – partial regression coefficient; t – Student's *t*-test; Q – significance of the *t*-test.

Table 3. Regression analysis of the technique hip headlock throw (ZAHGL)

Variables	r	beta	t	Q
BODY HEIGHT	.11	.03	.14	.88
BODY WEIGHT	.07	.08	.30	.75
MFEBML	.11	-.00	.01	.98
MFEDSM	.18	.11	.53	.59
MFE20V	-.10	-.09	.43	.66
MFE30N	-.07	.27	1.03	.30
MBFTA2	.15	.14	1.18	.24
MBUM15	.33	.38	2.57	.01
MRCDTK	.29	.23	1.88	.06
MFLPRR	-.00	-.18	1.24	.22
MFLCES	.15	.26	1.62	.11
MFLMOS	.21	.29	2.07	.04
MREPOL	-.04	.33	1.68	.09
MBKPOP	-.13	-.38	1.84	.07
MAGKUS	-.11	-.14	1.09	.27
MRASKL	.10	.07	.59	.55
MSLIVS	.14	-.15	1.16	.24
DELTA = .39 RHO = .63 Err = .77 F = 2.10		Q=.01		



Legend: r – correlation coeffcient; beta – partial regression coefficient; t – Student's *t*-test; Q – significance of the *t*-test.

lations, and 35 had medium and low correlations at the level of significance of p = .01. Positive and high correlations could be noted between the variable *body height* and *body weight*, *throwing the medicine ball from supine position* (MFEBML) and *straddling forward bend* (MFLPRR), whereas *body height* realised a negative correlation with the variable *crawling through and jumping over* (MBKPOP) – long levers obstruct the accurate and quick execution of this motor task.

Apart from having a high correlation with the variable *body height*, the variable *body weight* highly correlated with the test *throwing the medicine ball from supine position* (MFEBML), which was logical since the test *throwing the medicine ball from supine position* is the test of absolute strength. *Body weight* realised negative and above-medium correlations with the test *crawling through and jumping over* (MBKPOP) and with the variable *hang hold* (MSLIVS) which is in congruence with the results obtained in the series of previous studies, namely, the higher the weight category, the bigger the absolute strength, and the lower the relative one.

The variable *assuming the bridge position in 15 seconds* (MOST15) had above-average correlation with two coordination variables, namely, with *polygon backwards* (MREPOL) and *crawling through and jumping over* (MBKPOP). A somewhat higher correlation was obtained between the variables *polygon backwards* (MREPOL) and *crawling through and jumping over* (MBKPOP), as well as the correlation with the variable *assuming the bridge position in 15 seconds.*

Some of the reasons for such behaviour of anthropometric and motor variables could be:

- an exceptionally rigorous selection of subjects as regards their motor status has caused a strong contradiction of variances in the variables employed, which, undoubtedly, caused the narrowing of their covariability;
- a long-term and intensive participation in wrestling which, apart from special exercises, uses various kinesiological activities (athletics, bas-

ketball, football, gymnastics, working out with weights), enabled the efficient compensatory effects in highly complex motor manifestations, that is, the results in individual motor outputs could be realised due to the interactive operation of various latent structures developed under the influence of different kinesiological treatments.

By applying the classical regression analysis at the level of significance p = .01, 34 – 41% of common variance of criterion variables can be explained. Since the predictor system is formed in such a way that it covers a rather large portion of the motor space, it may be said that the complexity of each of the selected criterion variables (of each technique) is extremely high and that, accordingly, the variability of the efficiency of executing the techniques does not depend only on the influence of anthropometric and motor dimensions.

The classical regression analysis of results on the correlation between the predictor variables and the two techniques (*arm throw* – RAMBAC and a*rm lock and shoulder block* – OBA) showed to be statistically unreliable at the level of p = .05. In a similar study and on a sample of 99 young quality wrestlers Marić (1987) obtained a statistically significant correlation with some predictor variables addressing coordination, trunk strength and explosive strength of the legs.

The insufficient predictive agency of the technique *shoulder throw* (RAMBAC) is an index of its complexity, which is, to some point, surprising since this technique was regarded as much more simple, and this was particularly thought of its training variety. It may be assumed that all four factors of the second order are responsible for the efficient execution of the *shoulder throw*: the mechanism for the structuring of movement, the mechanism for the functional synergy and regulation of the muscle tonus, the mechanism for the regulation of the excitement intensity and the mechanism for the regulation of the excitation duration.

Considering the reasons for the statistically low correlation between the predictor variables and the criterion variable a*rm lock and shoulder block* (OBA), the authors recall from their long-term experience in working with beginners, students, and quality wrestlers, that this technique is difficult to acquire not only for beginners but also for students, as well as for quality wrestlers Although the efficiency of this technique is indisputable in modern wrestling, the young wrestlers have not acquired it to a sufficient level due to its complexity on the one hand and on the other probably due to the insufficient education of coaches as regards the methods of training and the anthropological analysis of wrestling.

The review of Table 2 containing the results of the regression analysis of the technique *take-down* (DPPON) makes it possible to emphasize that the predictor system helped to explain about 12% of the variance of the criterion and the variable for the evaluation of the speed of execution of complex motor tasks *crawling through and jumping over* (MBKPOP) and the variable *straddling forward bend* (MFLPRR) intended for the evaluation of flexibility proved to be the best predictors.

Table 4. Regression analysis of the technique throw (POJ).

Variables	r	beta	t	Q
BODY HEIGHT	-.14	.04	.19	.84
BODY WEIGHT	-.06	-.42	1.54	.12
MFEBML	.04	-.51	2.45	.01
MFEDSM	-.08	-.21	1.05	.29
MFE20V	.04	.49	2.21	.03
MFE30N	-.03	-.62	2.32	.02
MBFTA2	.19	.28	2.44	.01
MBUM15	.18	.16	1.14	.25
MRCDTK	.17	.20	1.65	.10
MFLPRR	-.04	-.00	.05	.95
MFLCES	-.24	-.28	1.77	.08
MFLMOS	-.04	.03	.24	.81
MREPOL	-.05	.02	.11	.91
MBKPOP	-.08	.11	.53	.59
MAGKUS	.12	.16	1.21	.23
MRASKL	.34	.27	2.09	.04
MSLIVS	.07	.15	1.13	.26
DELTA = .41 RHO = .64 Err = .76 F = 2.23		Q=.01		

Legend: r – correlation coeffcient; beta – partial regression coefficient; t – Student's *t*-test; Q – significance of the *t*-test.

In the vector correlation in the classical regression analysis surprising are the negative values of the test *20-meter run from the standing start* (MFE20V) and *polygon backwards* (MREPOL). This makes it possible to conclude that entities with expressed speed of forward and backward movement of upper and lower extremities are less efficient in executing the technique *take-down* (DPPON).

It is obvious that the efficient execution of this technique requires that several different movements be harmoniously, accurately, quickly and powerfully executed – this is indicated by the variables *side steps* (MAGKUS) and *throwing the medicine ball from supine position* (MFEBML).

In the vector of the beta coefficient the negative values of the variables *20m run from the standing start* (MRE20V), *polygon backwards* (MREPOL) and *straddling forward bend* (MFLPRR) are also high, as are the positive values for the evaluation of coordination *crawling through and jumping over* (MBKPOP), *push-ups on the floor* (MRASKL), of the speed *assuming the bridge position in 15 seconds* (MBUM15) and *body height* (VISINA).

It may be concluded that young quality wrestlers who have better coordination and bigger absolute and relative strength will be more efficient in executing the technique *take-down* (DPPON).

Table 3 that contains the results of the regression analysis of the technique *hip headlock throw* (ZAHGL) shows that all four factors of the so called second order – the mechanism for the structuring of movement, the mechanism for functional synergy and regulation of the muscle tonus, the mechanism for the regulation of excitement intensity and the mechanism for the regulation of excitation duration - are, through the manifest variables collected for this study, present in the variance of this technique.

The classical regression analysis of this technique and of the criterion may be explained at the level of significance p = .01, the multiple correlation (r) being .63 and the determination coefficient .40.

The values of beta coefficients of variables allow the following sequence of variables: *crawling through and jumping over* (MBKPOP), *assuming the bridge position in 15 seconds* (MBUM15), *polygon backwards* (MBKPOP), *wrestling bridge* (MFLMOS), *30m run from the crouch start* (MFE30N), *front split* (MFLCES) and *sit-ups on the bench* (MRCDTK). Out of the seven singled out variables two wrestling-specific variables *assuming the bridge position in 15 seconds* (MBUM15) and *wrestling bridge* (MFLMOS) realise the statistically significant correlation with the criterion variables *take-down* (DPPON).

The analysis of the data presented in table 4 led to the identification of the correlation between the predictor system and the criterion variable of .64 at the level of significance p = .01. Thus, the total of 41% of common variance of the criterion and of the predictor system may be explained.

Five predictor variables had statistically significant beta coefficients (Q = 0.5). These five variables are: *throwing the medicine ball from supine position* (MFEBML), *20-meter run from the standing start* (MFE20V), *double hand-tapping* (MBFTA2) and *push-ups on the floor* (MRASKL) that correlate positively with the criterion variable, and the speed in the test *30-meter run from the crouch start* (MFE30N) that had a negative sign. This variable probably had a suppressing effect because its structure is similar to the variable *20-meter run from the standing start.* However, it may also happen that the subjects from heavier weight categories achieve better results in running from the crouch start since the acceleration of body mass is added to the explosive start, whereas in the 20-meter run the motor reaction speed that is very important and expressed in top-level wrestlers is more emphasized, regardless of the weight category (Nastenko & Stašenko, 1966).

The negative sign designating the variables of *body height*, *body weight* and *front split* that are contaminated by longitudinal measures points to their unfavourable influence on the execution of this technique.

In his study Marić (1982) obtained the best predictor of efficiency in this technique by means of the variable *pull-ups on the bar* that was not measured in our study, however, the correlation lies in the fact that the best predictive value was expressed by the variable *push-ups on the floor* (MRASKL) which together with pull-ups belongs to the tests of relative strength.

The subjects were measured by two anthropometric and fifteen motor variables that served as the predictor system.

The identification of correlations between the set of selected predictor variables with each of the five wrestling techniques, i.e. with criterion variables, was done by the regression analysis.

Finally, it is important to emphasize that three out of five regression analyses showed statistically significant correlation of predictor and criterion variables. The wrestling techniques *hip headlock throw* – ZAHGL and a*rm lock and shoulder block* – OBA had no statistically significant correlation with the set of predictor variables in the performed regression analyses.

By employing the classical regression analysis of the technique *take-down* it is possible to explain 36% of the variance of the criterion. Successful execution of this technique depends on the coordinated, accurate, fast and vigorous execution of several different movements which is pointed to by the variables *side steps* (MAGKUS) and *throwing the medicine ball from supine position* (MFEBML). The results make it obvious that these techniques will be performed better by the young quality wrestlers who have a better coordination and a better absolute and relative strength.

The results of the regression analysis of the technique *hip headlock throw* show the correlation of 40% with the predictor set. The variables *crawling through and jumping over*, *assuming the bridge position in 15 seconds*, *polygon backwards*, *wrestling bridge*, *30-meter run from the crouch start*, *front split* and *sit-ups on the bench* are connected the most with the criterion. Therefore, the successful execution of this technique depends on all four motor factors of the second order.

By employing the classical regression analysis it is possible to explain 41% of the variance of predictor variables with the technique *throw* (POJ). Predictor variables that have higher values of beta coefficients are *throwing the medicine ball from supine position*, *20-meter run from the standing start*, *double hand-tapping* and *push-ups on the floor*. It is also interesting to point out the negative influence of the anthropometric measures on the execution of this throwing technique in wretsling.

The obtained results allow the conclusion that the technical efficiency in young top-level wrestlers depends on a large number of motor abilities, but also on the anthropological characteristics that were not the subject to this study. It is evident that motor dimensions of the third (mechanism for movement regulation and mechanism for energy regulation), and accordingly all four factors of the second order participate in the realisation of selected wrestling techniques. This points to the diverse fitness level of young wrestlers that was acquired during the long-term participation in this sport.

Therefore, all the predictor variables applied may be recommended for the selection, monitoring and conditioning level control in young wrestlers.

Further studies in the correlation between wrestling techniques with different anthropological dimensions are also recommended in order to contribute to the multitude of perceptions regarding the theory and practice in classical wrestling.

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TEHNIČKA EFIKASNOST HRVAČA U ODNOSU NA NEKE ANTROPOMETRIJSKE I MOTORIČKE VARIJABLE

Sažetak

Uvod

Hrvanje se ubraja u grupu sportova polistrukturalnih acikličnih gibanja s vrlo kompleksnim aktivnostima pa na uspješnost kako u izvođenju zadanih tehnika, tako i u samoj natjecateljskoj borbi utječu brojni faktori i dimenzije.

Istraživanja o utjecaju ili povezanosti različitih antropoloških podprostora i motoričkih sposobnosti s tehnikama u hrvanju pružaju korisne informacije koje je moguće koristiti u nastavno-trenažnom radu s hrvačima i s ne-hrvačima (školska populacija, studenti, pripadnici policijskih i vojnih snaga). Ovakva istraživanja potrebna su za selekciju i kontrolu trenažnog procesa. Cilj istraživanja je utvrditi strukture, smjerove i veličine utjecaja antropometrijskih (visina tijela, težina tijela) i motoričkih dimenzija mladih hrvača na uspješnost izvođenja tehničkih elemenata hrvanja klasičnim načinom u stojećem položaju.

Metode

Istraživanje je provedeno na uzorku od 72 hrvača (dob 16-20 godina), koji su potpuno zdravi i bez ikakvih tjelesnih aberacija. Ispitanici su se nalazili na početku priprema mladih hrvača z natjecanja na europskim i svjetskim prvenstvima.

Za prediktorske varijable izabrane su dvije antropometrijske mjere (visina i težina tijela - mjerena su provedena prema postupcima Internacionalnog biološkog programa) i 15 motoričkih varijabli: bacanje medicinke iz ležećeg položaja – MFEBML, skok u dalj s mjesta – MFEDSM, trčanje 20m iz visokog starta – MFE20V, trčanje 30m iz niskog starta – MFE30N, taping rukom – MBFTA2, spuštanje u most za 15 s – MBUM15, podizanje trupa na klupici – MRCDTK, sklekovi u uporu – MRASKL, pretklon raskoračno – MFLPRR, čeona špaga - MFLCES, hrvački most – MFLMOS, poligon natraške - MREPOL, provlačenje i preskakanje - MKPOP, koraci u stranu – MAGKUS i izdržaj u visu - MSLIVS.

Kao specifične hrvačke varijable koristila su se sljedeća bacanja: Ddvođenje u parter poniranjem - DPPON, ramensko bacanje hvatom ruke - RAMBAC, bočno bacanje hvatom glave i ruke - ZAHGL, prednji pojas obuhvatom ruke i trupa - POJ, obaranje hvatom ruke i trupa - OBA.

Kvalitetu izvođenja izabranih hrvačkih tehnika u ovom istraživanju (kriterijske varijable) procijenila su tri suca. Svaki ocjenjivač ocjenjivao je ocjenama od 1 do 5 izvođenje svih pet hrvačkih zahvata svakog ispitanika.

Rezultati i rasprava

Sve antropometrijske i motoričke varijable imaju normalnu raspodjelu rezultata i krivulju Gaussovog tipa. Jedino je varijabla provlačenje i preskakanje (MBKPOP) imala izrazitu zbijenost rezultata u zoni boljih vrijednosti, dok je za izduženost krivulje prema zoni slabijih rezultata odgovorno nekoliko izrazito visokih i krupnih, voluminoznih hrvača poluteške, teške i superteške kategorije. Provlačenje i preskakivanje kroz okvir švedskog sanduka predstavlja veću poteškoću za te tri težinske kategorije zbog većih mjera longitudinalne dimenzionalnosti kostura i voluminoznosti.

Primjenom klasične regresijske analize na razini značajnosti od p= .01 može se objasniti od 34 do 41 % zajedničke varijance kriterijskih varijabla. Budući da je prediktorski sustav formiran tako da pokriva prilično velik dio motoričkog prostora, može se smatrati da je kompleksnost svake od izabranih kriterijskih varijabli (svakog zahvata) izuzetno velik i da, prema tome, varijabilitet uspješnosti izvođenja zahvata ne ovisi samo o utjecaju antropometrijskih i motoričkih dimenzija.

Klasičnom regresijskom analizom rezultati povezanosti prediktorskih varijabli i dviju kriterijskih varijabli (tehnike ramenskog bacanja–RAMBAC i obaranja hvatom ruke i trupa – OBA) pokazale su se statistički nepouzdane na razini p= .05. Nedovoljna predikcijska moć za tehniku ramenskog bacanja – RAMBAC objašnjava se njenom kompleksnošću.

Razlozi statistički slabe povezanosti tehnike *obaranje hvatom ruke i trupa* (OBA) mogu se pronaći u činjenici da tu tehniku teško usvajaju ne samo početnici i studenti, već i kvalitetni hrvači. Iako je efikasnost ove tehnike u modernom hrvanju neosporna, kao što pokazuje hrvačka praksa, mladi je hrvači nisu usvojili na dovoljno visokoj razini.

Tablica 2 i regresijska analiza tehnike dovođenje u parter poniranjem (DPPON) pokazuju da je prediktorskim sustavom objašnjeno oko 12% varijance kriterija, pri čemu su se kao najbolji prediktori pokazale varijabla za procjenu brzine izvođenja kompleksnih motoričkih zadataka provlačenje i preskakivanje (MBKPOP) i varijabla fleksibilnosti pretklon raskoračni ravno (MFLPRR).

U vektoru korelacija u klasičnoj regresijskoj analizi iznenađuju negativne vrijednosti testa brzine trčanja na 20 m iz visokog starta (MFE20V) i *poligona natraške* (MREPOL), iz čega proizlazi da entiteti s izraženom brzinom kretanja donjih i gornjih ekstremiteta prema naprijed i natrag slabije izvode tehniku dovođenja u parter poniranjem.

Očito je da je za uspješno izvođenje ove tehnike potrebno koordinirano, precizno, brzo i snažno izvesti nekoliko različitih pokreta na što upućuju varijable koraci u stranu (MAGKUS) i bacanje medicinke iz ležanja (MFEBML).

U vektoru beta koeficijenta također su visoke i negativne vrijednosti varijabli brzine trčanja na 20 m iz visokog starta (MRE20V) i *poligon natraške* (MREPOL) te pretklon raskoračni ravno (MFLPRR), dok su visoke i pozitivne vrijednosti varijabli za procjenu koordinacije *provla*čenje i preskakivanje (MBKPOP), *sklekovi* (MRASKL), *brzina spuštanja u most za 15 sekundi* (MBUM15) *i tjelesna visina* (VISINA). Iz izloženoga se može zaključiti da će tehniku dovođenja u parter uspješnije izvoditi mladi kvalitetni hrvači većih koordinacijskih sposobnosti i veće apsolutne i relativne snage.

Zanimljivo je razmotriti rezultate regresijske analize pet prediktorskih varijabli koje imaju statistički značajne beta koeficijente (Q=0,5) To su varijable *bacanje medicinke iz ležanja* (MFEBML), trčanje 20*m iz visokog starta* (MFE20V), *dvostruki taping rukom* (MBFTA2), *sklekovi na tlu* (MRASKL), koje su pozitivno povezane s kriterijskom varijablom, te brzina trčanja na 30m iz niskog starta (MFE30N), koja ima negativan predznak. Ta varijabla ima vjerojatno supresorsko djelovanje jer je po svojoj strukturi slična varijabli brzina trčanja na 20 m iz visokog starta. No, može biti da ispitanici težih kategorija postižu bolje rezultate u trčanju iz niskog starta zato što se eksplozivnom startu pridodaje i ubrzanje mase tijela, dok je kod trčanja na 20 metara naglašenija brzina motoričke reakcije, koja je vrlo važna i izražena kod vrhunskih hrvača, bez obzira na težinske kategorije.

Negativni predznak visine, težine i čeone špage koja je kontaminirana longitudinalnim mjerama ukazuje na njihov nepovoljan utjecaj na izvođenje ove tehnike.

Zaključak

Za kraj potrebno je istaknuti; da su tri od ukupno pet regresijskih analiza pokazale statistički značajnu povezanost prediktorskih i kriterijske varijable. Hrvačke tehnike *bo*čno bacanje hvatom glave i ruke - ZAHGL i *obaranje hvatom ruke i trupa* - OBA nisu imale statistički značajnu povezanost sa skupom predikcijskih varijabli u provedenim regresijskim analizama. Klasičnom regresijskom analizom tehnike dovođenje u parter ponir*anjem* moguće je objasniti 36% varijance kriterija. Rezultati regresijske analize tehnike bočnog bacanja hvatom glave i ruke pokazuju povezanost s prediktorskim skupom od 40%. Klasičnom regresijskom analizom moguće je objasniti 41% varijance prediktorskih varijabli s tehnikom bacanje uvinućem obuhvatom ruke i trupa – prednji pojas. Prediktorske varijable koje imaju najveće vrijednosti beta koeficijenta jesu *bacanje medicinke iz ležanja*, trčanje na 20 metara iz visokog starta, *dvostruki taping rukom* i *sklekovi na tlu*. Također je zanimljivo istaknuti negativan utjecaj antropometrijskih mjera na izvođenje ove hrvače tehnike bacanja.

Prema dobivenim rezultatima može se zaključiti da tehnička učinkovitost mladih vrhunskih hrvača ovisi o velikom broju motoričkih sposobnosti, ali i drugim antropološkim dimenzijama koje nisu bile predmet ovog istraživanja. Očevidan je doprinos motoričkih dimenzija trećeg faktora (mehanizam za regulaciju kretanja i mehanizam za energetsku regulaciju), a prema tome i sva četiri faktora drugog reda pri realizaciji izabranih hrvačkih tehnika. To ukazuje na raznovrsnu pripremljenost mladih hrvača stečenu višegodišnjim bavljenjem tim sportom.

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