FACTOR STRUCTURE OF BOXER'S BASIC MOTOR ABILITIES

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Abstract
On the sample of 92 boxers from Croatian boxing clubs from different weight classes, the system of 15 basic motor variables was applied with aim to determine their factor structure. With appliance of factor analysis (direct oblimin) and Kaiser – criteria ($\lambda \geq 1.00$) for obtaining mutual characteristic roots and clarified parts of mutual variance, two latent variables have been isolated. The first one was interpreted as regulation of intensity and excitation duration and tone regulation whose structure consists of variables of explosive strength (Broad jump and throwing medicine ball while lying down), repetitive strength (lifting legs while lying down, deep squat with load and knuckles on high bar with under) and flexibility (forward bend on the bench, forward bend straddle and forward band to the right). The second latent variable is interpreted as motion structuring and regulation of intensity of excitation since it is defined by body coordination variables (pulling through and jumping over, agility in the air and polygon backward), frequency speed(hand tapping, leg tapping and leg tapping against the wall) and one variable of explosive strength (20 m run from standing start). Based on matrix of latent variable correlation it is visible there is no statistical significant correlation between isolated latent variables which is interpreted as wanted efficacy in boxing is achieved primarily with motor abilities of intensity and tone regulation and excitation duration, because research has shown that this latent variable is dominant, but structuring of motion and frequency speed are also relevant for top boxers.

Key words: *boxers, basic mobility, factor analysis, latent structure*

Introduction

During analysis of any sports activity, the biggest issue that has to be resolved is to find out what success in these activities depends on. According to this, the main task of sports preparation technology is to find and determine certain validities and procedures that will regulate efficacy in such activities.

To determine validity and procedures it is necessary to familiarize with all factors efficacy depends on, which means that if we want to determine what efficacy depends on it is necessary to determine all anthropological attributes, abilities and characteristics which affect result in certain sport and also which steps we have to take (what kind of training content, methods and ballast should we use) so we increase probability of athlete's success. Primarily this regards to basic motor abilities, their structure and relations with other relevant anthropologic characteristics, because with their development they indirectly develop abilities and characteristics that directly affect sports result (Metikoš, Gredelj, Momirović, 1979; Metikoš, Prot, Horvat, Kuleš, Hofman, 1982; Malacko, Rađo, 2004).

To successfully prepare athlete's technological preparation it is essential to learn which anthropological attributes, abilities and characteristics affect success in certain sport s branch or discipline, because these are the ones that need to be systematically changed during training process. Modern approach in sports training preparation and system is based on situation models (specification equation, complexity model). If such information doesn't exist, then such program can not be made and because of that we face intuitive and elemental approach. (Malacko, 1997).

In a frame of poly structural acyclic motion, boxing belongs to a group of discontinuous motions that belongs to sport activities where there is direct reaction to outside

changing conditions and are performed in direct fight with opponent, whose resistance must be overpowered, need to predict his intentions, oppose them and achieve the goal which is usually symbolic destruction of the opponent. Boxer has to possess comprehensive and relevant spectrum of motion activities automated during training and improvement in training process and high efficacy in competition operationalization. According to that, boxing is characterized by continuous change in motion structure in unpredictable conditions at work of transformational intensity and ballast duration, explosive strength of upper and lower extremities, speed persistency, strength persistency, well developed motion coordination of a whole body and ability to quickly resolve complex motor tasks. (Blažević, 2006; Blažević et al., 2008).

The modern approach to preparation and realization of sports training is based on situational model of boxer in which prevails the simplest high tempo actions and as close to the opponent as possible . In contact with opponent it is necessary to stick to the rule that it is relevant to stop attack during series of punches, step to the left or right, change the rhythm of fight, force opponent to lose balance and with side punch and with left upper-cat continue series of punches into body and head of the opponent (Filimonov, 2000; Blažević, 2007). To this so called "total boxing", it is possible to confront only with large mobility of lower extremities (good leg movement) with many "feinting" and tactical variants with the intent to challenge the opponent so he would move into straight attack and so he would loose his balance and with timely counter attack brings himself into inferior position. With well trained technique of transferring body weight from leg to leg, punching from all positions (under arm, over arm, repulse inside, on the side, blocking with one hand) and place final punches with transfer. (Savić, 1986).

The Aim

The aim of this research is to determine factor structure of basic motor abilities latent variables of top boxers, to form rational procedures for optimal modeling, planning, programming and control of training process, as well as efficient monitoring of their development during continuous selection of athletes and conducting transformational training process.

Methods

Based on a sample of 92 boxers from Croatian boxing clubs from different weight classes, the system of 15 basic motor variables was applied. For estimation of specific motor abilities following variables were applied: *body coordination* - 1. *Pulling through and jumping over* (MBKPOP), 2. agility in the air (MKTOZ), 3. *Polygon backwards* (MREPOL), *frequency speed* - 4. *hand tapping* (MBFTAP), 5. *leg tapping* (MBFTAN), 6. *leg tapping against the wall* (MBFTAZ), *exsplosive strenght* - 7. *Broad jump* (MFEDM), 8. *throwing medicine ball while lying down* (MFEBML), 9. 20m *run from standing start* (MFE20V), *repetitive strenght* - 10. leg lifting while lying down (MRCDNL), 11. deep squats with load (MRLDCT), 12. *Pulling up body on high bars arms in backward grip* (MRAZGP), *flexibility* - 13. *forward bend on the bench* (MFLPRK), 14. *forward bend straddle* (MFLPRR) i 15. *forward bend to the right pretklon desno* (MFLPRD).

Basic motor variable metric characteristics were determined in most researches (Kurelić et al., 1975; Gredelj et al., 1975) by factor validity and reliability parameters. For each variable applied the following central and dispersive parameters were calculated: arithmetic mean (M), minimal value (min), maximal value (max), standard deviation (S) and arithmetic mean standard error (Se). Variable distribution normality was tested with skewness (Sk) and Kurtosis (Ku). Correlation between applied manifest variables was performed by variable correlation matrix.

To determine latent basic motor variables factor analysis was used with appliance of inclined transformation (direct oblimin), and for extraction of number with characteristic roots (Kaiser) $\lambda \geq 1.00$ criteria was applied. Also we calculated communality (h^2) for each variable applied to gain their informational values. Structure of latent variables was calculated with main component matrix, set matrix (A-matrix) which contains parallel projections (coordinates) of variables on factors, structure matrix (F-matrix), apropos correlation between manifest and latent variables and correlation factor matrix (M-matrix). Data was processed with statistic packages SPSS 11.5 for Windows and STATISTICA 6.0.

Results

In table 1 we presented results of central and dispersive statistic parameters of basic motor variables as well as their differences. With skewness (Sk) analysis, with bolding and star (*) we marked variables that have normal (symmetric) distribution, which means that result goes from 0-1.00 of standard deviation.

The table points out that distribution of all applied variables is normal (symmetric) because they don't pass beyond values 1.00 of standard deviation, while variables pulling through and jumping over (MBKPOP) and agility in the air (MKTOZ) distributed unevenly and their skewness points out positive directions (1.38 and 1.57), which means that one of examinees had significantly increased values (actually weaker results) since values are in second where lower numbers mean better results.

Analyzing table 2, where we presented correlation between individual manifest basic motor variables, it is clear that with majority of applied variables we discover high and statistically significant correlations marked with a star (*). With factorization of correlation variable matrix and appliance of Kaiser criteria ($\lambda \geq 1.00$) we acquired two characteristic roots that explain 77,58% of mutual variance (CUM%) and individual contribution for first latent variable is 49,77% and the second 27.80%.

Table 1: Central and dispersive parameters of basic motor variables

Var	M	min	max	S	Se	Sk	Ku
MBKPOP	104.09	70	190	24.45	2.54	1.38	2.73
MKTOZ	59.79	38	118	16.47	1.71	1.57	2.67
MREPOL	87.29	59	140	16.17	1.68	**.64***	1.64
MBFTAP	40.54	30	49	3.94	.41	**-.41***	-.26
MBFTAN	57.38	43	72	6.42	.67	**-.39***	-.26
MBFTAZ	28.85	20	36	3.49	.36	**-.28***	-.40
MFEDM	237.13	168	279	23.62	2.46	**-.52***	.09
MFEBML	79.39	61	98	10.29	1.07	**-.04***	-1.31
MFE20V	30.55	27	38	2.96	.30	**.36***	-.08
MRCDNL	72.36	46	97	12.73	1.32	**.29***	-.68
MRLDCT	28.31	18	41	4.48	.46	**.59***	.25
MRAZGP	17.63	9	28	5.02	.52	**-.03***	-1.05
MFLPRK	28.03	6	41	7.94	.82	**-.57***	.10
MFLPRR	59.01	27	78	9.81	1.02	**-.75***	1.53
MFLPRD	46.29	20	65	9.08	.94	**-.67***	1.07

(M – Arithmetic mean, min – minimal value, max – maximal value, S – Standard deviation, Se – standard arithmetic mean error, Sk - skewness, Ku – kurtosis)

Table 2: Correlation and characteristic roots and explained parts of mutual variable variance

Var	1	2	3	4	5	6	7	8	9	10	11	12	13	14
MBKPOP	100													
MKTOZ	**.32***	100												
MREPOL	**.94***	**.31***	100											
MBFTAP	**-.65***	**-.20***	**-.59***	100										
MBFTAN	**-78***	**-.30***	**-.76***	**.81***	100									
MBFTAZ	**-73***	**-.24***	**-.67***	**.84***	**.88***	100								
MFEDM	**.22***	-.00	**.32***	.08	**-.09**	-.05	100							
MFEBML	**.76***	**.17***	**.76***	**-.48***	**-.65***	**-.58***	**.67***	100						
MFE20V	**.50***	.15	**.51***	**-.45***	**-.58***	**-.52***	**-.30***	.12	100					
MRCDNL	**.22***	-.01	**.28***	.00	-.12	-.11	**.90***	**.73***	**-.31***	100				
MRLDCT	**.25***	-.02	**.23***	-.10	-.12	-.17	**.81***	**.72***	**-.33***	**.89***	100			
MRAZGP	.06	-.04	.15	.13	.05	.06	**.87***	**.52***	**-.40***	**.84***	**.77***	100		
MFLPRK	**.47***	.12	**.58***	**-.24***	**-.45***	**-.33***	**.80***	**.82***	-.00	**.78***	**.68***	**.57***	100	
MFLPRR	**.46***	.12	**.56***	**-.17***	**-.36***	**-.25***	**.78***	**.80***	-.06	**.77***	**.69***	**.53***	**.96***	100
MFLPRD	**.49***	.11	**.57***	**-.17***	**-.37***	**-.26***	**.69***	**.80***	-.07	**.72***	**.65***	**.44***	**.91***	**.96***
	λ	**%**	**CUM %**											
1.	7.46	49.77	49.77											
2.	4.17	27.80	**77.58**											

(λ – characteristic roots, % - individual contribution to clarifying mutual variance, CUM % - mutual variance)

Determining structure of latent variables (Table 3) was based on main component matrix (GK – matrix), complex matrix (A-matrix) and structure matrix (F- matrix). Inspection of main components of matrix points out that the main component (Gk – 1) is responsible for the most of variability of the whole system of applied basic motor variables and such explains the most of information.

So in this research it can be defined as integrated latent variable of basic motor abilities that in it's structure contains body coordination, explosive strength, repetitive strength and flexibility variables, therefore motor abilities that are assumingly very relevant. Interpretation of isolated latent variables was conducted by applying inclined transformation and complex matrix (A-matrix) which contains parallel projections, in other words length of vector coordinates in coordinate system.

The first latent variable (Lv – 1) is interpreted as intensity regulation and excitation duration and tone regulation, whose structure is made of explosive strength variables (MFEDM- broad jump MFEBML – throwing medicine ball while lying down), repetitive strength (MRCDNL – lifting legs while lying down, MRLDCT – deep squats with load , MRAZGP - Pulling up body on high bar arms in backward grip) and flexibility (MFLPRK – forward bend on the bench, MFLPRR – forward band straddle and MFLPRD – forward band to the right).

Second latent variable (Lv-2) was interpreted as structuring of motion and frequency speed, since it is defined by body coordination variables (MBKPOP – pulling through and jumping over, MKTOZ – agility in the air and MREPOL – polygon backwards), frequency speed (MBFTAP – hand tapping, MBFTAN – leg tapping, MBFTAZ – leg tapping against the wall) and one variable of explosive strength (MFE20V - 20m run with standing start).

Table 3: Structure of latent variables and their correlation

Var	Main components		Projection matrix		Structure matrix		h^2
	Gk-1	Gk-2	Lv-1	Lv-2	Lv-1	Lv-2	
MBKPOP	**.71***	-.57	.22	**-.85***	.35	**-.89***	.84
MKTOZ	.20	**-.30***	-.02	**-.37***	.03	**-.37***	.13
MREPOL	**.76***	-.50	.30	**-.81***	.42	**-.86***	.83
MBFTAP	-.45	**.70***	.06	**.84***	-.06	**.83***	.70
MBFTAN	-.62	**.70***	-.08	**.92***	-.21	**.94***	.88
MBFTAZ	-.56	**.69***	-.03	**.88***	-.16	**.89***	.79
MFEDM	**.76***	.56	**.96***	.13	**.94***	-.01	.90
MFEBML	**.96***	-.06	**.73***	-.52	**.81***	-.63	.93
MFE20V	.10	**-.78***	-.39	**-.75***	-.28	**-.69***	.63
MRCDNL	**.78***	.54	**.96***	.10	**.95***	-.03	.91
MRLDCT	**.74***	.48	**.90***	.07	**.89***	-.06	.79
MRAZGP	.58	**.63***	**.85***	.28	**.81***	.15	.74
MFLPRK	**.91***	.19	**.85***	-.27	**.89***	-.39	87
MFLPRR	**.89***	.24	**.86***	-.21	**.89***	-.34	.85
MFLPRD	**.86***	.19	**.81***	-.24	**.85***	-.36	.78
Lv	**Lv-1**	**Lv-2**					
Lv-1	1.00						
Lv-2	-.15	1.00					

(h^2 – communalities, Lv-1,2=latent dimensions)

Besides variable MKTOZ – agility in the air, all other values of communality (h2) of individual variables have high values and range from .70-.93, which means that explained parts of vector variables are satisfying, in other words manifest variables were measured with no major mistakes. The matrix of latent variable correlation (M-matrix) points out that there is no statistically significant correlation between isolated basic motor latent variables (-.15).

Discussion and conclusion

Diagonal postures and large number of technical elements, tactics, whole body movement and extremities into different directions with adjustable strength and variant tempo are specific for boxing. During fight we have constant changing of dynamic situations with variations in fighting positions (rotation around vertical axis), hand techniques made of punches, blocks – transfer of power, defense with swinging left and right, leg defense left-right, back and forth etc. Performance of these techniques demands well accepted dynamic stereotypes, in other words to constantly create new programs of offense, defense and counter attack during fight attacking.

Starting from mentioned specific and situational movement structures, in the research the start point was the assumption that relevant basic motor abilities in boxing are, on one hand, coordination and speed abilities (whole body coordination, movement of arms and legs speed frequency) and on the other hand strength (topological explosive and repetitive strength) as well as body flexibility. It is familiar that in boxing without these abilities, it is not possible to achieve even average results. Necessity of fast movement in all basic structures in boxing, which is also poly structural, demands from a boxer significant level of coordination and it is defined as "speed of implementation of complex motor abilities".

During fight, the boxer has to synchronize leg movement with hands movement (punching, blocking, stopping etc), has to be able to quickly change direction of movement and be very fast in realization of closed motor structures which is shifting whole body in space for what he needs high level of coordination. Hand coordination, defined as ability of manipulation with objects, should not have influence of any significance on a boxing success, regarding to measuring instruments that define this factor. However, if it is assumed that factor exists in motor space, that it is not defined only with motor tasks of object manipulation, as well as all combinations of punches, guards and defense in phase of offence and defense and are performed by hands under this factor influence, then we can assume that hand coordination is one of the most important motor abilities of a boxer.

Leg coordination is ability which enables boxer to set a balance and to maintain it during fight conditions, faster approach to the opponent, stronger and more effective punches, the use of multiple punches, combination of different motions, good coming-on the opponent, good output from the fight on the short off, successful feinting, masking, etc. Various forms of speed (reaction speed, frequency speed and movement speed) enable boxer to timely react on opponent's actions, efficient use of defense techniques, fast performance of individual punches, performance of series of punches, fast movement around ring and effective use of counter attack technique. High level of explosive strength, especially in arms and shoulders along with speed are basic characteristics of quality boxers. Boxer with intense explosive strength of arms and shoulders can cause difficult and dangerous punches for the opponent and thus with one single. Explosive strength of legs is also important for boxers, because it enables faster movement toward the opponent and backward.

Mechanisms that regulate energetic output take significant place in equation of specification which is also confirmed by large impact of repetitive strength on the fight outcome. Repetitive strength enables boxer to endure through eight minute intensive fights characterized with constant movement and punching. It is very important that boxer performs as many punches as possible into the body and head of his opponent, because in case if the fight does not end before time runs out, the winner is the one who gave more punches. Since in punching we use whole body musculature (legs are active and in constant contractions in movement direction) we believe that all three topological factors of repetitive strength are important for boxers. Flexibility is less important motor ability, but not irrelevant. Pelvic flexibility affects mobility of the upper body part which is important during performance of some punches and defense while dodging body. Flexibility in shoulder joint is crucial because it enables large amplitudes of hand movement to allow punching technique performance. Listed assumptions and discussions are confirmed in this research, considering that on the sample of top boxers their existence was confirmed by factor structure determination.

Two latent variables of basic abilities were isolated. The first one was interpreted as intensity regulation, excitation duration and tone regulation and the second latent variable was interpreted as motion structuring and intensity excitation regulation. Based on correlation of latent variables matrix it is obvious that there is no statistically significant correlation between isolated latent variables. This explains that wanted efficiency in boxing fight is accomplished primarily by motor abilities of intensity regulation, excitation duration and tone regulation, because the results of this research pointed out that this latent variable is dominant but also that movement structuring and motion frequency speed is relevant for top boxers.

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FAKTORSKA STRUKTURA BAZIČNIH MOTORIČKIH SPOSOBNOSTI BOKSAČA

Sažetak

Na uzorku 92 boksača iz hrvatskih boksačkih klubova iz različitih težinskih kategorija, bio je primijenjen sustav od 15 bazičnih motoričkih varijabli, s ciljem da se utvrdi njihova faktorska struktura. Primjenom faktorske analize (direktni oblimin) i Kaiser-kriterija ($\lambda \geq 1.00$) radi dobivanja zajedničkih karakterističnih korjenova i objašnjenih dijelova zajedničke varijance, izolirane su dvije latentne varijable, od kojih je prva interpretirana kao regulacija intenziteta i trajanja ekscitacije i regulacija tonusa, čiju strukturu sačinjavaju varijable eksplozivne snage (skok udalj s mjesta i bacanje medicinke iz ležanja), repetitivne snage (dizanje nogu ležeći, duboki čučnjevi s opterećenjem i zgibovi na vratilu pothvatom) i fleksibilnost (pretklon na klupi, pretklon raskoračno i pretklon desno). Druga latentna varijabla je interpretirana kao strukturiranje kretanja i regulacija intenziteta ekscitacije, pošto je definiraju varijable koordinacije tijela (provlačenje i preskakivanje, okretnost u zraku i poligon natraške), brzine frekvencije (taping rukom, taping nogom i taping nogom o zid) i jedna varijabla eksplozivne snage (trčanje 20m iz visokog starta). Na temelju matrice korelacije latentnih varijabli vidi se da ne postoji statistički značajna korelacija između izoliranih latentnih varijabli, što se tumači tako da se željena efikasnost u boksačkoj borbi postiže prvenstveno motoričkim sposobnostima regulacije intenziteta i trajanja ekscitacije i regulacije tonusa, jer su rezultati istraživanja pokazali da ova latentna varijabla dominantno egzistira, ali i da su strukturiranje kretanja i brzina frekvencije također relevantni kod vrhunskih boksača.

Ključne riječi: *boksači, bazična motorika, faktorska analiza, latentna struktura*