

## SELECTING CHILDREN FOR SWIMMING SCHOOL - THE CASE OF CROATIA

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### Abstract:

The main goal of this study was to determine which anthropometric characteristics and which motor abilities were the best predictors for performance in 50 m front crawl swimming in pre-adolescent boys. For this purpose 37 male swimmers, aged 9–10 years, were tested. The swimmers have participated in the training process for 2–4 years. The second objective was to utilize the obtained findings in the construction of swimming tests that would be used for testing the primary-school children to be initially selected for swimming-school participation. Therefore, the study was aimed at identifying those anthropometric and motor tests that would help select potential future swimmers regardless of whether they were able or not to swim over a 25 m distance prior to the testing procedure. From the whole set of anthropometric characteristics and motor abilities predictors, only five characteristics and abilities can be singled out as significant for predicting success in the 50 m front crawl event. Among the tests that had been singled out as predictive - *sitting height, upper arm circumference, upper arm skinfold, hand diameter and vertical jump*, the two: *sitting height and upper arm skinfold* were negatively correlated with the 50 m crawl performance.

*Key words: swimming, selection, anthropometric characteristics, motor abilities, children*

### SELEKTION VON KINDERN FÜR DIE SCHWIMMSCHULE – EIN BEISPIEL AUS KROATIEN

#### Zusammensetzung:

Das Hauptziel dieser Studie war, festzustellen, welche Körperbaumerkmale und welche motorische Fähigkeiten die besten Prädiktoren der Leistung von Jungen im Vorpubertätsalter beim 50m Kraulen waren. Zu diesem Zweck wurden 37 Schwimmer, im Alter zwischen 9 und 10 Jahren, getestet. Die Schwimmer nahmen am Trainingsprozess 2-4 Jahre der Dauer teil. Das zweite Ziel war, die erhaltenen Ergebnisse zur Gestaltung von Schwimmtests anzuwenden, die als für die Schwimmschule bestimmte anfängliche Selektionstests bei Grundschulern gelten könnten. Anders gesagt, das Ziel war, diejenigen auf Körperbau bezogenen und motorischen Tests zu identifizieren, die dazu benutzt werden könnten, die potentiellen zukünftigen Schwimmer auszuwählen, ungeachtet dessen, ob sie vor dem Test die 25m Distanz schwimmen konnten oder nicht. Aus der Reihe von Prädiktoren der Körperbaumerkmale und motorischen Fähigkeiten konnten nur fünf Merkmale und Fähigkeiten als bedeutend für die Prädiktion des Erfolgs beim 50m Kraulen ausgewählt werden. Aus der Gruppe von Tests, die als prädiktionswert ausgewählt wurden, nämlich, *Sitzhöhe, Oberarmumfang, Oberarmhautfalte, Handdurchmesser und Vertikalsprung*, zwei, *Sitzhöhe und Oberarmhautfalte*, korrelierten negativ mit der Leistung beim 50m Kraulen.

*Schlüsselwörter: Schwimmen, Selektion, Körperbaumerkmale, motorische Fähigkeiten, Kinder*

#### Introduction

A survey of literature dealing with the process of top sport-specific training makes it possible to say that the starting point of each successful training process is the selection (Falk, Lidor, Lander, & Lang, 2004; Seifert, Boulesteix, & Chollet, 2004). The Croatian experience also confirmed that starting at

the age of 8 some children are ready for participation in a competitive swimming program (Volčanšek, 1979).

Swimming skills in early school age depend on a large number of exogenous and endogenous factors, such as residence in the vicinity of a swimming pool, the socio-economic status of parents, various hereditary

factors, motor abilities, etc. (Volčanšek, 1979; Taaffe & Marcus, 1999; Leone, Lariviere, & Comtois, 2002). Coaches that scout for swimming talents in the Zagreb area invite to their swimming team tryouts only the children who can complete at least one pool length of 25 metres (without a time limit). All children who manage to swim over the distance of 25 metres meet the selection criterion and are admitted to the swimming school program. Paradoxically, children with a higher body fat percentage, a quality that would hinder performance in competitive swimmers, are better swimmers at this age (Medved, 1987), so that it is to be expected that they can, due to the fatty tissue layers, tolerate cold water for a longer period. Thus, the 25-metre front crawl test procedure better separates between those who float well and those who float poorly rather than to serve as a valid test for children's swimming skills (Petrić, 1996). So, previous Croatian experience in this respect has shown that by testing only the children's swimming skills for admission to swimming schools, one gives preference to those children who, due to their social status or some other lucky factors, had the opportunity to learn how to swim. These children seldom have predispositions for competitive swimming. Moreover, the research results showed (Leko, 2001) that such a selection singled out those children who had a higher body fat percentage, a condition that is unfavourable for competitive swimming. While excessive body fat contributes to better buoyancy, it is detrimental to performance since it is associated with a relatively lower muscle mass (Cassell, Benedict, & Specker, 1996; Noland, Baker, Boudreau, Kobe, Tanner, Hickner, McCammon, & Houmard, 2001; Tuuri, Loftin, & Oescher, 2002). In previous research (Volčanšek, Grčić-Zubčević, & Marić, 1984), an attempt was made to control the body fat percentage factor by introducing negative coefficients for skinfold values. However, this addressed only one part of the problem and was therefore later abandoned as an inappropriate method. Therefore, in the present study the authors wish to propose a change in the protocol of the initial selection by identifying criteria that would single out the children with the best potential for success in a competitive swimming program.

The process of selection should be carried out in two phases. In the first phase all the second-form primary-school children in Zagreb or elsewhere in Croatia should be tested by

means of the set of tests which have proved to be statistically significant for predicting success in swimming and which can relatively easily be carried out in schools. In the second phase, the swimming proficiency of those children who had met the criteria set in the first phase of the selection would be tested. Those children who had passed the anthropometric and motor testing and showed that they could swim would be directly enrolled in the swimming school programme, whereas the non-swimmers would be first engaged in a two to three-week long process of learning how to swim and would join other swimmers upon completion of the basic swimming course. In that way the existing admission process to the swimming school would be turned into a process of initial selection, which would, undoubtedly, serve as a more valid admissions test.

Therefore, the purpose of the study was to design a battery of tests that could be used in the selection of children for swimming schools. That battery of tests should be appropriate and simple enough to be carried out by physical education teachers in primary education. In order to accomplish this purpose the authors first aimed at examining which anthropometric characteristics and motor abilities were the best predictors of performance of pre-adolescent boys in 50 m front crawl swimming.

## Methods

### Subjects

The sample was comprised of 37 male swimmers, 9-10 years of age, from Zagreb swimming clubs who participated in the 50m front crawl event (short course) at official competitions. All the subjects have been participating in a 2-4-year training process.

### Measurements

The subjects were tested in the Sports Diagnostic Centre of the Faculty of Kinesiology, University of Zagreb. Special attention was paid to the selection of measurers in a way that each measure was always measured by the same person. Prior to the study, all the measurers had been trained within the Kinesiological Anthropology course. The values of the criterion variable were measured during the national championships (Christmas Cup "Mladost", 1998, and Croatian National Junior Championship, 1998) by OMEGA time equipment under the control of the swimming judges with an international referee licence. The

environmental factors at the swimming pool (water and air temperature) were according to the FINA (Fédération Internationale de Natation Amateur) regulations.

## Variables

The measurements included the following variables:

### *Criterion variable*

The 50m front crawl swimming times measured and registered in the official records of the Croatian National Championships official competitions were taken as the criterion variable. Why was the 50 m-crawl result selected as the criterion variable? The influence of the anthropometric characteristics and motor abilities was monitored only in the 50m front crawl stroke, because this stroke is the one to be acquired and mastered first, so there should be no limitations in performance of the movement structure. Besides, the largest portion of the training process, aimed at the development of aerobic capacity, is realised by the front crawl stroke swimming.

### *Predictor variables*

#### (A) ANTHROPOMETRIC MEASURES

The anthropometric characteristics were measured by the tests that are an integral part of the International Biological Program (IBP) and that cover four segments of the anthropological status (Medved, 1987) and vital capacity:

##### *Measures of longitudinal characteristics (cm)*

- Body height – VISTIJ
- Hand length – DUZSAK
- Foot length – DUZSTO
- Arm span – RASRUK
- Sitting height – SJEVIS

##### *Measures of transversal characteristics (cm)*

- Biacromial span – SIRRAM
- Bitrochanteral span – SIRKUK
- Hand diameter – SIRSAK
- Foot diameter – SIRSTO
- Wrist diameter – DRZ

##### *Measures of voluminosity*

- Chest circumference – OGGK (cm)
- Upper arm circumference – OPSNAD (cm)
- Upper leg circumference – OPSNAT (cm)
- Body weight – TEZTIJ (kg)

##### *Skinfolds - 3 measurements (mm)*

- Upper arm skinfold – NABNAD

- Abdominal skinfold – NABTRB
- Subscapular skinfold – NABLED

##### *Lung volumes (ml)*

- Vital capacity - VITKAP

#### (B) TESTS ASSESSING MOTOR ABILITIES

The testing of motor abilities was carried out according to the instructions as described by Metikoš, Hofman, Prot, Pintar, and Oreb (1989).

##### *Measures of flexibility*

- Bar circumduction – ISK (cm)
- Sit-and-reach – SAR (cm)
- Plantar flexion – EKSSTO (cm)

##### *Measures of explosive strength*

- Throwing the medicine ball from supine position – BML (dm)
- Vertical jump – SVM (cm)
- Horizontal jump – SDM (cm)

##### *Measures of speed of repeated movements*

- Hand tapping in 15 seconds – TAPR (number of repetitions)

##### *Measures of power*

- Sit-ups in 60 seconds – PODT60 (number of repetitions)

##### *Measures of static strength*

- Pull-up hang – IVZ (s)

## Data processing methods

The obtained data were processed by the statistical package Statistica for Windows at the Faculty of Kinesiology, University of Zagreb. Summary statistics were obtained about the basic and dispersion parameters. First, the correlations between the predictors were identified. To determine the interrelationships between the anthropometric characteristics, motor abilities and performance, standard regression analysis was used. The backward stepwise regression was also used to define the interrelationships within the predictor set by eliminating the mutual influence (suppression) in such a way that one by one, the variables that displayed the smallest statistical significance were eliminated.

## Results

The normality of the distribution of results was tested by the measures of distribution (skewness and kurtosis), and the maximal

deviation (max D) revealed the departure from normal distribution. The reliability of composite tests was tested by Cronbach alpha. Table 1 presents the values of descriptive statistic parameters.

The multiple regression analysis was applied. The results of the correlation analysis are presented in Table 2.

High correlations between several measurements were found (Table 2), the highest being, of course, between the *body height* and *arm span* ( $r^2 = 0.91$ ) as well as between the *body height* and the *sitting height* ( $r^2 = 0.78$ ).

Table 3 shows the results of the regression analysis of the predictor set for the variable *50 m front crawl stroke*. The multiple correlation of the whole set is .95 which means that the coefficient of determination is .91. The analysis of the predictor set makes it possible to conclude that the influence of the test *vertical jump* (SVM) is the only one to be statistically significant ( $p=0.01$ ). However, the low number of statistically significant variables points to the fact that we are talking about redundant variables that have a high mutual suppressive influence.

Table 1. Descriptive statistics

	Mean	Min	Max	Std.Dev.	Skewness	Kurtosis	max D	Alpha
VISTIJ (cm)	140.29	131.50	155.00	5.85	0.58	-0.29	0.11	
DUZSAK (cm)	15.83	13.70	17.80	1.09	0.10	-1.15	0.12	
DUZSTO (cm)	21.42	19.20	24.50	1.24	0.36	-0.23	0.09	
RASRUK (cm)	137.39	127.00	155.00	7.23	0.83	0.27	0.10	
SJEVIS (cm)	73.88	68.00	81.00	3.23	0.39	-0.50	0.09	
OGK (cm)	70.32	59.00	86.00	6.03	0.42	-0.01	0.12	
OPSNAD (cm)	22.42	18.00	29.00	2.70	0.46	-0.30	0.11	
OPSNAT (cm)	42.77	35.20	52.30	4.67	0.19	-0.86	0.09	
NABNAD (mm)	11.55	4.80	23.53	4.96	0.78	-0.15	0.13	0.99
NABTRB (mm)	11.38	3.27	24.27	6.81	0.55	-1.18	0.19	0.99
NABLED (mm)	8.17	3.80	20.63	4.58	1.45	1.28	0.20	0.99
TEZTIJ (kg)	35.75	25.50	54.00	6.45	0.88	0.85	0.17	
SIRRAM (cm)	30.98	27.50	36.50	1.75	0.63	1.40	0.12	
SIRKUK (cm)	22.23	19.60	28.50	1.62	2.03	5.84	0.16	
SIRSAK (cm)	6.45	5.50	7.20	0.36	0.01	0.46	0.11	
SIRSTO (cm)	7.86	7.00	9.10	0.47	0.43	0.17	0.12	
VITKAP (ml)	2013.89	1300.00	3100.00	389.07	0.61	0.47	0.09	
DRZ (cm)	4.60	4.10	5.20	0.26	0.61	-0.09	0.19	
PODT60 (rep.)	34.31	22.00	46.00	5.99	0.10	-0.44	0.09	
IVZ (s)	22.52	4.79	64.24	12.68	1.49	2.62	0.19	
BML (dm)	45.70	28.70	62.30	8.40	0.36	-0.32	0.22	0.80
SVM (cm)	26.12	8.67	38.67	5.71	-0.62	1.84	0.12	0.90
SDM (cm)	145.17	113.33	172.33	16.61	-0.10	-0.93	0.08	0.94
TAPR (rep.)	23.99	18.00	29.67	2.94	-0.03	-0.69	0.07	0.95
ISK (cm)	55.44	30.00	83.00	13.64	0.27	-0.89	0.13	
SAR (cm)	4.22	-4.90	13.33	4.27	0.06	0.02	0.10	0.97
EKSSTO (cm)	8.90	6.30	11.20	1.35	-0.01	-0.85	0.09	
KRAUL50 (s)	40.47	32.99	49.25	5.10	0.24	-1.27	0.14	

*Legend:* VISTIJ - body height; DUZSAK - hand length; DUZSTO - foot length; RASRUK - arm span; SJEVIS - sitting height; OGK - chest circumference; OPSNAD - upper arm circumference; OPSNAT - upper leg circumference; NABNAD - upper arm skinfold; NABTRB - skinfold of the abdomen; NABLED - skinfold of the back; TEZTIJ - body weight; SIRRAM - biacromial diameter; SIRKUK - bitrochanteal diameter; SIRSAK - hand diameter; SIRSTO - foot diameter; VITKAP - vital capacity; DRZ - wrist diameter; PODT60 - sit-ups in 60 seconds; IVZ - pull-up hang; BML - throwing the medicine ball from supine position; SVM - vertical jump; SDM - horizontal jump; TAPR - hand tapping; ISK - bar circumduction; SAR - sit-and-reach; EKSSTO - plantar flexion; KRAUL50 - 50m front crawl result

Table 2. The table of intercorrelations among predictor variables

VISTIJ	1.00	0.76	0.83	0.91	0.78	0.58	0.49	0.46	0.22	0.24	0.29	0.71	0.65	0.60	0.51	0.58	0.69	0.68	0.26	-0.15	0.51	0.15	0.18	0.41	0.46	-0.38	0.46
DUZSAK	0.76	1.00	0.74	0.76	0.56	0.25	0.19	0.13	-0.03	0.02	0.03	0.40	0.49	0.45	0.25	0.25	0.60	0.49	0.13	-0.07	0.27	0.08	0.22	0.32	0.11	-0.35	0.29
DUZSTO	0.83	0.74	1.00	0.83	0.50	0.34	0.25	0.20	0.01	0.05	0.11	0.49	0.48	0.43	0.41	0.43	0.64	0.55	0.24	0.04	0.34	0.00	0.29	0.35	0.27	-0.40	0.51
RASRUK	0.91	0.76	0.83	1.00	0.67	0.53	0.44	0.40	0.20	0.25	0.27	0.66	0.68	0.57	0.53	0.60	0.66	0.61	0.29	-0.16	0.47	0.11	0.15	0.40	0.38	-0.33	0.40
SJEVISTIJ	0.78	0.56	0.50	0.67	1.00	0.60	0.53	0.55	0.34	0.37	0.35	0.69	0.68	0.54	0.36	0.44	0.50	0.47	0.26	-0.24	0.38	0.32	0.08	0.30	0.42	-0.05	0.22
OGK	0.58	0.25	0.34	0.53	0.60	1.00	0.91	0.80	0.78	0.78	0.80	0.95	0.56	0.71	0.59	0.64	0.46	0.76	0.18	-0.33	0.46	0.11	-0.11	0.26	0.26	-0.10	0.11
OPSNAD	0.49	0.19	0.25	0.44	0.53	0.91	1.00	0.86	0.87	0.87	0.87	0.92	0.46	0.69	0.56	0.58	0.23	0.73	0.06	-0.42	0.37	0.03	-0.25	0.09	0.29	-0.03	0.03
OPSNAT	0.46	0.13	0.20	0.40	0.55	0.80	0.86	1.00	0.81	0.77	0.71	0.84	0.37	0.58	0.59	0.61	0.16	0.71	-0.12	-0.42	0.24	0.10	-0.39	-0.04	0.27	0.14	0.12
NABNAD	0.22	-0.03	0.01	0.20	0.34	0.78	0.87	0.81	1.00	0.91	0.88	0.77	0.30	0.56	0.40	0.52	0.00	0.57	-0.10	-0.49	0.15	-0.06	-0.52	-0.12	0.11	0.14	-0.13
NABTRB	0.24	0.02	0.05	0.25	0.37	0.78	0.87	0.77	0.91	1.00	0.82	0.77	0.23	0.49	0.52	0.48	0.07	0.57	-0.01	-0.51	0.13	0.04	-0.46	-0.06	0.18	0.17	-0.22
NABLED	0.29	0.03	0.11	0.27	0.35	0.80	0.87	0.71	0.88	0.82	1.00	0.81	0.37	0.68	0.34	0.49	0.04	0.63	-0.04	-0.44	0.19	-0.13	-0.39	0.04	0.19	-0.02	-0.01
TEZTIJ	0.71	0.40	0.49	0.66	0.69	0.95	0.92	0.84	0.77	0.77	0.81	1.00	0.60	0.81	0.58	0.64	0.46	0.82	0.13	-0.41	0.42	0.06	-0.18	0.23	0.34	-0.15	0.18
SIRRAM	0.65	0.49	0.48	0.68	0.68	0.56	0.46	0.37	0.30	0.23	0.37	0.60	1.00	0.62	0.18	0.36	0.45	0.41	0.31	-0.11	0.46	0.14	0.20	0.47	0.32	-0.27	0.23
SIRKUK	0.60	0.45	0.43	0.57	0.54	0.71	0.69	0.58	0.56	0.49	0.68	0.81	0.62	1.00	0.27	0.44	0.41	0.63	0.25	-0.24	0.41	0.06	-0.04	0.31	0.21	-0.25	0.05
SIRSAK	0.51	0.25	0.41	0.53	0.36	0.59	0.56	0.59	0.40	0.52	0.34	0.58	0.18	0.27	1.00	0.61	0.34	0.62	0.10	-0.37	0.41	-0.02	-0.04	-0.01	0.29	0.16	0.20
SIRSTO	0.58	0.25	0.43	0.60	0.44	0.64	0.58	0.61	0.52	0.48	0.49	0.64	0.36	0.44	0.61	1.00	0.34	0.65	0.11	-0.27	0.38	0.18	-0.08	0.11	0.26	-0.03	0.16
VITKAP	0.69	0.60	0.64	0.66	0.50	0.46	0.23	0.16	0.00	0.07	0.04	0.46	0.45	0.41	0.34	0.34	1.00	0.45	0.38	0.10	0.51	0.46	0.42	0.50	0.17	-0.31	0.33
DRZ	0.68	0.49	0.55	0.61	0.47	0.76	0.73	0.71	0.57	0.57	0.63	0.82	0.41	0.63	0.62	0.65	0.45	1.00	-0.01	-0.40	0.32	-0.02	-0.18	0.08	0.25	-0.28	0.33
PODT60	0.26	0.13	0.24	0.29	0.26	0.18	0.06	-0.12	-0.10	-0.01	-0.04	0.13	0.31	0.25	0.10	0.11	0.38	-0.01	1.00	0.08	0.32	0.30	0.45	0.54	0.11	-0.34	-0.25
IVZ	-0.15	-0.07	0.04	-0.16	-0.24	-0.33	-0.42	-0.42	-0.49	-0.51	-0.44	-0.41	-0.11	-0.24	-0.37	-0.27	0.10	-0.40	0.08	1.00	0.15	0.25	0.56	0.34	-0.29	-0.06	0.24
BML	0.51	0.27	0.34	0.47	0.38	0.46	0.37	0.24	0.15	0.13	0.19	0.42	0.46	0.41	0.41	0.38	0.51	0.32	0.32	0.15	1.00	0.34	0.42	0.48	0.17	-0.17	0.14
SVM	0.15	0.08	0.00	0.11	0.32	0.11	0.03	0.10	-0.06	0.04	-0.13	0.06	0.14	0.06	-0.02	0.18	0.46	-0.02	0.30	0.25	0.34	1.00	0.40	0.32	-0.16	0.07	-0.07
SDM	0.18	0.22	0.29	0.15	0.08	-0.11	-0.25	-0.39	-0.52	-0.46	-0.39	-0.18	0.20	-0.04	-0.04	-0.08	0.42	-0.18	0.45	0.56	0.42	0.40	1.00	0.51	-0.08	-0.32	0.24
TAPR	0.41	0.32	0.35	0.40	0.30	0.26	0.09	-0.04	-0.12	-0.06	0.04	0.23	0.47	0.31	-0.01	0.11	0.50	0.08	0.54	0.34	0.48	0.32	0.51	1.00	-0.05	-0.28	0.09
ISK	0.46	0.11	0.27	0.38	0.42	0.26	0.29	0.27	0.11	0.18	0.19	0.34	0.32	0.21	0.29	0.26	0.17	0.25	0.11	-0.29	0.17	-0.16	-0.08	-0.05	1.00	-0.27	0.18
SAR	-0.38	-0.35	-0.40	-0.33	-0.05	-0.10	-0.03	0.14	0.14	0.17	-0.02	-0.15	-0.27	-0.25	0.16	-0.03	-0.31	-0.28	-0.34	-0.06	-0.17	0.07	-0.32	-0.28	1.00	-0.26	-0.26
EKSSTO	0.46	0.29	0.51	0.40	0.22	0.11	0.03	0.12	-0.13	-0.22	-0.01	0.18	0.23	0.05	0.20	0.16	0.33	0.33	-0.25	0.24	0.14	-0.07	0.24	0.09	0.18	-0.26	1.00

Legend: VISTIJ - body height; DUZSAK - hand length; DUZSTO - foot length; RASRUK - arm span; SJEVISTIJ - sitting height; OGK - chest circumference; OPSNAD - upper arm circumference; OPSNAT - upper leg circumference; NABNAD - upper arm skinfold; NABTRB - skinfold of the abdomen; NABLED - skinfold of the back; TEZTIJ - body weight; SIRRAM - biacromial diameter; SIRKUK - bitrochanteral diameter; SIRSAK - hand diameter; SIRSTO - foot diameter; VITKAP - vital capacity; DRZ - wrist diameter; PODT60 - sit-ups in 60 seconds; IVZ - pull-up hang; BML - throwing the medicine ball from supine position; SVM - vertical jump; SDM - horizontal jump; TAPR - hand tapping; ISK - bar circumference; SAR - sit-and-reach; EKSSTO - plantar flexion; KRAUL50 - 50m front crawl result

The comparison of results obtained by the two regression analyses makes it possible to conclude that in the 50 m front crawl swimming the backward stepwise regression analysis may help obtaining a smaller number of predictors with a relatively high reliability coefficient. In the cases when standard regression analysis is used it becomes clear that the total set is highly predictive (91%), however, only the *vertical jump*

(SVM) proved to be statistically significant. On the other hand, 5 statistically significant variables were extracted by using the backward stepwise regression analysis (Table 4). These variables represent a large portion of anthropometric space important for 50 m front crawl swimming. The relatively high prediction power (76%) was maintained.

Table 3. The results of the regression analysis of the predictor set for the variable 50m front crawl stroke

R= .95 R<sup>2</sup>= .91 F(27.8)=3,3434 p<0.05

	R	BETA	St. err.of BETA	B	St. Err.of B	t(8)	p-level
VISTIJ	-0.32	-0.33	0.55	-0.28	0.48	-0.59	0.57
DUZSAK	-0.15	-0.30	0.36	-1.40	1.70	-0.82	0.43
DUZSTO	-0.22	-0.16	0.34	-0.66	1.40	-0.47	0.65
RASRUK	-0.28	-0.21	0.46	-0.15	0.32	-0.45	0.66
SJEVIS	-0.18	0.73	0.36	1.16	0.58	2.01	0.08
OGK	-0.33	-1.20	0.79	-1.01	0.67	-1.52	0.17
OPSNAD	-0.27	-0.61	0.52	-1.15	0.97	-1.18	0.27
OPSNAT	-0.27	-0.09	0.46	-0.10	0.50	-0.19	0.85
NABNAD	-0.01	0.31	0.53	0.32	0.55	0.58	0.58
NABTRB	-0.18	0.72	0.59	0.54	0.44	1.22	0.26
NABLED	0.01	0.10	0.38	0.11	0.42	0.26	0.80
TEZTIJ	-0.25	0.13	1.40	0.10	1.10	0.09	0.93
SIRRAM	0.00	0.46	0.26	1.33	0.74	1.78	0.11
SIRKUK	-0.13	0.11	0.35	0.33	1.09	0.30	0.77
SIRSAK	-0.48	-0.32	0.40	-4.52	5.68	-0.80	0.45
SIRSTO	-0.40	0.12	0.26	1.35	2.84	0.47	0.65
VITKAP	-0.44	0.54	0.31	0.01	0.00	1.74	0.12
DRZ	-0.28	0.15	0.35	2.97	6.93	0.43	0.68
PODT60	-0.35	-0.11	0.27	-0.10	0.23	-0.42	0.69
IVZ	-0.17	-0.06	0.21	-0.02	0.09	-0.28	0.78
BML	-0.50	0.04	0.22	0.26	1.35	0.19	0.85
SVM	-0.61	-0.92	0.29	-0.82	0.26	-3.15	<b>0.01</b>
SDM	-0.38	0.06	0.29	0.02	0.09	0.21	0.84
TAPR	-0.31	-0.02	0.22	-0.04	0.37	-0.11	0.92
ISK	-0.01	-0.17	0.21	-0.06	0.08	-0.83	0.43
SAR	0.03	-0.10	0.25	-0.12	0.30	-0.40	0.70
EKSSTO	0.00	0.20	0.25	0.75	0.95	0.79	0.45

Legend: VISTIJ - body height; DUZSAK - hand length; DUZSTO - foot length; RASRUK - arm span; SJEVIS - sitting height; OGK - chest circumference; OPSNAD - upper arm circumference; OPSNAT - upper leg circumference; NABNAD - upper arm skinfold; NABTRB - skinfold of the abdomen; NABLED - skinfold of the back; TEZTIJ - body weight; SIRRAM - biacromial diameter; SIRKUK - bitrochanteal diameter; SIRSAK - hand diameter; SIRSTO - foot diameter; VITKAP - vital capacity; DRZ - wrist diameter; PODT60 - sit-ups in 60 seconds; IVZ - pull-up hang; BML - throwing the medicine ball from supine position; SVM - vertical jump; SDM - horizontal jump; TAPR - hand tapping; ISK - bar circumduction; SAR - sit-and-reach; EKSSTO - plantar flexion; KRAUL50 - 50m front crawl result

Table 4. The results of the backward stepwise regression analysis of the predictor set for the variable 50m front crawl stroke

R= .87 R<sup>2</sup>= .76 F(5.30)=19.89 p<0.001

	BETA	St. Err.of BETA	B	St. Err.of B	t(30)	p-level
SJEVIS	0.40	0.12	0.63	0.18	3.46	0.00
OPSNAD	-0.81	0.22	-1.52	0.42	-3.61	0.00
NABNAD	0.70	0.19	0.72	0.19	3.68	0.00
SIRSAK	-0.46	0.11	-6.55	1.55	-4.24	0.00
SVM	-0.68	0.10	-0.60	0.08	-7.12	0.00

Legend: SJEVIS - sitting height; OPSNAD - upper arm circumference; NABNAD - upper arm skinfold; SIRSAK - hand diameter; SVM - vertical jump

## Discussion and conclusions

Already the descriptive statistic showed that in the variable *pull-up hang* (IVZ) the results were grouped by their lower values (Mean 22.52±12.68 s; Min= 4.79 s; Max= 64.24 s). Such a grouping of results in this variable leads to the conclusion that either the test was too difficult for boys of this age or that the elements necessary for the development of the static strength of arms and shoulder girdle had still not been included yet in the training process. The reason for such results may also lie in the fact that the analysed sample had a higher percentage of body fat compared to the average population (Mišigoj-Duraković, 1995).

The comparison between the other variables makes it possible to conclude that the average height of subjects in this sample (140.29 cm) is somewhat larger than for the average population (135,8cm; Mišigoj-Duraković, 1995), however, it does not differ from the sample of swimmers of the same age in earlier works (Cazorla, 1993; Kapus, 1982, 1983, 1984; Mišigoj-Duraković, 1995). The abilities in which the analysed sample performed worse in comparison with Slovenian swimmers were *horizontal jump* (SDM) and *vital capacity* (VITKAP) (Kapus, 1983). Namely, the Croatian swimmers fall behind the Slovenian swimmers in these abilities by around 15%. A comparison with results obtained in other recent works by Croatian authors is almost impossible since, for example, the sample of swimmers in the study done by Petrić (1996) encompassed 4-5 age categories. The sample analysed in this study is significantly different in skinfold values from the average population scores (Mišigoj-Duraković, 1995). The variables addressing the specific body areas used to assess body fat percentage through skinfolds in the analysed sample displayed higher values than the ones

found in the average population. The average skinfold score at the abdomen (NABTRB) was 11.7 mm in the study group as compared to 5.8 mm in the average population. This data could be explained by the fact that according to the training curriculum prescribed for this age, the swimmers pay special attention to technique improvement

without high energy-related loads or a long aerobic workout. Also, the amount of body fat has a significant correlation with the buoyancy, which makes swimming easier at this age (Medved, 1987). Thus, children with a higher body fat percentage will display higher buoyancy and will execute the tasks, whose goal is a technically correct execution and not speed, more easily. Buoyancy was not measured in the present study because, according to the authors' previous experience, the available buoyancy test is very inaccurate, regardless of whether the subjects are tested in the horizontal or the vertical position. On the whole, the dimensions of the skeleton, both as regards circumference and skinfold magnitude in the sample of swimmers analysed in this paper, displayed higher scores in comparison to the average population (Mišigoj-Duraković, 1995).

In comparison with the results obtained by French authors (Cazorla, 1993), the Croatian swimmers displayed significantly lower values in flexibility than the French swimmers. These results were true for all three flexibility tests. The most significant difference in the flexibility scores was manifested in the 4.22cm and 16cm respective average of the Croatian and French swimmers' score on the flexibility of the trunk (SAR) test. However, the Slovenian swimmers (Kapus, 1983) scored similarly in the shoulder girdle flexibility tests, which may be interpreted as the consequence of insufficient work on flexibility both in the Croatian and the Slovenian swimmers as compared to the French swimmers. An *ad hoc* interview with coaches revealed that work on the development of flexibility was completely neglected in every Zagreb club. The finding is unexpected and surprising because flexibility is a critical component of efficient swimming skills. It contributes to the conservation of

energy, helps to protect the joints and muscles against injury, and allows an increased range of movement. The benefits of proper flexibility are self-evident at any age group and would certainly benefit 9-10-year-old swimmers.

The values of max D (Table 1) allow us to conclude that the results in the applied tests follow normal distribution except for the test *throwing the medicine ball from supine position* (BML), which was at the very edge of significance since the borderline value for the analysed sample (37 subjects) was .21 at a level of significance of 95%. This deviation of the variable BML from normal distribution can be explained by the very execution of the test, namely, according to the test protocol, it is very difficult to control all parameters, particularly the extension of arms, while throwing the medicine ball. If the subject lifts his head from the floor and bends his arms, then the test will also measure strength of abdominal musculature and arm abductors, and not only the explosive strength of the shoulder girdle. Other authors came to the same conclusion (Grčić-Zubčević, 1984). In their research the test *throwing the medicine ball from supine position* (BML) proved to be unreliable and too difficult for the observed age group.

It is interesting to point out that the values of correlation among the predictors pertaining to the anthropometric space are grouped similarly as in the latent structures obtained in certain previous research studies (Petrić, 1996; Medved, 1987). Vital capacity (VITKAP) displayed the positive correlation with anthropometric measures particularly with the *body height* (VISTIJ;  $r = 0.69$ ) and the length of the extremities (hand length - DUZSAK;  $r = 0.60$  and foot length - DUZSTO;  $r = 0.64$ ) on the one hand and *chest circumference* on the other (OGK;  $r = 0.50$ ). It is because of this reason that in most studies on swimming the measure of vital capacity is observed and interpreted as a part of the anthropometric space (Volčanšek, 1979). The zero correlation between *vital capacity* (VITKAP) and all skinfold measures was found as expected, because the changes in the percentage of body fat should not provoke any changes in lung volume.

Based on the high positive correlation ( $r > 0.75$ ) between the skinfold (NABNAD, NABTRB, NABLED) and circumference variables (OPSNAD, OPSNAT, OGK) it can be concluded that the increase in circumference at this age is mostly the result of the amount of body fat, because in pre-puberty the increase

in muscle mass is insufficient to significantly influence any body-related circumference growth.

The variable *sit-ups in 60 seconds* (PODT60) had a low correlation with almost all other variables, except with the variables *horizontal jump* (SDM;  $r = 0.45$ ) and *hand tapping* (TAPR;  $r = 0.54$ ). This correlation can be explained with the partial contribution of the abdominal musculature to the results in both tests. In the variable *horizontal jump* (SDM) the abdominal musculature participates in the phases of swing and landing, when the subject, after arching the body backwards during flight, attempts to swing both legs forwards and as far as possible. Upon analysing the movement structure performance in the test *hand tapping* (TAPR), it can be said that the subjects executed very small movement amplitudes in the shoulder joint. Instead, they executed almost the whole movement by rotating the trunk, thus recruiting the abdominal musculature as well. Since the execution of the test is rather demanding for this age category as far as the time of execution is concerned (3 x 15 seconds), a positive correlation between these variables is logical. To further confirm the interpretation we can say that the correlation between *upper arm circumference* (OPSNAD), which to a large extent determine arm strength, and *hand tapping* (TAPR) is only .09, whereas the correlation between *hand tapping* (TAPR) and *sit-ups in 60 seconds* (PODT60) is .54.

It is interesting that the flexibility tests show a very low correlation with almost the whole set of predictors, and vice versa. The same was obtained by Volčanšek (1979). On the other hand, Kapus (1984) demonstrated a big influence of flexibility on swimming over various distances. He concluded that the influence of flexibility increased with swimming distance. However, as already interpreted, poor flexibility in the analysed sample should be understood as the result of the shortcomings of the training process and not of the characteristics of the observed sample.

The correlation (.08) between the *pull-up hang* (IVZ) and the *sit-ups in 60 seconds* (PODT60) makes it obvious that the power of the trunk and the static hold of the arms do not depend on one another. From the energy-related point of view, both tests can be interpreted as measures of endurance, but from the point of view of the load type, as well as from the topological point of view, they again do not depend on each other.



The power of the trunk measure (*sit-ups in 60s* - PÖDT60) shows also very low or even negative correlation with the circumference (*chest circumference* - OGK,  $r = 0.18$ ; *upper arm circumference* - OPSNAD,  $r = 0.06$ ; *upper leg circumference* - OPSNAT,  $r = -0.12$ ) and skinfold values (*upper arm skinfold* - NABNAD,  $r = -0.10$ ; *skinfold of the abdomen* - NABTRB,  $r = -0.01$ ; *skinfold of the back* - NABLED,  $r = -0.04$ ). Since a higher circumference and the skinfold values actually define swimmers who have bigger body weight ( $r > 0.75$ ), it is clear that the execution of sit-ups will be more difficult for these subjects both due to the bigger load and, indirectly, due to the decreased relative oxygen uptake resulting from a higher weight.

The test *vertical jump* (SVM) measures the explosive strength of the whole body. Explosive strength is a desirable attribute for sprints, especially in the 25 m-swimming pools (Table 3). The low values achieved in the variable *horizontal jump* (SDM) and *throwing the medicine ball from supine position* (BML) may be explained by the suppressive influence of the most significant variable that describes the space of explosive strength of the body. This was to be expected on the basis of the values of intercorrelations ( $r = 0.40$  and  $r = 0.34$ ).

When attempting to define particular space, one tries to select the largest possible number of variables. In the case when some of them define the same latent space (Medved, 1987), a mutual suppressive influence occurs. In the statistical processing of data, regardless of the methods applied, one statistically significant variable, which is singled out, carries away a large portion of the common variability from the other variables that are highly correlated with it. That interaction among variables is called the suppression influence and is the reason why the standard regression analysis was tested here by applying the backward stepwise analysis. This backward stepwise regression approach rejects (eliminates), one by one, the least significant predictor variables, thus decreasing the redundancy of the set and leaving only those variables showing the statistical significance that is free from the influence of other variables.

The results of the backward stepwise analysis (Table 4) show a high correlation ( $r = .87$ ) of the following variables: *sitting height* (SJEVIS), *upper arm circumference* (OPSNAD), *upper arm skinfold* (NABNAD), *hand diameter* (SIRSAK) and *vertical jump* (SVM) that have a statistical significance at the level of 99% ( $p < .01$ ).

This study suggests that it may be possible to apply the five-test battery to achieve a relatively high level of swimming performance prediction (76%). Since the variables that have been singled out belong to various latent spaces, they can be used for the prediction of efficiency in the *50m front crawl stroke swimming*.

*Sitting height* (SJEVIS) is correlated to the criterion variable ( $r = 0.40$ ), but it has a negative influence on 50 m front crawl result. The negative influence can be explained by the significant contribution of the legs to propulsion when swimming over short distances. This means that the high portion of sitting height in the total body height would imply shorter lower extremities, and, consequently, a smaller propulsion force.

*Upper arm circumference* (OPSNAD) had the highest prediction power ( $r = -0.80$ ). This can be explained by the high correlation between the strength of the arms and upper arm circumference. Arm strength is one of the important factors in the 50 m front crawl swimming, which is performed, in an anaerobic regimen of work. Kapus (1984) also obtained similar results where the circumferences and body mass were singled out by their strong positive correlation, whereas skinfolds showed that they have a strong negative correlation with the speed of swimming. Highly trained swimmers undergo diverse preparation programmes aimed at developing their aerobic capacities and at developing and maintaining speed. It may be concluded that the larger the upper arm circumference, the more successful the swimmer. Better swimming performance is primarily associated with the cross-sectional area of the muscle and not with body fat percentage. Since the boys in this study were 9-10 years old, larger extremity circumferences were probably associated with hereditary and biological maturity factors and not with training.

*Upper arm skinfold* (NABNAD), as the measure of the amount of subcutaneous fatty tissue, is negatively correlated with the swimming results. Similar findings were also obtained in other studies (e.g. Petrić, 1996). Namely, elite swimmers have a significantly low amount of body fat due to the long-term high-intensity training process. This is particularly true for sprinters for whom body fat, as the source of aerobic energy, is not of primary importance during the racing event.

A positive correlation of the variable *hand diameter* (SIRSAK,  $r = -0.46$ ) can be explained

by propulsion requirements. A large hand diameter implies a larger surface that, when coupled with great arm strength, can produce a great propulsion force.

Performance on the *vertical jump* (SVM) test was expected to positively correlate with the swimming performance ( $r = -0.68$ ). This expectation was based on the fact that the swimming time was measured over a short course where the starting dive and the turn contribute considerably to the result in the 50 m event. Namely, according to swimming rules, after the start and after the turn a swimmer may swim underwater up to 15 metres. At the 15-metre point, in order not to be disqualified, he must come to the surface and start swimming using the front crawl stroke. Since the number of turns in short course swimming pools is double the number of turns in the Olympic swimming pools, the force of pushing-off from the wall of the swimming pool should presumably play a bigger role in the result. Since *vertical jump* (SVM) is the measure of explosive strength of a general character, the influence of this ability on short distance swimming performance is thereby bigger. Bloomfield and associates (1990) reported similar results in two studies in which they demonstrated that in the younger age categories, the children who participated in the training process and the children who did not participate in the training process differed mostly by the force of leg extensors. According to Bloomfield and associates (1990), it is only in puberty that the differences will occur in the measures of circumferences defining the strength of the upper extremities and their participation in the production of propulsion force.

It may be concluded that out of the entire space of anthropometric characteristics and motor abilities, 5 tests could be singled out that showed the statistical significance for predicting success in 50m front crawl swimming in boys 9 and 10 years of age. Out of these five tests (*sitting height, upper arm circumference, upper arm skinfold, hand diameter and vertical jump*), the tests *sitting height* and *upper arm skinfold* were negatively correlated with the 50m crawl results. Such a finding is not in accordance to the

previous research (Petrić, 1996; Kapus, 1983) and experience. Maybe it could be explained by the biological processes occurring at that age, meaning the increase of height with a small increase in muscle mass. The comparison of the contribution factors makes it possible to conclude that the influence of sitting height is the smallest when compared to the other four (out of five) variables that had been singled out. The tests are easy to perform and appropriate for field-testing as well. They could, with quite high certainty, anticipate the success in swimming of 9-10-year old boys.

### Application in practice

This actually means that the children whose scores in the five tests exceed the arithmetic mean should be regarded as apt or predisposed to swimming and they should be asked to participate in the second phase of swimming-selection skills testing over the 25m distance. The authors do not propose any general standards (model values) to be prescribed. Instead, in order to provide as wide a selection pool as possible, they suggest the values of the arithmetic means of the scores in individual tests be determined for each generation separately on the basis of the sample measured. Upon data processing, those children who meet the listed criteria will be asked to participate in the further testing of their swimming skills. The criterion in the very testing procedure will be continuous swimming for 25m using any stroke and swimming time. Those children who swim 25m within certain time limits will be immediately included in the swimming program (the swimming sports school), whereas the motivated children who do not meet the criteria (distance and time) of the test, will be directed to participate in the basic swimming course, lasting 3 weeks. Afterwards, they will be included in a further sport-specific program upon the successful completion of the swimming classes. Such a protocol will contribute to a more precise and economical selection of beginners in swimming in Croatia, but it will also maintain the selection pool as large as possible.

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## SELEKCIJA DJECE ZA PLIVAČKU SPORTSKU ŠKOLU U REPUBLICI HRVATSKOJ

### SAŽETAK

#### Uvod

U većini slučajeva plivački klubovi selekcioniraju djecu za plivačke škole svojih klubova na osnovi znanja plivanja na 25 metara. Takvim načinom se odabiru djeca koja su do tada imala priliku naučiti plivati, a u većini slučajeva su to bila djeca s većom količinom masnog tkiva (Medved, 1987). Takva djeca imaju bolju sposobnost plutanja, ali u natjecateljskom plivanju to masno tkivo predstavlja ograničavajući faktor za poboljšanje rezultata. Ovim se istraživanjem nastoji izdvojiti nekoliko testova na osnovi kojih se može predvidjeti uspjeh u plivanju. Početna selekcija bi se provodila na osnovi tog sklopa testova, dok bi se znanje plivanja testiralo na izdvojenom uzorku djece. Cilj je ovog istraživanja bio utvrditi bateriju jednostavnih testova koji bi se mogli provoditi i tijekom nastave tjelesne i zdravstvene kulture, a kojima bi mogli pristupiti i neplivači.

#### Metode

Uzorak se sastojao od 37 plivača muškog spola zagrebačkih plivačkih klubova koji su na službenim natjecanjima nastupili na dionici 50 metara kraul (kratki bazeni), starih 9-10 godina. Svi ispitanici su proveli u trenažnom procesu 2-4 godine.

Ispitanici su podvrgnuti mjerenju antropometrijskih obilježja i testiranju motoričkih sposobnosti.

#### Prediktorske varijable:

#### ANTROPOMETRIJSKA OBILJEŽJA

- VISTIJ (cm) - visina tijela
- DUZSAK (cm) - dužina šake
- DUZSTO (cm) - dužina stopala
- RASRUK (cm) - raspon ruku
- SJEVIS (cm) - sjedeća visina
- OGK (cm) - opseg grudnog koša
- OPSNAD (cm) - opseg nadlaktice
- OPSNAT (cm) - opseg natkoljenice
- NABNAD (mm) - nabor nadlaktice
- NABTRB (mm) - nabor na truhu
- NABLED (mm) - nabor na leđima
- TEZTIJ (kg) - masa tijela
- SIRRAM (cm) - širina ramena
- SIRKUK (cm) - širina kukova
- SIRSAK (cm) - širina šake
- SIRSTO (cm) - širina stopala
- VITKAP (ml) - vitalni kapacitet
- DRZ (cm) - dijametar ručnog zgloba

#### MOTORIČKE VARIJABLE

- PODT60 (br.) - pretkloni u 60 s
- IVZ (s) - izdržaj u visu (zgib)
- BML (dm) - bacanje medicine
- SVM (cm) - skok u vis s mjesta
- SDM (cm) - skok u dalj s mjesta
- TAPR (br.) - taping rukom
- ISK (cm) - iskret palicom
- SAR (cm) - "sit and reach"
- EKSSTO (cm) - plantarna fleksija

#### Kriterijska varijabla:

KRAUL50 (s) – rezultat na 50 m plivanja kraul tehnikom

Dobiveni podaci obrađeni su statističkim paketom Statistica for Windows. Dobivene su informacije o osnovnim i disperzivnim parametrima. Statističkim su paketom utvrđene i korelacijske veze među prediktorima. Za utvrđivanje međusobnih odnosa antropometrijskih karakteristika, motoričkih varijabli i situacijske uspješnosti (rezultata) korištena je standardna regresijska analiza čiji su rezultati provjereni *backward* metodom.

#### Rezultati

U tablici 1 prikazani su osnovni deskriptivni parametri. Kako je postojala dobra povezanost pojedinih varijabli (tablica 2), provedena je *backward* regresijska analiza. Iz cijelog sklopa mjera antropometrijskih karakteristika i motoričkih sposobnosti izdvojilo se 5 testova (sjedeća visina, opseg nadlaktice, nabor nadlaktice, širina šake i skok u vis s mjesta) koji su pokazali statističku značajnost ( $p < 0.01$ ) za rezultat u plivanju dionice 50 metara kraul tehnikom (tablica 4). Treba obratiti pažnju na to da su sjedeća visina i nabor nadlaktice negativno korelirane, uz napomenu da je kriterijska varijabla vremenska varijabla, tj. što niža vrijednost, to bolji rezultat.

#### Rasprava i zaključak

Regresijskom analizom izdvojenih mjera sjedeće visine, (SJEVIS), opsega nadlaktice (OPSNAD), nabora nadlaktice (NABNAD), širine šake (SIRSAK) i skoka u vis s mjesta (SVM) može se a). U praktičnom smislu može se smatrati da su ona djeca čiji su rezultati u navedenim testovima iznad aritmetičke sredine za tu generaciju (kod sjedeće visine i nabora nadlaktice ispod) bolje predisponirana

za plivanje te ih treba pozvati da se uključe u drugu fazu selekcije koja se sastoji od testa preplivavanja dionice od 25 metara. Djecu koja bi zadovoljila kriterij plivačke vještine treba uputiti u plivačku sportsku školu. U slučaju da u vrijeme testiranja neka djeca ne znaju plivati, bila bi usmjerena u program obuke neplivača,

a po uspješno završenoj obuci takva djeca bi zatim bila uvrštena u rad plivačke škole. Ovakav način selekcije doprinio bi boljem i ekonomičnijem odabiru plivača početnika, a velika mu je prednost što bi uključio veći broj djece, tj. i one koja u vrijeme testiranja još ne znaju plivati.

# MODELLING AND SIMULATION OF TWO COMPETITION SLALOM TECHNIQUES

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## Abstract:

The new geometry of skis highly affects skiing and consequently the slalom technique. A new improved slalom technique with a single movement has been recently presented. This study deals with the biomechanical modelling and computer simulation of the new technique and the old technique with double movement. The simulation is set to enable a comparison of forces and force distributions. It was found that the behaviour of the force is of vital importance because of the skier's movement. Due to the movement, the force causes an increase and decrease in the total ground reaction force. The consequence of the different movements is a higher presence of the highest and strongest ground reaction forces acting in skiing when the double movement technique is applied. Furthermore, a much better steering of the skis can be achieved as a consequence of better contact with the snow, especially during the transfer of weight using the single movement technique. In addition to that, much lower knee momentums act around the gate in the single movement technique as a result of a more stretched body position. The final conclusion relating to the forces point of view achieved with computer simulation is that the new technique with a single movement is much more appropriate for the new skis. The conclusion is consistent with the measurement of forces and times presented in previous articles.

**Key words:** *alpine skiing, slalom, competition technique, computer simulation, biomechanical modelling*

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## MODELLIERUNG UND COMPUTERSIMULATION ZWEIER SLALOMTECHNIKEN BEIM WETTBEWERB

### Zusammenfassung:

Die neue Beschaffenheit von Skiern hat einen starken Einfluss auf das Skifahren und als Folge dessen auf die Slalomtechnik. Eine neue verbesserte Slalomtechnik mit einer Bewegung wurde neulich vorgestellt. Dieses Projekt befasst sich mit der biomechanischen Modellierung und Computersimulation der neuen und der alten Technik mit doppelter Bewegung. Die Simulation sollte einen Kräftevergleich vermitteln, sowie einen Einblick in die Distribution der Kräfte gewähren.

Es wurde festgestellt, dass, was die Bewegung des Skifahrers betrifft, das Benehmen der Kraft von größter Wichtigkeit ist. Abhängig von der Bewegung verursacht die Kraft entweder eine Zu- oder Abnahme der gesamten Bodenreaktionskraft. Die Folge verschiedener Bewegungen ist eine höhere Anwesenheit der höchsten und stärksten Bodenreaktionskräfte, wenn die Doppelbewegungstechnik angewendet wird. Außerdem kann man eine weit bessere Skierführung erreichen, als Folge besseren Schneekontakts, besonders während der Gewichtsverlagerung bei der Einzelbewegungstechnik. Zudem macht der Skifahrer weit kürzere Schwünge um das Tor in der Einzelbewegungstechnik, als Folge einer ausgestreckteren Körperposition. Entsprechend der Computersimulation lässt sich folgern, im Bezug auf die mittels Computersimulation erhaltenen Kräfte, dass die neue Einzelbewegungstechnik für die neuen Skier angemessener ist. Das ist auch im Einklang mit den Messungen von Kräften und Zeit, die in vorhergehenden Artikeln beschrieben wurden.

**Schlüsselwörter:** *Ski alpin, Slalom, Wettbewerbstechnik, Computersimulation, biomechanische Modellierung*

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## Introduction

The new geometry of skis, i.e. carving skis, highly affects skiing (Casolo & Lorenzi, 2001; Kugovnik, Nemec, & Supej, 2000; Supej, Nemec, & Šmitek, 2001; Supej, Kugovnik, & Nemec, 2004, etc.). Consequently, a new improved slalom technique with a single movement has been presented and tested in natural conditions (Supej, Kugovnik, & Nemec, 2002; Kugovnik, Supej, & Nemec, 2004). Several differences and advantages relating to the "old" technique of double movement have been proven, e.g. better snow contact, lower maximal ground reaction forces, better racing times, etc. (Supej, Kugovnik, & Nemec, 2002; Kugovnik, Supej, & Nemec, 2004). The new technique, i.e. the single movement technique is the result of biomechanical modelling. By means of simulation the differences and advantages of the improved technique will be presented in laboratory conditions where all the disturbing factors of the changing conditions in nature can be eliminated. Since the fundamental measurements have been based on the force level (Supej, Kugovnik, & Nemec, 2002), the simulation has been set to enable a comparison of forces.

## Methods

Computer simulation based on the biomechanical model has been programmed in the software package *Matlab* that enables a simpler calculation than the classical software languages. A simulation basis contained four slalom turns with a vertical distance among the gates amounting to 13 metres and a shift of 2.5 metres. The skiing trajectory was generated by a sinusoid curve so that the gates were at the maximum or minimum of the curve. It was assumed the skier performed carved turns. Sampling of the trajectory was performed at 600 Hz. Due to a simple comparison and without any loss of the relevance of dynamic parameters, the simulated skier's speed was equal to 13 m/s at all times. The simulated slope had a permanent inclination of 20°.

A skier's model was a rigid body with its mass concentrated in the centre of gravity. Subsequently, movement in the main axis of the body imitating the movement, i.e. stretching and bending, was added. Radial force was calculated at each point on the trajectory. The vector sum of a radial force and static component of the weight force gave the first approximation of the ground reaction force hypothetically corresponding to the ground reaction force of the skier, without any of

the skier's movements in terms of stretching and bending or, in other words, it gave the single-pointed body approximation. The static component of the weight force was defined by an adequate balance of the skier, which means that the ground reaction force acted centrally on the centre of gravity in the body. The skier's centre of gravity moved only in one plane, taut over the normal and bi-normal vector of the movement trajectory, which is an optimal longitudinal balanced position of the skier, if the friction between the skis and the snow and the air resistance are neglected.

Since two slalom techniques were to be compared, one with a single and the other one with a double movement, the movement of the skier had to be simulated from the aspect of stretching and bending. Both models were presented in Figure 1. In both cases the skier's movement had been modelled in the main vertical axis of the body and always turned in the direction of the skier's inclination, as a consequence of maintaining an adequate balanced position. In the case of the single movement technique, the amplitude of the movement amounted to 20 cm; 40% of the turn's duration the skier stretched and he/she bent 60% of the time. Simulation of the movement consisted of two sinusoid curves that were joined at the top. Since the force would be abnormal due to the movement at the point of connection, the joined curve was flattened by a digital Butterworth filter of the 3<sup>rd</sup> order and frequency of 6 Hz. The double movement technique had been modelled by a sinusoid curve of the double turn frequency (the double movement) and lower amplitude 15 cm (see Fig. 1), because of the higher movement frequency. The amplitudes were different and estimated on the basis of kinematic measurements in slalom (Supej, Kugovnik, Nemec, & Šmitek, 2001; Supej, Kugovnik, & Nemec, 2004). Since the nature of movement in the second technique is of such a character that the skier is at the lowest position behind the gate, his/her movement was shifted by an eighth of the turn frequency.

The force caused by the movement of the first or the second technique was obtained by the calculation of the second differential of the modelled movement and by the multiplication of the skier's weight.

Besides the forces modelled, disturbances that in natural environment occur due to bumps on the slopes, the measuring method or other reasons usually appear during skiing. These disturbances were modelled in a simulation by



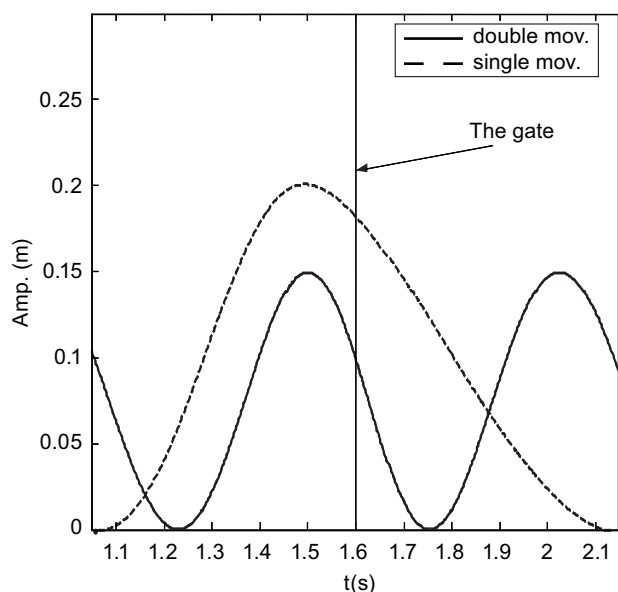


Figure 1. Modelling of the skier's movement in the single and double movement techniques.

50 Hz of coincidental noise of the amplitude  $\pm 150$  N. When the ground reaction force had been finally assembled, it had to be checked if it was lower than 0 in any of the points of the ground reaction force, which may happen due to the noise added. In this case the force was set at 0. The same effect can be observed in real measurements. The distribution of forces presented in the form of histograms with columns at a width of 300 N was calculated for a better comparison of techniques.

### Results

A simulation of the model calculated the forces for the single movement technique, presented in Figure 2, and the forces for the double movement technique, presented in Figure 3. In both cases the following is presented: force occurring due to movement, radial force, mutual ground reaction force and contribution of gravity to the total force calculated in the approximation as a difference between the absolute value of the vector sum of radial force and static component of the weight force and absolute value of the radial force.

Figures 2 and 3 show the course of a force in the turn. Figures 4–6 present the distributions of forces in histograms where the relative presence of forces of an individual size class (histogram columns) can be monitored. The first diagram corresponds to the distribution of forces for the single-pointed body model ("skiing without movement"); the second and the third ones correspond to the single and double movement technique.

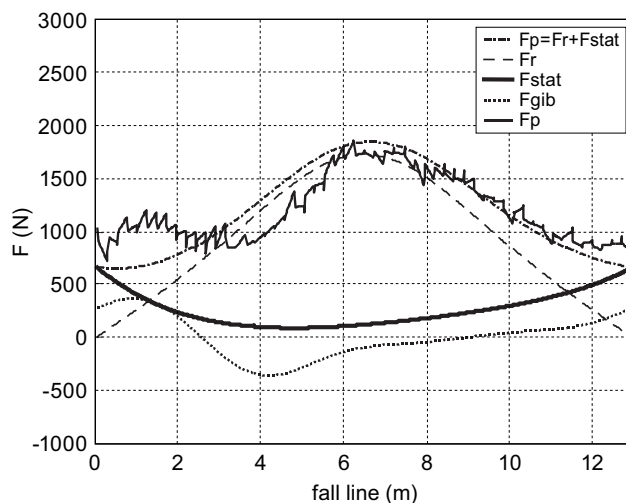


Figure 2. Forces in a turn that occur in the single movement technique:  $F_p$  – ground reaction force for a single-pointed body model ("skiing without movement"),  $F_r$  – radial force,  $F_{stat}$  – contribution of gravity to the force  $F_p$ ,  $F_{gib}$  – force occurring due to the skier's movement and  $F_p$  – total ground reaction force.

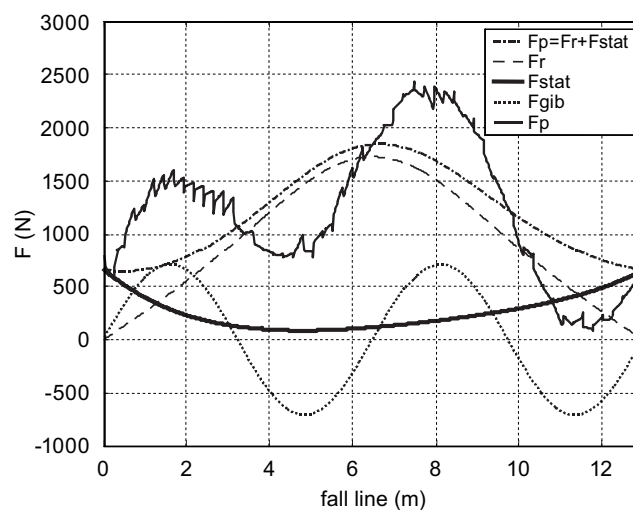


Figure 3. Forces in a turn that occur in the technique of double movement:  $F_p$  – ground reaction force for a single-pointed body ("skiing without movement"),  $F_r$  – radial force,  $F_{stat}$  – contribution of gravity to the force  $F_p$ ,  $F_{gib}$  – force occurring due to the skier's movement and  $F_p$  – total ground reaction force.

### Discussion and conclusions

The model of the double movement technique complies with the measurements of kinematics of the best racers in the world championships, which means that the simulated movement in Figure 1 complies with the description and analysis of actual competition techniques. The model of the single movement technique is a consequence of biomechanical

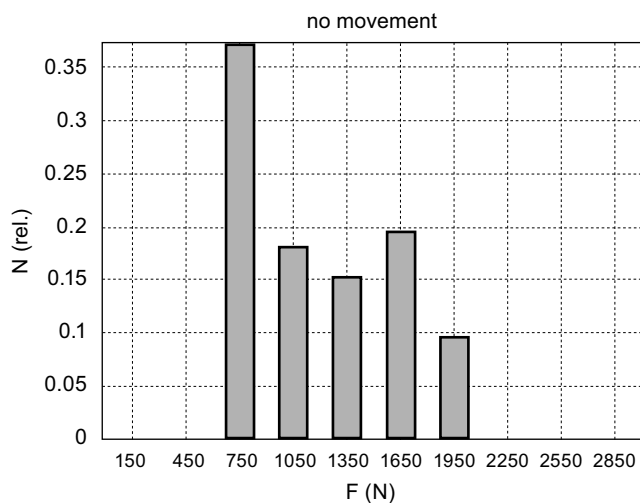


Figure 4. Histogram of forces for the single-pointed body model ("skiing without movement").

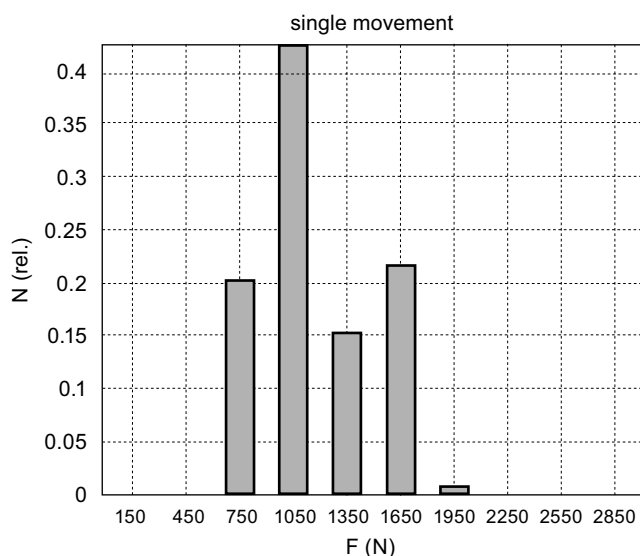


Figure 5. Histogram of forces for the single movement technique.

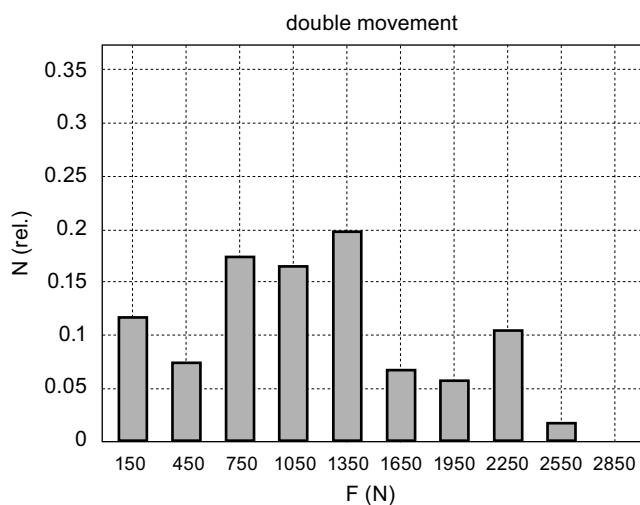


Figure 6. Histogram of forces for the double movement technique.

modelling and practical tests of the technique under competition conditions performed by selected racers.

In the single movement technique the skier is at the lowest position during the transfer of weight and then he/she stretches. He/she is most stretched already in front of the gate, which is also visible in the Figure 1. Further, he/she slowly bends and his/her centre of gravity gets close to the skis.

In the double movement technique the skier is not maximally bent during the transfer of weight. It happens later when he/she strongly places the skis on their edges. Then he/she continues moving downwards and reaches the lowest position (the centre of gravity is closest to the skis) soon after the gate. This is followed by a push and stretching; moving of the centre of gravity close to the skis begins when the weight is to be transferred again. A shortcoming of the model is that a sinusoid or compound sinusoid movement has been simulated in both cases. In real competition circumstances the movement may deviate from the simulated movement, but not to the extent which may drastically influence the distinction between the techniques, since the basic idea of movement is the same. The modelled trajectory of the skier is rather similar to the real one. In this case the leaning radii decreased down to less than 7 metres in the part of the turn where they were smallest. During the weight transfer they reached infinity, which was also evidenced in a good approximation on the snow. The only shortcoming of the model of a sinusoid turn is that skiers in the real world do not change their radius at each point, but they usually maintain the same radius of the turn in the vicinity of the gates. The approximation to reality is the even speed of the skier in the turn that typically and cyclically oscillates in real conditions in a range from 0.5 to 1 m/s. The changing speed does not cause any significant differences in the distribution of forces and besides that it complicates the problem without any need; therefore skiing has always been simulated at an even speed. Simulations with different even speeds (from 10 m/s up to 14 m/s) and different slope inclinations (0°, 10° and 20°) were performed, but all the results were similar and therefore not presented here. The present differences are the consequence of higher radial forces, shorter stretching and bending cycles and different inclinations of the skier.

Since we have been well aware of all the limitations, we can have a look at the results of

forces. Figures 3 and 4 present forces for the first and the second technique. The base is the same for both diagrams. In real terms all forces are equal, except the one that is a consequence of either a single or double movement. It can be established that the radial force determines the main form of the ground reaction force. The gravity contribution is relatively small in the top part of the turn or above the gate and it is larger on the bottom side of the turn or under the gate. Of course, the largest contribution can be observed in the vicinity of the weight transfer point. Behaviour of the force occurring due to the skier's movement is of a vital importance. Because of the movement the force causes an increase and decrease of the total ground reaction force. In the case of the double movement technique the force causes the skier to have an interval of very low minimal force at the time of weight transfer because of the movement. On the other hand, the maximum forces are under the pole, where all forces are summed up. The result is a typical curve with a double peak. The single movement technique shows a completely different picture, since the ground reaction force decreases at the time of maximum forces and increases in the area of minimal forces due to the skier's movement.

The results of the distributions of forces for both techniques and in terms of reference for theoretical "skiing without movement" (single-pointed body model) are presented in the histograms of Figures 4–6. It can be established in the single-pointed skier's model ("skiing without movement") that the distribution of the ground reaction force is limited at the bottom edge, to the slightly less than the force of the skier's weight (600 N), and at the top edge, to values approximately a three-time force of the skier's weight (2100 N) (see Fig. 4). The distribution reaches its peak in the vicinity of the value force of the skier's weight.

The double movement technique significantly expands the distribution (see Fig. 5). Firstly, there is a great concentration of forces in the vicinity of zero, which means that the skier can hardly manoeuvre the skis. The main peak is much lower and wider due to the broad distribution. It ranges from 600 N to 1500 N. Another disadvantage of this technique is also a rather high presence of the highest and strongest forces. The distribution reaches up to 2700 N, which corresponds almost to a four-time force of the skier's weight and the presence of forces in the interval ranging from 2100 N to 2400 N amounts even to 11%. In practice, the highest forces mean more braking and more difficult conditions for the skier who should be able to tolerate them.

The picture of the single movement technique is completely different since the peak of the distribution is similarly shifted by a column higher, to approximately 1.5 of the force of the skier's weight, but it is substantially narrower (see Fig. 6). The distribution is not expanded, but even shrunk and it approximately ends 300 N lower than in the single-pointed body model ("skiing without movement") or approximately 600 N lower than in the double movement technique. By means of the technique the skier decreases the highest forces and their presence. In the case of the single movement technique the area of forces does not exist in the vicinity of 0 N, which means that the skier has a good contact with the base all the time.

Another fact arising from the model is rather important. In the double movement technique the skier is bent in the interval of high forces which increases the muscle power due to the lever principle in joints (see Fig. 2 and 4). The situation is exactly the opposite in the single movement technique since the skier is quite stretched in the area of high forces (see Fig. 2 and 3).

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## MODELIRANJE I SIMULACIJA DVIJE NATJECATELJSKE SLALOMSKE TEHNIKE

### Sažetak

#### Uvod

Nova, poboljšana slalomska tehnika s jednim pokretom tek je nedavno predstavljena javnosti. U radu će biti prikazane razlike i prednosti poboljšane tehnike uz pomoć simulacije u laboratorijskim uvjetima, gdje su svi remeteći faktori i promjenjivi uvjeti prirodne okoline uklonjeni.

Temelj računalnog modela slalomske tehnike jesu četiri zavoja. Trajektorija skijanja generira se pomoću sinusoidnog zavoja i pretpostavlja da skijaš izvodi karving zavoj. Simulirana skijaševa brzina sve vrijeme iznosi 13 m/s, a nagib padine je konstantan i iznosi 20°. Model skijaša je kruto tijelo s masom skupljenom u centar težišta tijela. Zatim je dodan pokret koji, po glavnoj osi tijela, oponaša pokrete opružanja i sagibanja. Skijaševo težište tijela pokreće se samo po površini, protegnuto preko normalnih i binormalnih vektora trajektorija gibanja, što je optimalan ravnotežni položaj skijaša.

#### Metoda

Uspoređuju se dvije slalomske tehnike. U oba se slučaja skijaševi pokreti modeliraju po glavnoj vertikalnoj osi tijela i uvijek se okreću u smjeru skijaševa nagiba, što za posljedicu ima održavanje tijela u ravnoteži. U slučaju tehnike jednog pokreta, amplituda pokreta obuhvaća 20 cm, a tijekom zavoja skijaš se uspravlja 40% vremena, a sagiba 60% od ukupnog vremena. Simulacija pokreta sadrži dva sinusoidna zavoja koja su spojena pri vrhu. Tehnika dvostrukog pokreta modelirana je sinusoidnom krivuljom dvostrukog zavoja frekvencije i amplitude 15 cm (slika 1).

Za vrijeme tehnike jednog pokreta skijaš je u najnižoj poziciji za vrijeme prijenosa težine nakon čega se uspravlja. Najuspravniji je ispred vrata, a potom se sagiba. Za vrijeme izvođenja tehnike dvostrukog pokreta skijaš nije maksimalno pognut za vrijeme prijenosa težine, već tek nakon toga, kada već čvrsto premjesti skiju na rubnik. U tom se trenutku počinje kretati prema dolje i zauzima najniži položaj ubrzo nakon vrata. Potom slijedi odguravanje i uspravljanje, pokretanje težišta tijela bliže skiji počinje kada skijaš ponovno priprema prijenos težine.

#### Rezultati

Dijagrami na slici 3 i 4 prikazuju silu generiranu za vrijeme simulirane izvedbe prve i druge tehnike. Može se utvrditi da zakretna sila deter-

minira glavni oblik sile reakcije podloge. Najveće je djelovanje gravitacije u blizini prijenosa težine, a mnogo manje u blizini vrata. Ponašanje sile zbog skijaševa kretanja je iznimno važno. U slučaju tehnike dvostrukog pokreta sila uzrokuje da skijaš ima područje vrlo niske minimalne sile u vrijeme prijenosa težine. Suprotno tome maksimum sile jest ispod štapa, kada se svi doprinosi sile zbrajaju. Rezultat je tipičan zavoj s dvostrukim vrhom. Tehnika jednog pokreta pokazuje potpuno različitu sliku, reakcija podloge se smanjuje u vrijeme djelovanja maksimalne sile i povećava u području vrlo niskih minimalnih sila.

#### Rasprava i zaključak

Može se utvrditi da je u modeliranju skijaša kao krutog tijela u jednoj točki ('skijanje bez kretanja') raspodjela sile reakcija podloge ograničena na donji rub, nešto manje nego  $F_g$  na gornjem rubu, do približno  $3 \cdot F_g$  (vidi sliku 4). Distribucija doseže vrh u blizini sile skijaševe težine. Tehnika dvostrukog pokreta značajno proširuje distribuciju sile (slika 5). Prvo, postoji veća koncentracija sile u blizini nule, što znači da skijaš teško može manevrirati skijama. Glavni vrh je mnogo niži i širi zbog širine raspodjele. Drugi nedostatak ove tehnike je također veća prisutnost najviše i najjače sile (do 2700 N). U praksi, najviša sila znači više kočenja i teže uvjete skijanja.

Slika tehnike jednog pokreta potpuno je različita, vrh distribucije je slično pomaknut višom kolonom, do otprilike  $1.5 \cdot F_g$ , ali je bitno uži (vidi sliku 6). Raspodjela nije rastegnuta, naprotiv čak se sužava i završava otprilike 300 N niže od skijaševa modela u jednoj točki, ili otprilike 600 N niže nego u tehnici dvostrukog pokreta. Pomoću ove tehnike skijaš umanjuje najvišu silu i njezinu prisutnost. U slučaju tehnike jednog pokreta područje sile nije vidljivo u blizini 0 N, što znači da skijaš cijelo vrijeme ima dobar kontakt s podlogom. Važna je još jedna činjenica koja proizlazi iz ovog modela. U tehnici dvostrukog pokreta skijaš je pognut u području visokih sila, što povećava snagu mišića zbog poluga u zglobovima (vidi slike 2 i 4). Situacija je upravo suprotna u tehnici jednog pokreta; skijaš je prilično opružen u području djelovanja većih sila, koje su u ovom slučaju prilično niske (slike 2 i 3).

Konačni zaključak sa stajališta djelovanja sile, utvrđen računalnom simulacijom, jest da je nova tehnika jednog pokreta znatno prikladnija za novo skijanje kada skijaš izvodi karving zavoj. Zaključak je sukladan mjerenju sile i vremena predstavljenima u prethodnom članku.

# HEAVY TRAINING STRESS IN MALE ROWERS: EFFECTS ON CIRCULATORY RESPONSES AND MOOD STATE PROFILES

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## Abstract:

The effects of short-term overreaching on the circulatory responses and mood state parameters were investigated in male rowers. Fourteen national team level rowers ( $18.6 \pm 2.0$  yrs;  $186.9 \pm 5.7$  cm;  $82.4 \pm 6.9$  kg) were monitored during a six-day training camp. The training regimen consisted mainly of low-intensity on-water rowing and resistance training, for  $19.2 \pm 3.9$  h, corresponding to an approximate 100% increase in the training load. The 2,000 m rowing ergometer performance time increased from  $395.9 \pm 10.8$  to  $404.2 \pm 11.9$  s corresponding to a mean power of  $361.9 \pm 28.5$  and  $349.0 \pm 32.8$  W, respectively. Blood lactate concentration measured five minutes after the test (from  $19.2 \pm 2.9$  to  $16.2 \pm 2.3$  mmol·l<sup>-1</sup>) and mean heart rate (from  $184.6 \pm 7.5$  to  $179.2 \pm 7.4$  beats·min<sup>-1</sup>) decreased. Maximal oxygen consumption remained unchanged. The subjective ratings of fatigue and muscle soreness increased and were related to the training volume ( $r > 0.52$ ). The blood parameters of the red blood cell count, hemoglobin concentration and hematocrit were decreased, while blood and plasma volumes were increased after the training period. The blood variables were not correlated with the training volume ( $r < -0.44$ ;  $p > 0.05$ ). The change between tests in the corresponding heart rate demonstrated correlation to the changes in blood ( $r = -0.48$ ) and plasma ( $r = -0.55$ ) volumes. It is concluded that the most appropriate and simple tool for monitoring a short-term overload training period is the self-reported ratings of well-being on a daily basis.

**Key words:** *overreaching, fatigue, rowing performance, mood state parameters*

## HOHE TRAININGSBELASTUNG BEI RUDERERN: AUSWIRKUNGEN AUF KREISLAUFWERTE UND GEMÜTSZUSTANDPARAMETER

### Zusammenfassung:

Die Auswirkungen einer kurzfristigen Überbelastung bei Ruderern auf die Blutkreislaufwerte und Gemütszustandparameter wurden geforscht. Vierzehn leistungsstärkste estonische Ruderer ( $18,6 \pm 2,0$  Jahre alt;  $186,9 \pm 5,7$  cm;  $82,4 \pm 6,9$  kg) wurden während eines sechstägigen Trainingslagers beobachtet. Das Trainingsprogramm bestand überwiegend aus dem Rudern niedriger Intensität auf Gewässern und Krafttraining, durchschnittlich  $19,2 \pm 3,9$  Stunden der Dauer, was einer fast 100% Erhöhung der Trainingsbelastung entspricht. Die Dauer des 2000m Ruderns steigte von  $395,9 \pm 10,8$  bis auf  $404,2 \pm 11,9$  Sekunden, was einer durchschnittlichen Kraftaufwand von  $361,9 \pm 28,5$  und  $349,0 \pm 32,8$  W entspricht. Die Konzentration von Blutlaktaten (von  $19,2 \pm 2,9$  bis  $16,2 \pm 2,3$  mmol·l<sup>-1</sup>) wurde fünf Minuten nach dem Test gemessen und die durchschnittliche Herzfrequenz nahm ab (von  $184,6 \pm 7,5$  bis  $179,2 \pm 7,4$  Herzschläge·min<sup>-1</sup>). Der maximale Sauerstoffverbrauch blieb unverändert. Die subjektive Einschätzungswerte von Erschöpfung und Muskelschmerz nahmen zu, was mit dem Trainingsumfang zusammenhängt ( $r > 0,52$ ). Die Blutparameter, wie z. B. die Anzahl von roten Blutzellen, die Hämoglobinkonzentration und Hämatokrit nahmen ab, während das Blut- und Plasmavolumen nach der Trainingsperiode zunahm. Die Blutvariablen korrelierten nicht mit dem Trainingsumfang ( $r < -0,44$ ;  $p > 0,05$ ). Der Unterschied zwischen den Tests der durchschnittlichen Herzfrequenz zeigte die Korrelationen mit den Unterschieden im Blut- ( $r = -0,48$ ) und Plasmavolumen ( $r = -0,55$ ) auf. Daraus lässt sich folgern, dass das meist geeignete und einfachste Mittel zur Beobachtung einer kurzfristigen Trainingsperiode mit Überbelastung die tägliche persönliche Auffassungsweise des Sportlers über seinem Wohlbefinden ist.

**Schlüsselwörter:** *Überbelastung, Erschöpfung, Rudern, Gemütszustandparameter*

## Introduction

The overtraining syndrome has been defined as a long-term decrement in performance capacity induced by the accumulation of training and non-training stress (Hooper & Mackinnon, 1995; Kreider, Fry, & O'Toole, 1998). Overtraining is considered to occur in response to large volumes and/or high intensities of training with inadequate recovery periods between training sessions. Many indicators of overreaching and overtraining have been proposed using different physiological and psychological parameters. Currently, there is no single marker that allows for the diagnosis of the condition (Flynn, 1998). In fact, many physiological markers may vary similarly during training and overtraining (Bosquet, Leger, & Legros, 2001). Athletes have been classified as either overtrained or not overtrained when in fact the condition is on a continuum (Hooper, Mackinnon, Howard, Gordon, & Bachmann, 1995). While the overtraining syndrome requires a recovery period of several months up to a year (Lehmann, Foster, & Keul, 1993), overreaching, the result of short-term overtraining, can be reversed with a resting period of a few days (Hedelin, Kennta, Wiklund, Bjerle, & Henriksson-Larsen, 2000).

Although there is a variety of symptoms reported on overreached and overtrained athletes, the main symptoms are reduced performance and pronounced fatigue (Lehmann et al., 1993; Hooper et al., 1995). Other parameters that have been studied as possible markers of overreaching and overtraining include various blood circulatory indices at rest and/or during exercise (Lehmann, Dickhuth, Gendrisch, Lazar, Thum, Kaminski, Aramendi, Peterke, Wieland, & Keul, 1991; Hedelin et al., 2000), resting and/or exercise heart rate (HR) and oxygen consumption (Hedelin et al., 2000), and different mood state indices (Lehmann et al., 1991; Hooper et al., 1995). However, special equipment is needed to record many of the above mentioned parameters, and the procedure can be time-consuming and expensive (Hedelin et al., 2000; Bosquet, Leger, & Legros, 2001). The identification of easily monitored, reliable indicators of overreaching may aid in monitoring the adaptive process during intensive training and recovery periods in athletes.

Rowing training is performed mainly as an extensive endurance type (Jürimäe, Jürimäe, & Purge, 2001). For rowers, it has been demonstrated that the kilometers trained are positively related to the success in cham-

pionships (Steinacker, 1993). However, the risk of overtraining increases with increasing daily training time and insufficient regeneration (Steinacker, Lormes, Lehmann, & Altenburg, 1998). This means that it is important to identify the specific parameters which could be used to monitor everyday training in order to avoid the overtraining syndrome in rowers. Therefore, the purpose of this investigation was to investigate whether a short-term overreaching state in rowers, as indicated by a decrease in performance parameters, is reflected in different circulatory and/or mood state parameters.

## Methods

### Subjects

Fourteen national-team-level male rowers ( $18.6 \pm 2.0$  yrs;  $186.9 \pm 5.7$  cm;  $82.4 \pm 6.9$  kg) volunteered to participate in this study. The rowers had trained regularly for the last  $4.1 \pm 1.8$  years. The training period and tests constituted their first training camp on water after the winter training period and at the prospect of the coming season. The subjects were informed about the procedures and the aims of the investigation, and their written consent was obtained. This study was approved by the Medical Ethics Committee of the University of Tartu.

### Procedures

The volume of training during the six-day training period amounted to  $19.2 \pm 3.9$  h, which was equivalent to an average increase in the training volume by approximately 100% compared with their average weekly training during the preceding four weeks. In total, 12 training sessions were completed during the overreaching training period compared to six training sessions during the previous four weeks. Eighty-five percent of the total training volume was low-intensity endurance training (rowing or running), 5% was high-intensity anaerobic training (rowing) and 10% was resistance training. The maximal 2,000 m rowing ergometer test was performed before (Test 1) and after (Test 2) the six-day training period. The subjects were only allowed to train easily or not at all on the afternoon before the final test day. Blood samples were collected in the morning of each performance session. Early morning body mass and heart rate (HR) were recorded daily. In addition, the rowers were asked to record daily their subjective ratings of their quality of sleep, fatigue, stress and muscle

soreness on a scale of one to seven from very, very low (point 1) to very, very high (point 7) (Hooper et al., 1995).

### Performance testing

The maximal 2,000 m rowing ergometer test was performed on a wind resistance braked rowing ergometer (Concept II, Morrisville, USA). The rowers were fully familiarized with the use of this apparatus. Power and stroke frequency were delivered continuously by the computer display of the rowing ergometer. HR was measured continuously and stored at 5 s intervals during exercise tests by a sporttester Polar Vantage NV (Kempele, Finland). Expired gas was sampled continuously for the measurement of maximal oxygen consumption ( $\text{VO}_2\text{max}$ ; TrueMax 2400 Metabolic Measurement System, Parvo Medics, USA) (Russell, LeRossignol, & Sparrow, 1998; Jürimäe, Mäestu, Jürimäe, & Pihl, 2000). The analyzers were calibrated prior to the test using commercial gases of known concentration. Fingertip capillary blood (20  $\mu\text{l}$ ) was sampled five minutes after the completion of the test. Blood lactate concentration was determined from these samples enzymatically (Lange, Germany) (Greiling & Gressner, 1987). Two parameters were considered to represent the rowing performance: the time ( $T_{2000}$  in s) and the average workload ( $P_{2000}$  in W) (Jürimäe et al., 2000).

### Blood analysis

A five milliliter blood sample was obtained from the antecubital vein with the subjects in an upright position (Jürimäe, Jürimäe & Purge, 2001). Red blood cell count (RBC), hemoglobin concentration (Hgb), hematocrit (Hct) and mean corpuscular volume (MCV) were measured on Sysmex SE9000 (TOA Medical Electronics, Kobe, Japan). The coefficients of variation for those analyses were < 3%. Concentrations in the lower normal range were accompanied by higher coefficients of variation values. Relative changes in blood volume (BV) and plasma volume (PV) were calculated from Hgb and Hct in each subject using the formula of Dill and Costill (1974).

### Statistical analysis

Descriptive statistics (mean  $\pm$  standard deviation, SD) for each of the dependent variables were determined. The Wilcoxon matched-pairs signed-ranks test was used to compare the results from Test 1 with Test 2. Spearman correlation

coefficients were calculated for correlation analysis. For all tests, the level of significance was set at 0.05.

## Results

### Performance data

The 2,000 metre rowing ergometer performance time was significantly increased from Test 1 to Test 2 (Table 1). While mean power, mean HR and blood lactate concentration measured five minutes after the test were significantly lower in Test 2 compared to Test 1.  $\text{VO}_2\text{max}$  values remained unchanged between the tests.

Table 1. 2,000 metre rowing ergometer performance before and after the training period (Mean  $\pm$  SD).

	Test 1	Test 2
Time (s)	395.9 $\pm$ 10.8	404.2 $\pm$ 11.9*
Power (W)	361.9 $\pm$ 28.5	349.0 $\pm$ 32.8*
$\text{VO}_2\text{max}$ ( $\text{l}\cdot\text{min}^{-1}$ )	4.85 $\pm$ 0.70	4.83 $\pm$ 0.61
$\text{VO}_2\text{max}/\text{kg}$ ( $\text{ml}\cdot\text{min}^{-1}\cdot\text{kg}^{-1}$ )	60.4 $\pm$ 6.1	60.3 $\pm$ 5.0
La 5' recovery ( $\text{mmol}\cdot\text{l}^{-1}$ )	19.2 $\pm$ 2.9	16.2 $\pm$ 2.3*
Mean HR ( $\text{beats}\cdot\text{min}^{-1}$ )	184.6 $\pm$ 7.5	179.2 $\pm$ 7.4*

$\text{VO}_2\text{max}$ , maximal oxygen consumption; La, blood lactate concentration; HR, heart rate

\* Significantly different from Test 1;  $p < 0.05$ .

### Resting data

Morning HR and body mass values were not significantly changed after the training period (Table 2). The subjective ratings of fatigue and muscle soreness increased significantly from Test 1 to Test 2 (Table 2). The blood parameters of RBC, Hgb and Hct were significantly decreased after the training period (Table 3). Changes in BV and PV values were calculated to be  $+4.9 \pm 4.6\%$  ( $p < 0.05$ ) and  $+6.4 \pm 8.0\%$  ( $p < 0.05$ ), respectively. Only one of the 14 subjects showed reduced volumes.

### Correlation analysis

The training volume ( $19.2 \pm 3.9$  h) of the six-day training period was significantly related to the following parameters measured in Test 2:  $T_{2000}$  ( $r = 0.63$ ),  $P_{2000}$  ( $r = -0.62$ ),  $\text{VO}_2\text{max}$  ( $r = -0.65$ ), body mass ( $r = -0.70$ ), and subjective ratings of fatigue ( $r = 0.52$ ) and muscle soreness ( $r = 0.53$ ). The measured blood parameters were not significantly correlated with the training volume ( $r < -0.44$ ;  $p > 0.05$ ). The change between tests in the mean HR demonstrated significant



Table 2. Morning HR, body mass and subjective ratings of quality of sleep, fatigue, stress, and muscle soreness before and after the training period (Mean  $\pm$  SD).

	Test 1	Test 2
HR (beats $\cdot$ min <sup>-1</sup> )	56.8 $\pm$ 9.9	57.6 $\pm$ 10.4
Body mass (kg)	81.6 $\pm$ 9.6	81.5 $\pm$ 9.6
Sleep	3.3 $\pm$ 1.4	3.4 $\pm$ 1.6
Fatigue	3.1 $\pm$ 1.2	3.9 $\pm$ 1.3*
Stress	3.1 $\pm$ 1.7	3.3 $\pm$ 1.7
Muscle soreness	3.1 $\pm$ 1.5	3.8 $\pm$ 1.4*

HR, heart rate

\* Significantly different from Test 1;  $p < 0.05$ .

Table 3. Morning blood parameters before and after the training period (Mean  $\pm$  SD).

	Test 1	Test 2
RBC ( $10^{12} \text{ l}^{-1}$ )	4.9 $\pm$ 0.2	4.7 $\pm$ 0.2*
Hgb (g dl <sup>-1</sup> )	14.9 $\pm$ 0.6	14.3 $\pm$ 0.6*
Hct (%)	43.4 $\pm$ 1.7	42.3 $\pm$ 1.8*
MCV (fl)	88.8 $\pm$ 2.9	89.7 $\pm$ 3.1

RBC, red blood cell count; Hgb, hemoglobin; Hct, hematocrit; MCV, mean corpuscular volume

\* Significantly different from Test 1;  $p < 0.05$ .

correlations to the changes in BV ( $r = -0.48$ ) and PV ( $r = -0.55$ ). In addition, the change in the mean HR correlated significantly to the changes in blood parameters of Hct, Hgb, RBC and MCV ( $r > 0.48$ ). The change in mean HR was also significantly related to the changes in subjective ratings of fatigue ( $r = -0.57$ ) and muscle soreness ( $r = -0.49$ ).

## Discussion and conclusions

The main diagnostic criterion of overtraining has been reported to be a significant decrease in performance capacity, without a return to baseline after a sufficient period of rest (Lehmann et al., 1993; Hooper et al., 1995). The decrease in rowing performance as illustrated by the significant increases in  $T_{2000}$  and decreases in  $P_{2000}$ , mean HR and blood lactate concentration values (see Table 1) was thought to reflect a state of fatigue or maybe overreaching in our subjects. However, it has to be considered that success in rowing is characterized by the amount of time spent on water as low-intensity endurance training (Steinacker et al., 1998; Jürimäe et al., 2000).

The results of our study indicate that self-reported mood state indices can be used for the diagnosis and monitoring of overreaching in

rowers. However, only few investigations have focused on self-assessment by the athletes themselves for monitoring overreaching and overtraining (Lehmann et al., 1991; Hooper et al., 1995; Bosquet, Leger, & Legros, 2001). In addition, different questionnaires have also been used to assess training stress in athletes (Kellmann & Günther, 2000; Bosquet, Leger, & Legros, 2001). However, questionnaires cannot be used on a daily basis to monitor the effect and recovery of high volume training loads. This study aimed at identifying the specific inquiries that could be used on a daily basis to monitor training stress during a period of dramatically increased training volume in rowers. The self-rated inquiries of fatigue and muscle soreness demonstrated a close association with the increased training time ( $r > 0.52$ ;  $p < 0.05$ ). However, it must be considered that the capacity of such measures to identify potentially overtrained athletes is very much dependent on the data interpretation by the reviewer (e.g. coach) (Hooper & Mackinnon, 1995; Hooper et al., 1995). Although the reliability of the self-assessment scores is questioned, it appears that the daily recording of mood state may provide useful information for the coach.

Similarly to our results, body mass has been reported to remain unchanged in cases of presumed overreaching in endurance events (Dressendorfer, Wade, & Scaff, 1985; Kuipers & Keizer, 1988; Lehmann et al., 1991; Hooper & Mackinnon, 1995). An increase in the morning resting HR may be absent (Kuipers & Keizer, 1988; Lehmann et al., 1991) or only slight (Dressendorfer, Wade, & Scaff, 1985) during overreaching in endurance athletes. Morning resting HR values in our group of rowers were also not affected by a short-term overreaching training period (see Table 2). Loss of body mass and increase in morning resting HR have been reported to be symptoms of overreaching mainly in speed and power athletes (Hooper & Mackinnon, 1995).

Another important finding of this study was that the measured blood parameters and HR values were not significantly correlated with the increased training time, although changes were significant at the end of the six-day overreaching training period (see Tables 2 and 3). In agreement with our results, it has been suggested that such blood variables as Hgb, Hct and RBC values have a smaller diagnostic capacity in short overexertion periods (Lehmann et al., 1991; Hedelin et al., 2000). The decrease in Hgb, Hct and RBC in 13 of the 14 athletes

is likely to be a consequence of an increased PV as demonstrated in other studies (Kirwan, Costill, Houmard, Mitchell, Flynn, & Fink, 1990; Sawka, Convertino, Eichner, Schneider, & Young, 2000). Thus, it appears difficult to distinguish normal changes occurring during training from the abnormal changes associated with the syndrome of overtraining by using different physiological parameters. Similarly to our results, it has been reported that many physiological parameters change in the normal response to intensive training (Hooper et al., 1995; Sawka et al., 2000).

The reduced mean HR values (by 2 to 10 beats·min<sup>-1</sup>) during maximal 2,000 metre ergometer rowing in Test 2 could be attributed to an exercise-induced hypervolemia leading to an increased stroke volume and maintenance of cardiac output with lower HRs (Hedelin et al., 2000). In turn, the increased stroke volume compensates for the reduced arteriovenous oxygen difference due to dilution (Kanstrup & Ekblom, 1984). Furthermore, the reduced HR values can also be attributed to an increase in the stroke volume as a significant relationship was observed between changes in HR and BV values as a result of the six-day training period ( $r=-0.48$ ;  $p<0.05$ ). This demonstrates that changes in HR values during maximal exercise might be a good tool for the evaluation of intraindividual performance changes on a weekly basis during intense training periods in rowers.

Reduced blood lactate concentrations after maximal exercise have been reported previously and attributed to the depleted glycogen stores

in overtrained athletes (Hooper & Mackinnon, 1995). This was also the case in our study (see Table 1). Maximal blood lactate values have been suggested as markers that can distinguish between overtraining and overreaching in long endurance events (Bosquet, Leger, & Legros, 2001). In contrast, it has been reported that factors unrelated to overtraining may influence maximal blood lactate levels (e.g. diet) and inconsistent changes have been found in overtrained athletes (Hooper et al., 1995). In this study, an increased training volume was not related to the measured maximal blood lactate level after the maximal 2,000 metre rowing ergometer test in Test 2. Further studies using sufficient rest periods after an overreaching training period are necessary to evaluate the suitability of maximal blood lactate as a marker of overreaching in rowers.

The reduced maximal performance in rowers was interpreted to reflect a state of fatigue or maybe overreaching. According to the results of the present study, the most appropriate and simple method for monitoring a short-term overreaching training period is self-analysis of mood states using daily training logs. Comprehensive physiological testing is less sensitive to the dramatic increase in the training volume of rowers. At present, it appears that self-analysis by the athlete who trains with high training loads is the most efficient method of monitoring any possible short-term overreaching. Long term daily records of self-analysis can be kept with relative ease and compared with the more sophisticated physiological methods when necessary.

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# STRES KAO POSLJEDICA NAPORNOG TRENINGA VESLAČA - UTJECAJ NA CIRKULACIJSKE ODGOVORE I PROFILE RASPOLOŽENJA

## Sažetak

### Uvod

Sindrom pretreniranosti definira se kao dugoročno sniženje kapaciteta za sportske rezultate uzrokovano nakupljanjem trenažnog i izvantrenažnog stresa. Pretreniranost se javlja kao odgovor na velike volumene trenažnih opterećenja i/ili visoke intenzitete treninga uz neadekvatne periode oporavka između pojedinačnih treninga. Brojni pokazatelji pretreniranosti i preopterećenosti (overreaching) izdvojeni su na temelju različitih fizioloških i psiholoških parametara. Svrha ovog istraživanja bila je istražiti učinke kratkotrajne preopterećenosti na cirkulacijske odgovore i parametre raspoloženja kod veslača.

### Metoda

Uzorak ispitanika činilo je 14 veslača, natjecatelja na nacionalnoj kvalitetnoj razini ( $18.6 \pm 2.0$  godina,  $186 \pm 5.7$  cm,  $82.4 \pm 6.9$  kg) koji su praćeni za vrijeme šestodnevnih priprema. Volumen treninga tijekom šest dana narastao je do  $19.2 \pm 3.9$  sati, što odgovara povećanju trenažnog volumena za otprilike 100% u usporedbi s njihovim prosječnim tjednim trenažnim opterećenjem u prethodna četiri tjedna. Ukupno, provedeno je 12 pojedinačnih treninga u eksperimentalnom periodu s preopterećenjem, za razliku od 6 takvih pojedinačnih treninga u četiri tjedna koja su prethodila pripremanju. Osamdeset i pet posto ukupnog trenažnog volumena otpadalo je na trening izdržljivosti nižeg intenziteta (veslanje ili trčanje), 5% na anaerobni trening visokog intenziteta (veslanje) i 10% na treninge s otporom. Maksimalni test veslanja 2000 m na veslačkom ergometru proveden je prije (test 1) i nakon (test 2) šestodnevnog perioda treninga. Ispitanicima je bilo dozvoljeno da lagano treniraju ili da ne treniraju uopće to popodne kada se provodilo finalno testiranje. Uzorci krvi prikupljali su se na svakom jutarnjem treningu. Ranojutarnja tjelesna težina i frekvencija srca pratili su se svakog dana. Osim toga, od veslača se tražilo da svaki dan sami procijene kvalitetu spavanja, umor, stres i bol u mišićima na skali od 1 do 7 (1 - vrlo, vrlo malo, 7 - vrlo, vrlo jako).

### Rezultati

Wilcoxonov test ekvivalentnih parova korišten je za usporedbu rezultata prvog i drugog testiranja. Izračunat je Spearmanov koeficijent korelacije. Za sve testove utvrđena je razina značajnosti od 0.05. Vrijeme veslanja na ergometru na 2000 m poraslo je sa  $395.9 \pm 10.8$  s na  $404.2 \pm 11.9$  sekundi zajedno s opadanjem snage sa  $361.9 \pm 28.5$  W na  $349.0 \pm 32.8$  W. Koncentracija laktata u krvi, mjerena pet minuta nakon provedenog testa, smanjila se (sa  $19.2 \pm 2.9$  na  $16.2 \pm 2.3$  mmol $^{-1}$ ), kao i frekvencija srca (sa  $184.6 \pm 7.5$  na  $179.2 \pm 7.4$  otk $^{-1}$  min $^{-1}$ ). Maksimalni primitak kisika ostao je nepromijenjen. Subjektivna ocjena umora i boli u mišićima povećala se, a i pokazalo se da je povezana s razinom trenažnog volumena ( $r > .52$ ). Parametri iz krvi, kao što su broj crvenih krvnih stanica, koncentracija hemoglobina i hematokrita, smanjili su svoje vrijednosti, dok su volumen krvne plazme i volumen krvi bili povećani nakon trenažnog perioda. Varijable krvnih parametara nisu pokazale povezanost s trenažnim volumenom ( $r < -0.44$ ,  $p > 0.05$ ). Promjene u testovima prosječnih vrijednosti frekvencije srca pokazale su povezanost s promjenama u volumenima krvi ( $r = -0.48$ ) i plazme ( $r = -0.55$ ).

### Rasprava i zaključak

Smanjenje maksimalnih rezultata kod veslača interpretiralo se kao odraz premorenosti, možda i preopterećenosti. Prema rezultatima ovog istraživanja mogli bismo reći da je najprikladnija metoda za praćenje kratkotrajnog trenažnog perioda preopterećenosti samoanaliza raspoloženja uz korištenje dnevničkih bilježaka o treninzima. Sveobuhvatno fiziološko testiranje manje je osjetljivo na dramatično povećanje trenažnog volumena kod veslača.

Za sada se čini da je samoanaliza sportaša, koji je podvrgnut visokim trenažnim opterećenjima, najučinkovitija metoda za praćenje moguće kratkotrajne preopterećenosti. Dugoročno vođene dnevničke samoanalitičke bilješke mogu se jednostavno čuvati i uspoređivati sa sofisticiranim fiziološkim metodama za procjenu pretreniranosti kada je to potrebno.

# SPORT MANAGEMENT: VARYING DIRECTIONS TOWARDS THE NARRATIVE

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## Abstract:

Until now sport managers have had difficulties in identifying core issues that form the framework for successful sport management practice. The purpose of this study was to explore what sport managers believe are the core issues that can contribute to successful sport management practice. This was achieved through an examination of the narrative experiences of 7 sport managers (4 male and 3 female) that highlighted how narrative can be used to enhance a sport manager's understanding of their work environment through critical reflection. Through this examination the overriding issues that the participating sport managers believed provided a unique insight into their everyday lives centered on: (1) experience and power, (2) accountability; (3) demands of the job; (4) professional development; (5) ways of knowing; (6) collegiality; and (7) critical reflection.

This narrative approach to understanding the lived experiences of sport managers allowed the researchers to connect theory with experience and to establish a relationship between daily practice and knowledge. Understanding the lived experiences of sport managers in this way can allow sport managers to establish new insights into how they interact with their sport organizations and the individuals and communities they serve in their daily operations.

The following paper concludes by suggesting that through an increased interest in narrative as a way of knowing the stories disclosed may move other sport managers to share their own stories and experiences to assist in framing their own identity. Moreover, by prompting other sport managers to tell their stories, a deeper understanding of how professionals continue to grow and advance their sport management knowledge may be promoted. These narratives also taught us about deepening and extending our understanding of how sport managers construct meaning. In this way, new insights may be derived about the practice of sport management and how important it is to adding new knowledge for the discipline.

*Keys words:* core issues, critical reflection, demands of the job, professional development, job identity

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## SPORTMANAGEMENT: UNTERSCHIEDLICHE ANLEITUNGEN ZUM ERZÄHLEN

### Zusammenfassung:

Bis jetzt hatten die Sportmanager Schwierigkeiten mit der Erkennung der Kernfragen, die den Rahmen für eine erfolgreiche Managementpraxis darstellen. Die Absicht dieser Studie war zu untersuchen, was, nach der Meinung von Sportmanagern, die Hauptvoraussetzungen sind, die zu einer erfolgreichen Sportmanagement-Praxis beitragen können. In der Untersuchung wurden 7 Sportmanager (4 Männer und 3 Frauen) gebeten, über ihre Erfahrungen zu sprechen, was die Rolle der mündlicher Aussage bei der Vertiefung ihres Verständnisses der Arbeitsumgebung durch kritische Reflexion hervorhebt. Die vorrangigen Probleme, die gemäß der tätigen Sportmanager einen einzigartigen Einblick in ihr Alltagsleben gewähren sind folgende: (1) die Erfahrung und Macht (2) die Verantwortlichkeit; (3) die Jobanforderungen; (4) die berufsbezogene Entwicklung; (5) die Art und Weise des Kenntniserwerbs; (6) die Kollegialität; und (7) die kritische Reflexion.

Dieses erzählungsbezogene Verfahren, das darauf gerichtet wird, zum Verständnis der Alltagserfahrungen der Sportmanager zu gelangen, machte es den Forschern möglich, die Theorie mit der Erfahrung zu verknüpfen, sowie neue Einblicke in ihre Zusammenarbeit mit den sportlichen Vereinen, mit den Individuellen und den Gemeinschaften, denen sie in ihrer alltäglichen Tätigkeit dienen, zu gewinnen.

Die nachfolgende Studie schließt mit dem Vorschlag, das, durch ein erhöhtes Interesse für das Erzählen als eine Art vom Verständnis, die erzählten Geschichten die anderen Sportmanager dazu veranlassen könnten, ihre eigene Geschichten und Erfahrungen mitzuteilen, was zur Gestaltung ihrer Identität verhelfen könnte. Außerdem, wenn man andere Sportmanager dazu auffordert, ihre Geschichten zu erzählen, kann man es besser verstehen, wie sich die Profis weiterentwickeln und wie sie ihre Fachkenntnisse erweitern. Diese Geschichten waren auch eine Lehre für uns, indem wir unser Verständnis vertieft und erweitert haben, wie die Sportmanager die Bedeutung erfassen. Daraus kann man neue Einblicke in die Sportmanagement-Praxis bekommen und neues Wissen dieser Disziplin beitragen.

**Schlüsselwörter:** Kernfragen, kritische Reflexion, Jobanforderungen, berufsbezogene Entwicklung, Jobidentität

## Introduction

Our group came together for the first time in 2001. Ranging in experiences from a thirty-year sport administration veteran to a recent graduate, the group of three females and four males (not including the researchers) became a close-knit group, willing to meet once a month to converse and share ideas on sport management. The experiences and stories of this particular group uncovered many rich perspectives and this series of narrative events evolved over approximately ten (10) months in different locations. Described here are the overriding issues and unique perspectives that were problematic for everyone. In the words of Maxine Greene (1995, p. 198), we tried, as a group, to “attend to the plurality of consciousnesses – and their recalcitrances, their resistances, along with their affirmations, their songs of love,” in order to make meaning of the issues before us. Our motivation for assembling this group was to explore the potential for further professional development of sport managers by having them meet with fellow sport practicing professionals to discuss and reflect on their practices.

Epistemologically, we sustained one another through group support, communication between meetings, celebration of one another's successes and personal invitations to each others' workplaces. There were various reasons why people had chosen to join the group. The most evident was expressed by Anne and echoed by others:

“Actually one of the reasons I don't mind doing this is because it forces me to be more reflective and during my working life I don't do it as much as I should”.

The need for comparing ideas, sharing experiences, and getting up to speed on new developments seems critical. Within the context of sport development David describes the conversations in a group meeting this way:

“I'm very glad to get an opportunity to learn different perspectives but I also like to

go beyond my own sport organization. I think that's very important so that you don't just see the attitudes and the mind sets of the people in your sport”.

The stories these sport managers told were rich, colorful descriptions of their complex roles and argued that the learning never stops. As Steve indicated:

“I think the one critical piece that I came to learn, as a sport manager, is that you don't have to be the one with all the answers. All you need to do is ask the right questions and to facilitate the processes. It took me a long time to learn that. I used to think I had to have all the answers and I had to show everyone how to do it, but then I learned that all you have to do is ask the right questions”.

However, before exploring the experiences and stories of these individuals further it is necessary to classify and distinguish how narrative is defined. The reason for this is that because sport management research narratives should not be seen as merely anecdotal or casual accounts of the research participants, but involve a blending of theoretical with empirical or experiential materials. Thus, a narrative approach to sport management research allows the researcher to connect theory with experience and to establish a relationship between daily practice and knowledge. Understanding narrative in this way can allow sport management researchers to establish new insights into sport organizations and the individuals who are responsible for their effective operation.

## Defining story, narrative and voice

It is important if narrative is to become a genuine focus for sport management research inquiry that it is adequately defined and delimited. However, in order to do this the meaning of the associated concepts of story and voice must also be addressed.

The term *story* refers basically the “to discussion of particular situations” (Clandenin & Connelly, 1994, p.125). According to van Dijk (1997, p. 123), the relevant properties of stories are that:

- they are primarily about (past) human actions and perceptions although also descriptions of other events, objects, places or circumstances may be part of the stories, for example, as conditioned or consequences to human action.
- they are usually about events and action that are (made) interesting for the audience. This ‘pragmatic interestingness’ is usually obtained by the account of events or actions that are unexpected, deviant, extraordinary or unpredictable, given the knowledge and beliefs of the audience.
- they are usually told to entertain the audience. For example, by influencing their aesthetic or emotional reaction. However, stories may also have broader social, political or cultural functions or play a role in the argumentative schema.
- they may be told from different perspectives or points of view, may feature the storyteller as a participant or not, and may be realistic or fictitious.

There is something impermanent, perishable and exploratory about a story. Stories are not always of course spoken, though the ‘short story’, the ‘tale of detection’, the yarn, terms that refer to literary forms, represent a sophisticated and specialized usage. Within the sport management research context stories are almost always less finished, less formal and less deliberated than the narrative. From this distinction some others follow. Stories and tales are casual, informal and contingent. Narratives are premeditated, organized, formal and have a structure that is their own.

The term *narrative* - though it refers to spoken and informal discourse - reflects the professional and conceptual processes through which the original material (the story or stories) has been put. The real point of this is that narratives should contain a reflective or theoretical component. It may not be overt, but the shaping and organization of a narrative will usually reflect and transmit the consequences of a meditative or generalizing process of thought. Narratives do not exist as Bruner (1991, p. 8) wrote:

“... in some real world, waiting there patiently and eternally to be veridically mirrored

in a text. The act of constructing a narrative moreover, is considerably more than selecting events either from real life, from memory, or from fantasy and then placing them in an appropriate order. The events themselves need to be constituted in the light of the overall narrative.”

To construct a narrative is to make an intervention into a field conceptualized (whether fully consciously or not is insignificant) as problematic. It is to address issues, though these are not addressed directly, but through the selection and arrangement of material.

Narrative is thus a reflective practice whereas story is not. And because it is a reflective practice narrative is connected with authority. The ‘narrator’ is automatically endowed with power, with control over the material he or she presents, a power that flows to him or her through the position as organizer of the material. In moving from *story* to *narrative* it has become part of a reflective, self-conscious and intervention process. In other words, to construct a narrative requires abstract thought. To write a narrative requires intellectual commitment and energy. Moreover, the construction of a narrative involves mediation upon social and ethical issues.

### Voice

There is a related term that must be discussed – the term of *voice*. Along with story and narrative it is presently in vogue, though this time its antecedents are not with ‘postmodern theorists’ but with the Russian literary critic and philosopher, Mikhail Bakhtin. Sometimes *voice* is used synonymously for *story*, at other times it means ‘professional knowledge or orientation’. When one calls writing a *voice* one is enlisting the residual power of this tradition to give power to the group or individual concerned. The term *voice* tends to carry with it unconsciously the assumption that the group has a natural authenticity, is identical to itself, uncontaminated by the language and values of other usually more dominant groups.

But as Jacques Derrida (1981) insisted, the meanings given by the living voice depend upon a process of differentiation between signs, in this case sound signs, as much as writing does. Speech can, no more than writing, be said to be a transparent medium of subjective experience. The term *voice* lays claim to this by its own independent natural authority. But in fact no language is like this, and no voice is unproblematically free from or uncontaminated

by the terms, values or concepts of others. When the term *voice* is used in reference to what is in practice writing, we have a rhetorical trope whose complicated elision of these points is quite different from the supposed innocent directness that it is simultaneously claiming. *Voice* thus collaborates with *story* in valorizing that which is unpremeditated and apparently unmediated, but the term is in fact involved in quite complicated contestations and valorizations of meaning. It carries much the same meaning as 'representation' in the political sense, but without the separation between origin and signifier that 'representation' always insists upon.

As the story goes the narrative use of the individual's voice is perhaps one of the most important issues relating to research utilizing the narrative perspective. Indeed, few traits of current biographies are more firmly entrenched than the conventional use of the individual's voice. Past research, (Alvesson, 1993; Goodson, 1991; Schratz, 1993) has attempted to throw light upon the issue of the voices of marginalized groups within the society. In point of fact in recent years 'many researchers have become disenchanted with the academic process of noise reduction' (Schratz, 1993, p. 1) by suppressing the more disturbing aspects of representing the individuality of human interaction. Academics such as Ball (1989), however, began to lead researchers to break down some of the established conventions of objectivity and highlight issues such as gender, race, homophobia, and socio-economic class by representing the marginalized voices within culture. Some have argued that at times Ball (1989) enters into a dialogue with the respondent. Consequently, a distinction must be drawn here between *dialogue* and *voice*. As Ruddick (1993) remarked:

"Dialogue is a part of social convention where rules underwrite the possibility of speaking and being heard: turn taking offers more promise of equality". (p. 8)

She continued by referring to voices being:

"... emotive more disembodied, more disturbing. At one level they can 'represent' individuals or groups who have been denied the right to contribute or who have simply not been heard". (p. 8)

The issue of voice can be well represented by narrative writing and the use of narratives as "frequently embedded exemplars - concrete

situated examples of action" (Witten, 1993, p. 107) as told by the marginalized individual. In this manner the stories of narrative are thus "the stories of everyday life" (Clegg, 1993, p. 32) and more importantly the stories of everyday people's voices, like those of sport managers.

Narratives "are embedded so deeply in culture and everyday life" (Nakagawa, 1993: 145) that it could be argued that the configuration of language indicates a profound pursuit for storytelling, which appears as a basic instinct common to all human life. Indeed, Nakagawa, (1995) remarked that language utilized in narrative has become so sedimented and 'natural' in our daily experience that only rarely, if ever, do we consider how they construct, legitimate, and perpetuate a particular order of coherence and sense-making. In summary narratives indicate a "major discourse genre for reproduction" (Van Dijk, 1993, p. 125) of individual or group voices.

### Narrative and reminiscing

When engaged in narrative research the researcher can be accused of using prior knowledge by reminiscing about their own life experiences. Sparkes (1995) referred to this process as 'narrative of self' (p. 175). Porter and Washington (1993) remarked "the individual is not admitting to the self that he/she is denying the existence of things prior" (p.149). However, the self should be prepared to accept a situation of neutrality before the research begins. Consequently, the sport manager's life could be interpreted in the context of a narrative report and the act of reminiscing also becomes an important tool for representing the narrative of the manager's life. In other words, the act of reminiscing can have a major effect on the final production of the narrative. Furthermore, and perhaps more importantly, reminiscing is the precursor to reflection which requires a deeper form of thought. Another form of interference in the narrative comes from the acceptance of nostalgia. This can also function as an important perspective in the act of reminiscing. Thus, the nostalgic or positive thoughts of the past may lead some respondents to reminisce and over-emphasize the nature of certain points in the narrative. When this happens, if the researcher has experienced similar occurrences, the passage of narrative might take on a stronger significance than warranted within the text. Porter and Washington (1993) went further and argued that:



“... the very implicitness of nostalgia leads one to assume that, previous knowledge and experience must affect the context and overall development of the narrative account of an individual’s life or voice”. (p. 151)

In short, nostalgia must therefore have some influence over the ‘truth’ of the narrative.

### **Narrative and truth**

Through the use of narrative language and dialogue researchers can make courageous and convincing pronouncements that can be camouflaged from finite inquiry and interrogation. Witten (1993) also believes this is true because of the “cognitive and psychological effects of stories on listeners” (p. 105). It could be argued that narratives render the listener susceptible to having their attention caught by often provocative speech or through tone of voice, tense, and vivid and concrete details whereby plots and episodes are unfurled (McLaughlin, 1984). The importance of these salient narratives is likely to be retained and persist over time, for as Martin (1982) suggested immediate language is memorable. Consequently, narratives can have a powerful impact and plausible persuasive effects on the listeners. In addition, the unparalleled strength of narrative talk stems from its ability to state claims of truth which are shielded from testing or debate in the memorable and persuasive text. As Jefferson (2000) suggested the rules of narrative - the conventions of the game - make it difficult for a listener to question the narrative’s content. Witten (1993) supported this comment by stating that:

“The presumption, encased in narrative, is shielded from testing or debate; it is a claim to validity that denies the need for justification or proof. In short, the narrative is a powerfully persuasive, presumed claim to truth and correctness that is not ordinarily subject to challenge”. (p. 107)

So how can we be sure that the *narrative* has been written correctly and does not falsify the *truth*? It appears as though all the normal conventions of interpretative research are followed when writing the narrative, cross-checking by the use of triangulation and rereading by the subject can counteract any contradictions of the truth. However, if working in isolation or of a clandestine nature the narrative discourse utilized often relies on its ‘truth’ by the reputation of the writer.

## **Methods**

### **Applying narrative research**

Typically, in qualitative research methodology, the researchers try to listen first to the practitioners’ stories. However, in our research effort, we tried telling and responding to one another’s stories concurrently so that we could reflect a sincere effort to listen to all the participants. Thus, our shared story began to evolve with all our voices enacting it. Because we were able to expand on and extend another’s stories by adding our own experiences and reflections, the story became richer and more meaningful for us.

By sharing stories, and remaining open to the variety and eloquence of others’ stories, we pursued a narrative reflection on practice that Schon (1983) discussed as critical to professional development. Our conversations were marked by a feeling of equality that allowed each of us to establish freely the form we were comfortable with and to share the content of our experiences (Oakley, 1981). We gathered together for this project in a climate of respect and mutual trust. In our conversations, we learned trust, confidence, and the critical importance of the relationship in human interactions (Noddings, 1984).

In choosing to share experiences as sport managers, our group focused on the taken-for-grantedness of our roles. We were in agreement that the text of sport management professional development was in need of revision. Its one-dimensional, single perspective stories told in a distant, authoritative language of expertise no longer represented our understanding of the multiple realities of today’s sport management practice. In our own collaborative way, by slowly uncovering our stories, we began to reflect on our day-to-day actions. We learned from each other’s successes and failures. Our efforts of coming together, listening attentively, and responding to each other’s stories created in us a stronger, more meaningful connection to one another and fostered our growth as a professional community.

As we participated in sharing stories, the more reflective we became about the construction of personal knowledge. Personal experiences – inward feelings, hopes, and reactions, external conditions of reality and context all tempered by a timeframe - helped us to reconcile the importance and relevance of our stories. This is evidenced by the remarks of Steve, he stated:

“Each of us have our own biography of experiences that impact on our sport management practices”.

Anne agreed and added:

“I think your experiences as a administrator gives you a lens through which you view particular events and incidents and that informs your reaction”.

The group therefore came to realize that there is not one individual knowledge, but a variety of competing *knowledges*, each of which is developed within a specific cultural, professional or institutional framework.

### Researchers as participants

One of our difficulties in carrying out this collaborative research project had to do with gaining an understanding that we were collaborating together. Our role as researchers in this group was relatively undefined. We wanted to be viewed as participants and not necessarily as researchers. As researchers we went into every group not sure what would transpire. We took the role of participants purposely in order to level the landscape and encourage everyone to feel a part of the whole.

Although it took time the group eventually viewed us as participants as well as researchers. This was supported by the comments of Paul, he stated:

“At the beginning I saw you guys as the researchers, but as we journeyed through it, I began to see you more and more as a part of the group, especially because you were very amenable to keep meeting even after the main part of your research was done. You felt, we can still keep going with this, and this was a support to us”.

Anne added her thoughts:

“I saw you as members of the group, because you often talked about your experiences, reliving and revisiting incidents. ...I've been in that position: I've had to suffer through this myself. This is what I did.' No, I didn't see you as someone sitting outside watching the group and writing up their scientific notes, sitting above or beyond the group, but rather, very much a member of the group”.

In their article, “Working in the Interpretive Zone”, Wasser and Bresler (1996) commented on the importance of the researcher's presence and how the interactions of the researcher with the participants serve to shape study outcomes. This shift, they say, is occurring in tandem with the increasing recognition of the collective nature of knowing and our greater

attention to social theories of development. By working in “the interpretive zone” (Wasser & Bresler, 1996), multiple voices and viewpoints were encouraged, and participants had an opportunity to bring together their different kinds of knowledge, experiences, and beliefs, hopefully forging new meanings through the process of joint inquiry.

Christine shared her insights on the relaxed boundaries of the group:

“I see all of us in the group. I considered you to be part of the group. You were the researchers but at the same time you were part of the group. It wasn't like we were the group and you were taping the group”.

Less important, but not entirely without problems, the question of the researcher or participant is an important issue to examine after the fact. There were some difficult moments as researchers/participants. We were reticent to speak out or in any way try to lead the group. This was problematic because there were moments when we floundered and needed some direction. At these times, we felt we had to step in and give more shape to the events. Other times we felt the concern as researchers that one person or another was taking too much time in the group. Part of us, as researchers, wanted to end the conversation and move on to other issues, while part of us, as participants said we had no right to think that.

### Discussion

This section discusses the core issues that contribute to successful sport management practice. It draws on the narrative experiences of 7 sport managers (4 male and 3 female) to provide a unique insight into their everyday lives and experiences.

### Experience and power

According to Castells (1998), experience is the:

“... action of human subjects on themselves, determined by the interaction between their biological and cultural identities, and in relationship to their social and natural environment and it is constructed around the endless search for fulfillment of human needs and desires”. (p. 15)

Moreover Castells (1998) argued that experience is part of the social structure of society together with power and production. Foucault (1979) explained that power permeates society as a whole, and it constrains individual space

into a well-knit grid of official tasks and informal aggressions.

“This political investment of the body is bound up, in accordance with complex reciprocal relations, with its economic use, it is largely as a force of production that the body is invested with relations of power and domination; but, on the other hand, its constitution as labor power is possible only if it is caught up in a system of subjection (in which need is also a political instrument meticulously prepared, calculated and used): the body becomes a useful force only if it is both a productive body and a subjected body”. (p. 26)

Foucault (1979) explained that there might be knowledge of the body that is not exactly about how it functions but rather about how to dominate it. This he calls the “political technology of the body” and it consists of “micro-chips” that form a set of tools to subtly dominate (p. 26). Institutions then implement “a micro-physics of power”, which are “dispositions, maneuvers, tactics, techniques, functionings, that one should decipher into a network of relations (p. 26). “Micro-powers” deal with strategic positioning of the player (privileged and/or dominated): and they are not unidirectional/univocal: “they define innumerable points of confrontation, focuses of instability, each of which has its own risks of conflict, for struggles, and of an at least temporary inversion of the power relations” (p.26). Knowledge of these dispositions, maneuvers, tactics, techniques, and functionings becomes power-knowledge; knowing how to play the game to one’s advantage. As Foucault (1979: 28) suggested:

“It is not the activity of the subject of knowledge that produces a corpus of knowledge, useful or restraint to power, but power-knowledge, the processes and struggles that traverse it and of which it is made up, that determines the forms and possible domains of knowledge.”

In learning to tell, to listen, and to respond, we ultimately began to uncover significant consequences particularly associated with issues of power. Anne provided the initial comments that began this discussion. She stated:

“I think the picture of the sport manager is changing too. As short a time as I’ve been in this, it’s changing our relationships too. I find what used to be decisions of the Chief Executive are no longer decisions exclusively of the boss”.

David took the discussion further and suggested the power dynamics had also changed. He commented:

“Sometimes that hits you in the face. When somebody comes and says, ‘Is it all right if I do this?’ I’ve had that experience where I think, ‘Why are they asking me that?’ Do they feel that they need my approval? Because you’re hoping that you’ve created a situation where they feel more independent. But sometimes that question comes and hits you every now and again. It makes you stop in your tracks and think”.

Paul commented on his experience as a ‘boss’:

“Some people see you as the boss. The “boss”, a ubiquitous term that is heard far too often and in ways that are often uncomplimentary. One of the hardest things that I’ve coped with is just being willing to admit that I don’t know or don’t have a skill in that area. Yet, I think that has been a very freeing thing for staff, because it has given them freedom to not know everything in all areas”.

Anne spoke for the whole group when she stated:

“Whether we realize it or not our experience and role give us certain power in our organization that we are not always aware of and that power can work for and against us”.

David agreed and added:

“I think because of our role we have certain knowledge which is not available to others in our organizations which reinforces our power”.

The group accepted however, that despite their positions and experiences justifying the power they held within their organizations, the issue of accountability was a consequence of having power.

## Accountability

A constant theme in our series of conversations was the theme of accountability. Accountability was central to the way each participant structured their understanding of their jobs. In its simplest form accountability was seen as a relationship in which people were required to explain and take responsibility for their actions.

As Anne indicated:

“Accountability is about accepting responsibility for acting responsibly”.

Steve added:

“Accountability provides for an account of efficiency and effectiveness of management”.

David recalled a definition of managerial accountability from his Master of Business Administration (MBA) studies program. He commented that:

“Accountability defined within a managerial model requires those with delegated authority to be answerable for producing outputs or the use of resources to achieve certain outcomes”.

David added that managerial accountability is about the:

“... nuts and bolts of sports administration like delivering the budget and developing a strategic plan”.

Each of us agreed that often the sports administrators become the “meat in the sandwich” or the “sacrificial lamb” for decisions that can be judged with expediency of hindsight, as “not the best option”.

Discussions indicated an understanding that accountability also involved professional and personal accountability. With respect to professional accountability David suggested:

“Professional accountability invokes the sense of duty we have as sports administrators”.

Christine added:

“It’s not our responsibility to ASSA [Australian Society of Sports Administrators] which I see as meaningless but to the professionalism we have amongst ourselves”.

This comment evoked a consensus about personal accountability. As Steve suggested:

“Personal accountability is based upon my belief that I respect the rights of others and act in a way that doesn’t unduly affect others’ lives”

Christine added:

“It may be a little passé in today’s business world but I believe that there is a strong need for effective sports administrators to adhere to their own set of moral and ethical values”.

Each of us agreed that accountability is an intersection of managerial, personal and professional demands. Another constant theme of discussions within the group was the “demands of the job”.

### **Demands of the job**

The demands on sport managers have traditionally been very high (Shilbury, 2001; Smith & Stewart, 1999). In an era that has now embraced a more professional approach to the management of sport organizations volunteers are still a vital component of the human resource pool (Cuskelly, 1995). However, the introduction of paid professionals into the field has created

a situation where many club members believe paid staff should be responsible for nearly all the operational facets of the organizations. These demands are reflected in the comments of Anne, who stated:

“It’s hard, because we have so much to do. It’s a very demanding job”.

Christine supported this statement and noted that:

“There are so many evening commitments that are related to the job. You’re going back in the evening for this, that, and the other thing”.

Paul added:

“We are ‘meetinged’ (*sic*) to death! We’re sitting on committees that basically do nothing but because it’s related to the sport, and you are paid, you must go”.

Anne was concerned about the demands of the job on her health. She stated:

“How do you take care of yourself in that situation? Do you say, ‘I’m not going in till noon tomorrow?’”

Michael concurred but was more concerned about the perceptions of others if he was not the first to arrive at work. He elaborated:

“I came in at 2.05 p.m., after several meetings consecutively and one assistant said to me, ‘Good morning! Where have you been? You sure have started your day late’. I said, ‘Maybe I was not here, but I can assure you I started my day earlier than you did’.

Joan joined in with her views:

“But the workaholic’s attitude is that the best person is the one that comes in at six in the morning and stays until ten at night. Now, that’s your best administrator, because they’re so dedicated. But they’re not alive!”

Steve continued the discussion, and stated:

“Often you don’t even know who you are, know what you feel, what you care about, or even if you had a shower in the morning. I think you get to the point where you don’t even know where you are. Those sixty – or – seventy hour weeks there, I think, ‘Who am I? What am I doing in this job?’”

These concerns in some ways were accepted by the group as being similar to those of individuals in other professions. However, the process of discussing these concerns, according to the group, was a positive one. In many ways it was seen as a form of professional development

### **Professional development**

A key factor in this project was to foster ongoing professional development. In many

ways our group had committed to a public discourse in order to evolve professionally. Christine talked about her experience in the group:

“To be able to speak to a group who have common experiences, to hear how other people handle things, and to hear that you’re not the only one handling issues, has been a real bonus”.

Instead of ignoring the difficult or uncomfortable issues, we tried to understand, speak the unspeakable and reveal ourselves fully. Guided by Schon’s (1983; 1991) work on the reflective practitioner and acknowledging work by Stacey (1992) with regard to managing ambiguity and the unknowable, we were prepared to help ourselves to create maps from which to act. Within the group, the continuous interaction among the people created a certain amount of coherence and self-organizing (Stacey, 1992). Often what our conversations did help create were the boundaries that provide a field for the reciprocal processes of understanding and meaning making. As we continuously reflected, inquired, and summarized, we were more able to facilitate the construction of meaning among ourselves.

The lexicon of leaders in a professional development relationship bears examination. Our approach required enabling, connecting structures that ensured a level of trust. There had to be an environment of safety so that we could feel safe enough to “break set with old ideas” and develop a meaningful dialogue that would uncover and provide a mechanism for addressing difficult topics. Paul’s comments are an example of how this process allowed members of the group to think about how they dealt with particular issues. He stated:

“The learning that’s happening through the dialogue, conversations, has really changed things, changed the way I think about situations and made me really rethink some of my practices”.

Consequently, this process allowed the group to come to grips with the variety of ways people address similar problems. In essence they established new “ways of knowing”.

### **Ways of knowing**

Many of the participants have one or two confidants with whom they meet on a regular basis. It is with these people and often behind closed doors that the secret stories are told. They also gather together at a workplace meeting and management retreats. Stories in

front of their colleagues are often full of descriptions of the things they are doing. Tales of how they managed are often the substance of these stories. While their stories are not always the same stories they resonate in similar ways. Too much to do, not enough time to do it, one more thing to do, the same old stories are commonly heard.

Our need to tell stories to help create meaning was as strong as our need to reflect on actions taken and things thought. Often at the beginning of a group development members of a group aren’t always clear as to why they are assembling. However, when we inquired of the different participants what their thoughts were when they were first asked to join the research group, their responses were similar. Anne’s comments best reflected the general consensus:

“... to have a purposeful conversation about our work, about who we are and what we are and what it means to be in this role of sport manager. I know I’ve learned a lot of things from the other people – there were so many gifts around the table, and we were so different”.

We were a privileged group to be able to learn not only from our own experiences but also from those of the people around us. We had a capacity for building on each other’s stories and not closing down when uncomfortable issues surfaced. We sustained each other and gained glimpses of how we might do our work differently. The diversity of the people added an important dimension. The fact that we were open to continuous learning was one of the many significant reasons we succeeded. As we worked together as a group, our learning processes were quite basic but important. Probably the most significant was the realization that there was no magic truth of sport managers which to seek.

The research group drew on their memories and experiences, looking and seeing, listening and hearing, supporting and caring. We tinkered with ideas and listened to each other, and tried to open ourselves to the possibilities of the moment. It soon became clear that while new ideas and actions would likely emerge in the messiness and discomfort, we would not discover the “truth and only the truth”. This seeming lack of direction, even incoherence, sometimes created frustration not only with the process but also with the participants. Paul spoke about this when he shared his early concerns that he wasn’t always comfortable

with people's remarks. He talked specifically about his feelings of frustration:

"Some [participants] people tend to want to dominate, and I don't know that it's conscious, because they've had some really good ideas, and I think they want to share them".

In time, however, these frustrations dissipated and we formed a collective bond and spirit that fostered professional growth and an understanding about the issues that we confronted as sport managers.

### Collegiality

An important act of learning the group gained was that the more we linked together, the greater our knowledge expanded and we thrived. Each time that we met, we engaged at a different level. Growing together and merging our ideas into a new collectiveness taught us the importance of co-laboring and being partners in this process. We became more intense knowers of ourselves, of one another and of our work in sport management. Telling and retelling stories where both the researchers' and the participants' voices were heard, formed the collaborative effect of our narrative inquiry. From our conversations together, we not only learned facts, but also trust, confidence, and the importance of relationships in human interactions. Christine was reflective in her remarks:

"Life is lonely at the top". "To be able to speak to a group of people who have common experiences has been a real bonus, to hear how other people handle things, and to hear that you're not the only one handling them is helpful. When I heard somebody say that, I thought, 'Oh my God! "Somebody understands that, somebody else is having that experience'. I think in almost every experience we have, we question ourselves. 'Did I handle this right? Are my values in place?' So for me, that has been one of the most important things – the collegiality and then the opportunity to see and observe practice."

In many ways the group also learned how to address issues from a different perspective. Factors that previously were considered not important were now seen as relevant to solving particular problems, as David commented:

"I have been able to recognize that other influences that I previously considered unimportant could very well be the major cause of the problem. I have been able to extend the knowledge base on what I need to look at before I attempt to address a particular concern".

In a sense the group has taken their learning to a new level. They were beginning to "reflect on things unseen".

### Critical reflection

As a group we learned about things we weren't looking for, influences and behaviors we hadn't anticipated. Looking back, our work together was an act of faith, and as such, we hoped for something unseen but helpful to use. This is evidenced by David's words:

"The learning that's happened through the dialogue, the conversations, has really changed things, changed the way I think about situations and made me really rethink some of my practices. After the first meeting with the people, I realized: Here are some people I can learn from! New level of thinking - right?"

We became more conscious participants willing to accept and notice things we didn't know would be important. As Steve put it:

"Another learning for me was the importance of my own professional development and that it's a constant: I have always to be looking at that and refining and refocusing what I do to make me a better sport administrator. I really enjoyed the honesty, when people said, 'I'm having a problem with this. Can we brainstorm some strategies? I really appreciated that, because then that made me think, okay, now, this is my situation or could be my situation. What can I do or could I do? Who can I speak to or could I speak to? What advice can I get from people or could I get from people?'"

From a researcher's perspective it was very pleasing to hear that the group evolved professionally from the interaction that took place. It was our hope that this would occur but we also wanted to be able to add to this learning experience. At the same time, however, we did not want to control the agenda. We wanted the group to establish its own direction, to formulate a learning curve that they controlled. As a result, we had to come to grips with the fact that as researchers we were also participants who could influence the direction and outcomes of our discussions.

### Conclusion

This paper, in part, has been a plea for clarity in the use of narrative in our profession. Until recently, quantitative research has been the dominant research paradigm in sport studies and sports management areas. Throughout this paper the writers have argued that qualitative

research methods such as 'story', 'narrative' and 'voice' can provide rich descriptions of the sport environment and at the same time provide an alternative to the positivistic approach. In particular, Bruner (1986; 1991) argues that "narrative is a useful a way of approaching the world of sport research". We understand that the most important aspects of this paper are to develop interest in the qualitative research paradigm but we are also cognizant of the strength of the combination of research methods.

As previously mentioned, the researchers conducted group meetings with 7 sport managers (4 male and 3 female) over a period of 10 months. These series of narrative events addressed the overriding issues that the participating sport managers believed provided a unique insight into their everyday lives and the results highlighted some of the major difficulties in their reasoning and provided areas of concern which could be utilized in further research studies. These issues centred on:

- (1) experience and power,
- (2) accountability;
- (3) demands of the job;
- (4) professional development;
- (5) ways of knowing;
- (6) collegiality; and
- (7) critical reflection.

By examining how sport managers deal with their experiences and how their involvement in their sport organization has created a dominant set of meanings about what constitutes sport management practice, this paper has indicated how critical reflection through the sharing of lived experiences can be beneficial to the development of sport management knowledge. Therefore we argue that the use of critical reflection and narrative are strong paradigms which could be utilized together to produce research previously not encountered in our fields of expertise. As the data has illustrated, not all sport managers have the ability to analyze their own practice, however, it has argued that critical reflection is a vital component of sport management practice. Again we reiterate the importance of the combination of research paradigms. Moreover, it is suggested the sharing of narratives help shape and frame the unique experiences of sport managers and assist them ultimately in understanding the complex nature of the practitioner's world. Finally, we argue that this process of writing, sharing, reflection and analysis should lead to improved sport management practice and improved leadership qualities.

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## MENADŽMENT SPORTA: PRIPOVIJEDANJEM OSMIŠLJENA DJELATNOST MENADŽERA

### Sažetak

Članak je pokušaj da se istraži pripovijedanje sportskih upravitelja (menadžera) u Australiji. Sastajali smo se jednom mjesečno tijekom dužeg razdoblja kako bismo razmjenjivali svoje ideje o sportu. Tijekom tih sastanaka otkrili smo neke skrivene probleme i teškoće s kojima se svakodnevno moraju nositi sportski upravitelji, a onda smo postupno došli i do nekih zaključaka o težini zadataka koje valja obaviti. U članku smo definirali epistemologiju pripovijedanja kako bismo pokazali da pripovijedanje valja promatrati kao izvorno istraživačko oruđe znanstvenika iz područja sportskog menadžmenta, a ne kao još jednu "kvalitativnu paradigmu" koju je bolje ignorirati. Kao što raspravljamo u članku, narativni pristup sportskom menadžmentu dopušta istraživačima da povežu teoriju s iskustvom i uspostave odnos između svakodnevne prakse menadžera i njihovog znanja. Prihvatimo li takav pristup pripovijedanju, otvorit će nam se sasvim nov pogled na organizaciju sporta i pojedince koji su zaduženi za njeno učinkovito funkcioniranje. Stoga termin pripovijedanje, naracija, premda pripada govoru i premda je neformalan diskurs, odražava profesionalan i konceptualan proces kojim pojedinci iznose svoje osobne pripovijesti. Vrlo brzo smo otkrili da je prava svrha pripovijedanja obuhvatiti promišljanje ili teorijsku sastavnicu. Pripovijesti ne postoje, kako piše Bruner (1991): "u nekom stvarnom svijetu, gdje strpljivo i vječno čekaju da bi se vjerodostojno odrazile u tekstu. Čin stvaranja, oblikovanja naracije puno je više od pukog biranja, izvlačenja događaja iz stvarnosti, sjećanja ili mašte i od njihova slaganja nekim prikladnim redoslijedom. Događaji zapravo sami po sebi moraju tvoriti samo pripovijedanje."(str. 8)

Tako je pripovijedanje, naracija reflektivna, misaona praksa, a priča nije. Pripovjedač automatski dobiva moć da nadzire materijal koji predstavlja, moć koja izvire iz položaja organizatora da bi se pretočila u konačnu pripovijest. U našem druženju s upraviteljima, menadžerima impresioniralo nas koliko su se trudi-

li i koliko su vremena uložili da bi dali značnije svome glasu. Drugim riječima, složili smo se da termin "glas" sa sobom nesvjesno nosi pretpostavku da je grupa prirodno autentična te da taj moćan medij dopušta sudionicima da tijekom istraživanja daju glas svojim problemima i brigama. Jer, kako kaže Ruddick (1993) o poimanju glasova: "koji su emocionalno više bestjelesni, više uznemirujući. Na jednoj razini mogu predstavljati pojedince ili skupine kojima je zaničevano pravo da sudjeluju ili ih se jednostavno nije slušalo."(str. 8)

Također smo dali pregled ideja koje se bave prisjećanjem (reminiscencijama) i istinitošću naracijskog istraživanja te smo nakon zapisivanja pripovijedanja, promišljanja i ponovnog zapisivanja zaključili da treba pažljivo istraživati i ispitivati kako bi se osiguralo učinkovito pokrivanje oba područja.

Nekoliko se tema tijekom istraživanja stalno pojavljivalo: iskustvo, odgovornost, zahtjevi položaja, profesionalni razvoj, radne skupine, kolektivni duh i istraživač kao radnik na svome radnom mjestu. To su vrlo važna pitanja koja su menadžere kao skupinu zabrinjavala, a i nas istraživače su zanimala jer o njima prije istraživanja, tj. naših pripovjedačkih seansi nismo znali ništa. Kako se menadžeri nose s nepredvidljivošću života te kako rješavaju probleme s kojima se susreću? Svi odgovori su u naraciji. Njihove pripovijesti su pokazale kako je naracija vrlo snažna metoda koja omogućuje da se čuje kolektivni glas budući da većina menadžera zapravo radi u izolaciji i da, u biti, nemaju s kime podijeliti svoje ideje jer moraju paziti (čak se i boje) da bi drugi sportski kolektivi mogli iskoristiti njihove ideje.

Naracijsko istraživanje omogućilo nam je da razumijemo i druge načine upoznavanja svijeta menadžera koji se svakodnevno bave problemima sporta. Nadamo se da će ovo istraživanje potaknuti i istraživače, ali i sve sudionike u sportu da razgovaraju, razmjenjuju ideje, umjesto da rade u samoći. Tako bi se mogle dobiti nove spoznaje o praksi sportskih menadžera.

# THE INCIDENCE OF OROFACIAL INJURIES IN HIGH-SCHOOL BASKETBALL PLAYERS

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Preliminary communication  
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## Abstract:

Orofacial injuries are common in all sports. According to literature, sports injuries occur frequently but are relatively minor, except in hockey, rugby and American football. The aim of this preliminary study was to determine the frequency, type and severity of orofacial injuries in basketball, and the frequency of using protective requisites in the high-school population. The survey was conducted on 53 high-school male students playing basketball during their physical education class who were asked to fill in a specially designed questionnaire. The total of 160 orofacial injuries was reported, or 3.02 injuries per player. The most common injuries were lacerations and contusions of lips, cheeks and tongue (156 injuries, i.e. 97.5%), whereas other types of orofacial injuries amounted to 2.5%. Just a fraction of high-school students uses a mouthguard though its application could completely prevent the incidence of lacerations and contusions.

*Key words: orofacial injuries, basketball, male players, school sport, mouthguards*

## DIE INZIDENZ VON OROFAZIALEN VERLETZUNGEN BEI DEN BASKETBALLSPIELERN IN DER MITTELSCHULE

### Zusammenfassung:

Orofaziale Verletzungen sind in allen Sportarten üblich. Literaturgemäß kommt es oft zu verhältnismäßig geringfügigen Sportverletzungen, außer im Hockey, Rugby und amerikanischen Fußball. Das Ziel dieser Forschung war, die Inzidenz, den Typ und die Stärke der orofazialen Verletzungen im Basketball festzustellen, und wie häufig die Schüler die Schutzsportartikel benutzen. Die Studie umfasste 53 Schüler aus der Mittelschule, die während des Sportunterrichts Basketball spielten. Sie wurden gebeten, einen speziell entworfenen Fragebogen auszufüllen. Es wurden insgesamt 160 orofaziale Verletzungen angeführt, bzw. 3,02 Verletzungen pro Spieler. Die häufigsten Verletzungen waren Lazerationen und Kontusionen von Lippen, Wangen und der Zunge (156 Verletzungen, d.h. 97,5%), und 2,5% bezogen sich auf andere Arten der orofazialen Verletzungen. Nur ein Bruchteil der Schüler benutzt einen Mundschutz, obwohl seine Anwendung die Lazerationen und Kontusionen völlig verhindern konnte.

*Schlüsselwörter: orofaziale Verletzungen, Basketball, Basketballspieler, Schulsport, Mundschutz*

## Introduction

Basketball is popular worldwide. The Fédération International de Basketball Amateur (FIBA) incorporates two hundred national basketball leagues all over the world, with over a hundred million active basketball players. Owing to the nature of the game, basketball is one of the most dynamic sports from the first till the last minute of the game. Accordingly, the players must show a whole spectrum of basic and specific cardiorespiratory fitness levels and motor abilities. The game is dominated by explosive power, coordination of specific motor functions and spatial coordination,

agility in effective problem-solving, rapid neuromuscular reaction and rapid movements (Matković, Bo. & Matković, B.R., 1996). The increasing number of games, the demands for more dynamic and aggressive play, particularly during the defense part will increase the number of injuries in sports (Hill, Crosher, & Mason, 1985; Berg, Berklej, Tang, Altman, & Londere, 1998; Jerolimov & Carek, 1997; Diangelis & Bakland, 1998; Ishijima, Saitoh, Asahina, Kanazawa, & Imamura, 1998). In his 1952 article, Cathcart states the need for protecting the orofacial system, not only in boxing and American football, but also in other sports

such as ice hockey, basketball and automobile racing. The rules and tactic of basketball have changed which has led to the increased number of injuries (Guyette, 1993). The basketball court is relatively small resulting in frequent contacts among players. Frequent contacts in the midst of game cause unintentional and intentional injuries (Gjuric, 1989). According to the taxonomy of the World Dental Federation (FDI), basketball is a medium-risk sport as regards orofacial injuries (FDI Technical Report, 1990). Contrary to the standpoint of the World Dental Federation (FDI), Morrow and Kuebker (1986) have pointed out that the incidence of orofacial injuries is higher in basketball and football than in American football which is, according to the FDI taxonomy, a high-risk sport. The research reveals that 40% of all orofacial injuries occur in basketball and baseball (McNutt, Shanon, Wright, & Feinstein, 1989). This is also supported by the research of Leshoier, Gallagher, & Guger (1990) and Lee-Knight, Harrison and Price (1992) who, during the Canadian Games in 1989, detected that wrestlers were at the top of the scale followed by basketball players as regards the frequency of orofacial injuries. The same study revealed that female basketball players were the most frequently injured female competitors. The analysis of sport injuries reveals that in 51% of cases, injuries are caused by the sportpersons themselves. These are triggered by lack of attention, fatigue, poor training record and poor technique. Other participants or, the opposing players in team sports cause injuries intentionally or unintentionally in 28% of cases and these, more often than not, include serious knee injuries, bone fractures or head injuries. 21% of injuries can be attributed to other causes such as gymnastics apparatus, sports grounds, clothes, footwear, etc. (Gjurić, 1989).

Data regarding orofacial injuries in high-school basketball in the Republic of Croatia are scarce. Hence, the aim of our study was to identify the frequency and severity of orofacial injuries on the basis of a selected sample of the 3<sup>rd</sup> and 4<sup>th</sup> grade high-school basketball players from Zagreb and the surrounding area.

## Methods

The survey was conducted on the basis of a short questionnaire given to 53 high-school male students, 13 third-graders and 40 fourth-graders, playing basketball during physical education classes in high school (Table 1). Reported data refer to the period of four years.

Prior to filling in the questionnaire, all the participants received instructions and explanations regarding the aim and the purpose of the survey and gave the informed consent. The questionnaires were filled in individually with the help of the researchers.

Table 1. Structure of the sample

3 <sup>rd</sup> graders	13
4 <sup>th</sup> graders	40
Total	53

## Results

The data obtained by the survey reveal a total of 160 orofacial injuries (an average of 3.02 injuries per player) (Table 2 and 3). The most common injuries were lacerations and contusions of lips, cheeks and tongue (a total of 156). Thirteen third-graders reported 7 lacerations of lips, cheeks and tongue, i.e. 0.54 injury per player, while 40 fourth-graders reported 149 injuries of lips, cheeks and tongue, i.e. 3.73 injuries per player. This can be attributed to a higher bodily weight in the transition stage between junior and senior players, i.e. to a more rapid physical development and a relatively uncoordinated agility caused by a sudden increase in body mass and the length of the extremities. Four cases of loose, knocked out and/or broken teeth were reported (2 loose and 2 broken). The therapy of broken teeth included one crown and one endodontic therapy as a consequence of trauma.

Injuries in basketball also depend on the position on a team. The five-position concept of playing positions was utilized in the study. The most frequently injured players were the power forwards (position 4) with an average of 10 injuries during their basketball career. They were followed by the point guards (position 1) with an average of 5.5 injuries, the small forwards (position 3) with an average of 1.71 injuries, and the shooting guards (position 2) with an average of 1.35 injuries, whereas the least frequently injured were the centers (position 5) with an average of 1.14 injuries during their basketball career (Table 4).

Players have reported pain while opening/closing the mouth 37 times. Five injuries of temporomandibular joints and 20 cases of pains and stiffness in facial muscles have been reported (Table 5). Three players have indicated that they have tried to use mouthguards, but only one of them uses it on a regular basis (Table 6).

Table 2. Lacerations and contusions of lips, cheeks and the tongue

Players	Lacerations and contusions					
	Lips		Cheeks		Tongue	
	Practice	Game	Practice	Game	Practice	Game
3 <sup>rd</sup> graders	1	5	1	0	0	0
4 <sup>th</sup> graders	76	41	6	3	22	1
Total	77	46	7	3	22	1

Table 3. Dental injuries and therapy

Players	Teeth				How many crowns were made	Endo-dontics
	Loose		Broken			
	Practice	Game	Practice	Game		
3 <sup>rd</sup> graders	0	0	1	0	1	0
4 <sup>th</sup> graders	0	2	0	1	0	1
Total	0	2	1	1	1	1

Table 4. Lacerations and contusions of lips, cheeks and the tongue across the playing position

Playing position	Number of players	Lacerations and contusions						Total	Average number of injuries
		Lips		Cheeks		Tongue			
		Practice	Game	Practice	Game	Practice	Game		
Point guard (1)	10	29	25	1	0	0	0	55	5.5
Shooting guard (2)	17	9	4	0	0	10	0	23	1.35
Small forward (3)	7	3	1	1	0	7	0	12	1.71
Power forward (4)	5	29	10	5	1	4	1	50	10
Center (5)	14	7	6	0	2	1	0	16	1.14
Total	53	77	46	7	3	22	1	156	

Table 5. Injuries of muscles and temporomandibular joints

Players	Pain and stiffness of facial muscles	Pain during opening/closing of the mouth	Injuries of temporomandibular joints
3 <sup>rd</sup> graders	11	15	0
4 <sup>th</sup> graders	9	22	5
Total	20	37	5

Table 6. The frequency of mouthguard application

Players	Mouthguards	
	Occasional use	Regular use
3 <sup>rd</sup> graders	1	0
4 <sup>th</sup> graders	1	1
Total	2	1

### Discussion and conclusions

In the study conducted by Jerolimov, Seifert and Carek (2001), the most frequently injured players were the centers with an occurrence average of 9.57 injuries during their basketball career, followed by the guards with 6 injuries, whereas the least frequently injured players were the forwards with 3.75 injuries. Pursuant to the data collected by Meeuwisse, Sellmer and Hagel (2003), the most frequently injured were the centers, followed by the guards, whereas the least frequently injured were the forwards. The results of our study discussed

herein are in accordance with the results stated in the literature which points to the fact that the most frequently injured players are the centers, followed by the guards and the forwards. The difference between other scientific data and the data from this study lies in a different player categorization, and, ostensibly, in the smaller number of interviewees.

Namely, there are five players on a basketball team taking the following positions on the playing court: position 1 – the point guard, position 2 – the shooting guard, position 3 – the small forward, position 4 – the power forward,

and position 5 – the center. Some studies have classified basketball players into three groups: the guards (positions 1 and 2), the forwards (position 3) and the centers (positions 4 and 5). If this categorization is applied to our research, then our results will be: the most frequently injured position are the centers (positions 4 and 5) with 3.47 injuries during their basketball career, followed by the guards (positions 1 and 2) with 2.89 injuries, and the forwards (position 3) with 1.71 injuries, which means that our research has produced similar results as the mentioned studies. The centers (positions 4 and 5) are the tallest players on a team who play near the basket. They are in continuous contact with the opposing players, and the aim of their play is to prevent direct scoring in the defensive, and to score or set a screen for teammates in the offensive part of the game. From a technical-tactical perspective, rebounding predominates in their play. It implies vertical movement with sudden rotations making the players extremely vulnerable to injuries. The guards' play (positions 1 and 2) is predominated by scoring and initiation of offensive play with horizontal movement and sudden changes of direction with a possible collision with other players. Accordingly, the guards are also more exposed to injuries. The forwards (position 3) combine all of the above-mentioned positions which is why these players are regarded as the most proficient ones. From a technical-tactical perspective their play is dominated by rebounds, penetration and scoring which also determines the combination of injuries they can be exposed to.

Some players state that they use mouthguards due to previous lacerations and contusions of lips caused by using fixed orthodontic appliances. Fixed orthodontic appliances increase the risk of sports injuries in all sports, including basketball (Kvittem, Hardie, Roettger, & Conry, 1998). Although most of the players believe that a mouthguard prevents orofacial injuries, only 6% of them use it. According to scientific data, just a fraction of players has tried to use a mouthguard or uses it on a regular basis, except in those sports where wearing a mouthguard is mandatory. What motivates a player to use a mouthguard is either his previous injury or the injury of his co-player. A mouthguard is used and procured voluntarily and individually, i.e. without prior advice from the dentist. In their research, Maestrello-deMoya and Primosch (1989) pointed out that from a total of 1,020 interviewed players only 4.2% used a

mouthguard while playing basketball. The latter group reported only two minor injuries that needed no further medical attention. However, 32% of the remaining 977 players who did not wear a mouthguard reported orofacial injuries. This indicates that the incidence of injuries is 6.7 times higher if a mouthguard is not used. In basketball the use of mouthguards is not mandatory, and according to Flanders and Bhat's study (1995), orofacial injuries make up 62% of all injuries during a basketball game. The results regarding the usage of a mouthguard detected in our study correspond to the findings of other scientific studies. Hence, it can be concluded that the application of a mouthguard should be made mandatory for basketball players. However, in order to change the rules and accept a mouthguard as a mandatory protection of basketball players, it is necessary to educate and inform the dentists in order to encourage them to familiarize coaches and players with the problems of protecting the orofacial system. Lacerations and contusions can be almost completely eliminated by the use of mouthguards. This is extremely relevant because the orofacial system is exposed mostly to these two types of injuries. Our study needs to be expanded, especially to include those players who participate in professional leagues because Croatian high-school players represent just a segment of all basketball players.

The incidence of orofacial injuries among the 3<sup>rd</sup> and 4<sup>th</sup> grade high-school students who play basketball during their physical education class is relatively high (160 injuries). The most common orofacial injuries are lacerations and contusions of lips, cheeks and tongue, and they represent 97.5% of all orofacial injuries. These, as well as other injuries, depend on the position on a basketball team. According to the results obtained, the most frequently injured players are the centers (positions 4 and 5), followed by the guards (positions 1 and 2), whereas the least injured players are the forwards (position 3). According to the taxonomy of the World Dental Federation, basketball is a medium-risk sport for developing orofacial injuries, and, accordingly, the use of mouthguards is not mandatory. This study shows that there is a huge number of orofacial injuries that might be minimized, mitigated or prevented by the use of mouthguards. The research should be expanded to include professional and non-professional basketball players for the purpose of obtaining more comprehensive data.

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## INCIDENCIJA OROFACIJALNIH OZLJEDA KOD SREDNJOŠKOLSKIH KOŠARKAŠA

### Sažetak

#### Uvod

S obzirom na prirodu igre, košarka je jedan od najdinamičnijih sportova. Igrači moraju pokazati čitav spektar bazičnih i specifičnih funkcionalnih i motoričkih sposobnosti. Sve veći broj utakmica, zahtjevi za dinamičnijom i agresivnijom igrom, posebno tijekom faze obrane, bitan su čimbenik porasta broja ozljeda u ovoj sportskoj igri. Prema taksonomiji Svjetske stomatološke federacije (FDI), košarka se ubraja u sportove srednjeg rizika za razvoj orofacijalnih ozljeda pa, prema tome, korištenje štitnika za usta nije obavezno. Ipak, neka su istraživanja pokazala da je incidencija orofacijalnih ozljeda u košarci i nogometu veća nego u američkom nogometu, koji je, prema taksonomiji FDI-a, klasificiran kao sport visokog rizika..

Podaci o orofacijalnim ozljedama igrača u srednjoškolskoj košarci u Republici Hrvatskoj su oskudni. Stoga je cilj ovog preliminarnog istraživanja bio identificirati učestalost i ozbiljnost orofacijalnih ozljeda na temelju izabranog uzorka košarkaša trećih i četvrtih razreda srednjih škola iz Zagreba i okolice.

#### Metode

Ispitivanje je provedeno na temelju kratkog upitnika koji su ispunila 53 učenika srednjih škola, 13 učenika 3. razreda i 40 učenika 4. razreda koji treniraju košarku tijekom nastave tjelesnog odgoja u srednjoj školi (tablica 1). Prije ispunjavanja upitnika, svi su ispitanici dobili upute i objašnjenja vezana uz cilj i svrhu istraživanja..

#### Rezultati, rasprava i zaključak

Podaci dobiveni istraživanjem pokazuju ukupno 160 orofacijalnih ozljeda u razdoblju od četiri godine (prosječno 3.02 ozljede po igraču) (tablica 2 i 3). Najčešće ozljede su laceracije (razderotine) i kontuzije (nagnječenja) usana, obraza i jezika (ukupno 156). To je moguće pripisati relativno slabijoj koordinaciji i agilnosti uzrokovanoj naglim porastom tjelesne mase i dužine ekstremiteta u razdoblju na kraju puberteta.

Ozljede u košarci ovise i o igračkom mjestu u ekipi. U ovom smo istraživanju dobili da su između pet pozicija u košarkaškoj ekipi

najčešće ozlijeđeni igrači snažno krilo (igračka pozicija 4), s prosječno 10 ozljeda, zatim bek organizator igre (pozicija 1), s prosječno 5,5 ozljeda, krila (pozicija 3), s prosječno 1,71 ozljedom, te bek šuter (pozicija 2), s prosječno 1,35 ozljeda, dok su najmanje ozljeđivani centri (pozicija 5), s prosječno 1,14 ozljeda tijekom promatrane četiri godine (tablica 4).

U dosadašnjim istraživanjima rezultati su malo drugačiji (Jerolimov, Seifert i Carek, 2001; Meeuwisse et al., 2003) pokazuju da su najčešće ozljeđivani igrači centri, zatim bekovi, dok se najrjeđe ozljeđuju krila. Ovdje obrađeni rezultati istraživanja u velikom se stupnju podudaraju sa spomenutim rezultatima navedenim u znanstvenoj literaturi ako se upotrijebi tročlana klasifikacija igračkih pozicija u košarci. Tako se i u našem istraživanju dobiva da su najčešće ozljeđivani centri sa 3,47 ozljeda, slijede bekovi sa 2,89 ozljeda te krila sa 1,71 ozljedom.

Igrači su 37 puta naveli da su osjećali bol prilikom otvaranja/zatvaranja usta. Navedeno je 5 ozljeda temporomandibularnog zgloba i 20 slučajeva boli i ukočenosti mišića lica (tablica 5). Navedena su i 4 slučaja klimavih, izbijenih i/ili slomljenih zuba (2 klimajuća i 2 slomljena). Tri su igrača naznačila da su pokušala koristiti štitnik za usta, ali ga samo jedan od njih redovito koristi (tablica 6).

Iako većina igrača vjeruje da štitnik sprečava orofacijalne ozljede, samo ga 6% koristi, premda su Maestrello-deMoya i Primosch (1989) u svom istraživanju istaknuli da je incidencija ozljeda 6,7 puta veća ako se ne upotrebljava štitnik. Prema istraživanju Flandersa i Bhata (1995), orofacijalne ozljede čine 62% svih ozljeda tijekom košarkaške utakmice. Rezultati dobiveni ovim istraživanjem, vezani uz korištenje štitnika za usta, odgovaraju nalazima drugih znanstvenih istraživanja. Stoga možemo zaključiti da bi korištenje štitnika za usta kod košarkaša srednjoškolske dobitrebalo postati obavezno. Korištenjem štitnika mogle bi se gotovo u potpunosti eliminirati laceracije i kontuzije, dvije vrste ozljeda kojima je orofacijalni sustav najviše izložen.

Istraživanje bi trebalo proširiti uključivanjem amaterskih i profesionalnih košarkaša radi prikupljanja opsežnijih podataka.

# AN ATTEMPTED DETERMINATION OF THE LATENT STRUCTURE OF LEISURE-TIME SPORTING AND OTHER RECREATION ACTIVITIES' CHARACTERISTICS

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## Abstract:

The aim of this study was to determine the latent structure of characteristics of leisure-time sporting and other recreation activities practised in the Republic of Croatia. The analysis was based on the survey of 1,126 adults of both sexes who filled in an open-ended questionnaire, which resulted in a list of 93 items - sporting and other recreation activities - that the subjects wrote as answers to the questions regarding their participation in sporting and other recreation activities according to their own preferences and attitudes as well as their experience. Taking into account the existing well known approaches to classifications, a new solution and elaborated. On the basis of the basic information about recreation activities ten variables were obtained. Factor analysis was applied, interpreted and discussed. In accordance with the Guttman-Kaiser criterion, nine factors were obtained that explained 95% of the total variance. The factors were, as a rule, defined by only one criterion variable each. Therefore, the expected latent structure of the characteristics describing leisure-time sporting and other recreation activities was not obtained.

*Keywords:* kinesiology, classification, sport science, recreation, sporting activities, other recreation activities, active life

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## EIN VERSUCH DER BESTIMMUNG VON LATENTER STRUKTUR DER CHARAKTERISTIKEN VON FREIZEITSPORTARTEN UND ANDEREN FREIZEITAKTIVITÄTEN

### Zusammenfassung:

Das Ziel dieser Studie war, zu versuchen, die latente Struktur von Charakteristiken sowohl der Freizeitsportarten, die in Kroatien getrieben werden, als auch anderer Freizeitaktivitäten zu bestimmen. Die Analyse ruhte auf der Untersuchung an 1126 Erwachsenen, Männer und Frauen, die einen offenen Fragebogen ausgefüllt und die Frage über deren Teilnahme sowohl an den Freizeitsportarten als auch an anderen Freizeitaktivitäten gemäß Präferenzen, Meinungen und Erfahrungen beantwortet haben. Das Resultat war eine aus 93 Item, Freizeitsportarten und anderen Freizeitaktivitäten, bestehende Liste. Eine neue Möglichkeit der Klassifikation von solchen Tätigkeiten wurde in diesem Artikel bearbeitet. Aufgrund Informationen über die Freizeitaktivitäten wurden 10 Variablen erhalten. Die Faktorenanalyse wurde angewandt, interpretiert und erörtert. Gemäß dem Guttman-Kaiser Kriterium wurden neun Faktoren abgeleitet, die 95% der gesamten Varianz erklärten. Die Faktoren wurden, in der Regel, nur mit einer Kriteriumsvariable definiert. Deswegen wurde die erwartete latente Struktur von Charakteristiken, die die Freizeitsportarten und andere Freizeitaktivitäten beschreiben, nicht erhalten.

*Schlüsselwörter:* Kinesiologie, Klassifikation, Sportwissenschaft, Erholung, Freizeitsportarten, andere Freizeitaktivitäten

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## Introduction

The course of western civilization led to the development of a large number of a variety of sporting activities (Klingsworth, James, & Morris, 2003; Bercovitz, 2000; Tarrant & Green, 1999). Their origin varies to a great extent, ranging from those that date back to the ancient types of contest, through games, up to modern sport and recent exercise movements like jogging, aerobics, and the latest so-called extreme sports. Consequently, the issue of classification of such a big number of sports and sporting activities arises.

The necessity of classifying sporting activities is recognized worldwide. The COMPASS project, for example, is the most important European project that is aimed at classifying and, subsequently, at a standardized monitoring of participation in (leisure-time) sporting activities in a coordinated manner. Such a common reference scheme will make it possible to interpret and better understand the existing differences, and, simultaneously, the characteristics of each European country as regards the type of sporting and other recreation activities in which people participate. Beside this European project, there are other worldwide projects including all continents (e.g., Russell, Storm, & Craig, 2002). In the *Sports for All Incentives Policy* from 1996, a collaborative effort was initiated by Dr. Michael Booth (Sydney, Australia) to develop a valid and reliable questionnaire to measure health-related physical activity for both research and global surveillance (Booth, Macaskill, McLellan, Phongsavan, Okely, Patterso, Wright, Bauman, & Baur, 1997; Booth, Okely, McLellan, Phongsavan, Macaskill, Patterson, Wright, & Holland, 1999). With the support of the World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC), an international working group was formed that consisted of physical activity researchers from 14 countries. The first step was to establish the goal to develop an International Physical Activity Questionnaire (IPAQ) to enable the collection of directly comparable physical activity data across countries in order to provide a common instrument that could be used internationally to obtain comparable estimates of physical activity participation from surveillance system data. Croatia is not (yet) a formal member of COMPASS, or any other similar world project, and has the status of not being able to provide relevant data in this respect at the moment.

Nowadays in kinesiology or sport science, there are several types of sporting and exercise activities' classification. Mraković (1994) divided the total population of kinesiological contents into conventional and unconventional movement structures. The conventional contents were further investigated (Horvat & Mraković, 1978; Kurelić, 1967; Mraković, 1971; Mraković, 1994) and four relatively homogenous sporting activity groups were obtained: monostructural kinesiological activities, polystructural acyclic activities, polystructural complex activities and polystructural conventional activities. Further, various classifications were made in: physical education (for example, Findak, Mraković, Metikoš, Neljak, & Prot, 2000; Corbin, 2002), kinesiotherapy (Buijs, R., Ross-Kerr, J., O'Brien Cousins, S., Wilson, D., 2003; Hammell, Carpenter & Dyck, 2000; Karaiković & Karaiković, 1986) and leisure-time sport (Blagajac, 1994; Savić, 1987; Trkulja Petković & Andrijašević, 1994).

This study was aimed at classifying leisure-time sporting and other recreation activities practised in Croatia. Recreation in its broad meaning encompasses activities one conducts according to his/her own choice and in his/her own free or spare time (Lavizzo-Mourey & McGinnis, 2003). In general, these activities are: various types of physical exercise, activities belonging to the sphere of culture and art, social and entertainment activities, collection, craftsmanship and technical activities, activities in nature, etc. Recreation in the narrow meaning of the word refers to kinesiological recreation, fitness and healthpromotion, social and entertaining contents, that is, physical activities offered in some programs (Relac, 1984).

Sporting activities (SA) can be defined in various ways. The authors opted here for a definition proclaimed by COMPASS (Allin, Rossi Mori., 1999): "*Sport* means all forms of physical activity which, through casual or organized participation, aim at expressing or improving physical fitness and mental well-being, forming social relationships or obtaining results in competition at all levels" (Mussin, 2002).

The aim of this paper was two-fold. Firstly, to obtain a list of sporting and other recreation activities in which people in the Republic of Croatia participate, and secondly, to determine, on the basis of that list, the latent structure of leisure-time sporting and other recreation activities' characteristics.

Ultimately, such studies could contribute to an attempt to adjust the Croatian standards in this

respect, both practically and methodologically, with those declared in Europe.

## Methods

### The sample of entities

The sample of entities consisted of a list of sporting and other recreation activities practised in leisure-time sport-oriented programs and other leisure-time activities regularly or occasionally practised by people in the Republic of Croatia. This sample was obtained by an open-ended questionnaire (Trkulja Petković, 2000) filled in by 1,126 randomly selected citizens, from 16 out of 20 regional counties plus the capital city of Zagreb, of the Republic of Croatia. In Table 1 it is evident that both sexes are evenly represented as regards the duration of their sport participation.

The resulting list consisted of 93 items, that is, different sporting and other recreation

European countries people are also engaged in activities such as vita-parcours, snow-boarding, snow-shoeing, ski touring, qui-gong, disco dancing, mushrooming, horse dressage, and bandy.

### The sample of variables

The obtained list served to the group of experts in kinesiological recreation to define the ten criterion variables that were regarded as leisure-time sporting and other recreation activities' characteristics whose latent structure determination was the aim in this study.

The ten obtained criterion variables (characteristics) were as follows.

### Collective sporting and other recreation activities

Co-operation of the members of the group is necessary because the result of a particular activity depends on that co-operation. The

Table 1. Total number of years of the sample's participation in different sporting activities

Participation	Current						Previous					
	m	m%	f	f%	T	T%	m	m%	f	f%	T	T%
None	180	63.6	103	36.4	283	25.1	242	58.5	172	41.5	414	36.8
Up to 3 yrs	220	50.6	215	49.4	435	38.6	145	56.6	111	43.4	256	22.7
From 4 to 10 yrs	138	63.0	81	37.0	219	19.4	207	62.2	126	37.8	333	29.6
Over 10 yrs	153	81.0	36	19.0	189	16.9	97	78.8	26	21.2	123	10.9
Total	691	61.4	435	38.6	1126	100	691	61.4	435	38.6	1126	100

f - female, m - male, T - total

activities (Table 2). It should be noted that this list was generated both by those who used to practise sporting and other recreation activities and by those who still participate in them. Therefore, our intention was not to obtain a list of all possible sporting and other recreation activities in which people could participate, but to obtain a realistic survey of activities in which people actually do take part. Our list is to a large extent compatible with similar studies from other European countries, e.g. Switzerland (Lamprecht & Stamm, 2001), the Netherlands (Breedveld, 2002), or the Czech Republic (Rychtecky, 2000). However, certain differences were found, as regards a smaller number of specific activities in which people participate. In Croatia, for example, people participate also in sailing, water skiing, speleology, darts, fencing, water polo, bocce, sport shooting, croquet, paragliding, indiaca, hunting and traditional sports, whereas in other

goal is either to defeat the opposing group or to achieve an aesthetic standard. The variable encompasses numerous sporting games, synchronized swimming, dancing, and folk dancing. To be a part of the group, to have the feeling of belonging to the group, may be a significant motivation factor for participation. Collective sporting and other recreation activities may contribute to the realisation of goals such as an improvement of interpersonal relations (Rubeša, 1990; Žugić, 1990), disalienation, reducing the feeling of loneliness, etc.

### Martial arts

Martial arts were extracted in a separate variable for several reasons. These activities have a long East Asian tradition, but are frequently practised in Europe as well. Attributes connected with them are usually nobility, skill,

Table 2. List of different sporting and other recreation activities obtained in the population of the Republic of Croatia

Gymnastics	Fencing	Water skiing	Indiaca
Tennis	Soccer	Sky diving	Indoor golf
Swimming	Aerobics	Rhythmic gymnastics	Football tennis
Handball	Bowling	Hiking	Swing bowls
Orienteering	Bodybuilding	Hunting	Excursion
Skiing	Water polo	Thai boxing	Programmed active rest
Underwater diving	Bocce	Scouting	Callisthenics
Horseback riding	Windsurfing	Motorcycle racing	Aqua-aerobics
Table tennis	Boxing	Baseball	Jazz dance
Basketball	Karate	Judo	Traditional sports
Athletics	Running (jogging)	Wrestling	Medical programmed active rest
Exercising for fitness	Lifting weights	Fishing	Martial arts
Ballet	Cycling	Squash	Gardening
Volleyball	Rowing	Taekwondo	Water sports
Jujitsu	Sport shooting	Budokai	Massage
Rafting	Yoga	Car racing	Corrective gymnastics
Sailing	Synchronized swimming	Cross-country skiing	Recreational exercising
Archery	Field hockey	Badminton	Biking
Rugby	Croquet	Chess	Exercising at home
Billiards	Paragliding	Full contact	Dancing/folklore
Golf	Ice hockey	Miniature golf	Walking
Speleology	Sauna	Roller blading	
Beach volleyball	Trim track	Stretching	
Darts	Ice skating	Wheelchair volleyball	

etc. Most of them imply a certain 'philosophy of living' and rituals. By means of these activities one can develop motor skills to symbolically destroy an opponent. Since combat implying direct physical contact lies in the basis of all these sports, certain personality traits are also necessary beside a particular level of motor skills. The interest of people for these activities is evident, but, since they require elements which may affect the general health status of a person negatively, they should be extremely carefully planned, programmed and selected.

### Individual outdoor sporting and other recreation activities

One person alone, as a rule, suffices for participation in these activities, and the result depends on the abilities and skills of an individual. The activities are executed outdoors, however, in contrast to *outdoor activities* they demand that specially constructed sports grounds be built and that special equipment be supplied. Activities that one may execute on one's own, independently of other people,

enable a completely free selection of place, time, frequency and duration of activity. The broad freedom of place selection thus has its advantages, but also its disadvantages, particularly when the motivation of a person for physical exercise is low. This group encompasses activities such as golf, skiing, fishing, athletics, etc.

### Attractive/extreme sporting activities

The meanings of the words *attractive* and *extreme* largely describe the types of activities belonging to this category. We are talking about those activities that provoke the interest of people, regardless whether the reason for interest be the high price of equipment or the thrill and the danger that these activities imply. These activities are also executed outdoors, however, in the full meaning of the word, that is, they are done under ground, on the ground, in the air, on and under the water. This group encompasses speleology, horseback riding, car-racing, sky diving, underwater diving, etc. All those people who want to produce a demonstration effect or

feel the thrill ('adrenalin-rush') find a motive for participation in these activities, which may be the basis for the planning and realisation of recreation programs.

### **Individual indoor sporting and other recreation activities**

This variable is, according to the way of participation and realisation of results, identical to the previous variable. The basic difference, however, between the two variables regards the space in which the activities are executed. From a health and financial point of view, the activities are preferably executed outdoors in open space (in nature, if possible), however, the advantage of continuous exercising indoors is not neglected since it does not depend on weather conditions. This group encompasses activities such as gymnastics, ballet, lifting weights, yoga, sport shooting, etc. As for the ways of participation in an activity and as for the realisation of results, this variable is identical to the previous one.

### **Recreationally beneficial sporting and other recreation activities**

Any of the 93 activities listed may be partially or with some modification termed and/or applied as recreation activity. However, this variable encompasses one part of exclusive recreation activities/programs. This term implies those activities that almost exclusively belong to the domain of leisure-time sport, and that are usually not institutionalized (they do not have either an umbrella association or fixed rules). Recreationally beneficial activities are all those exclusive recreation activities that may lead to the optimization of the psychosomatic status provided that they are conducted on a regular basis (over a longer period of time) with an appropriate intensity, volume and frequency of exercising. This variable encompasses activities such as aerobics, aqua-aerobics, exercising for fitness, calisthenics, etc.

### **Leisure-time sporting and socializing activities**

In leisure-time the goal is not always to achieve a certain result, a measurable advancement, a victory or the like. The goal is the activity itself, satisfaction, relaxation, entertainment, well-being. The goal of recreation activities that have the attribute *leisure-time* is precisely to spend quality free time. The activities belonging to this category may be of a

kinesiological character (miniature golf, swing bowls, croquet), but they may also be social and entertainment activities (dominos, card games, chess, raffles, quizzes, carnivals, etc.).

### **Leisure-time medically controlled recreation activities**

Almost all activities employed in recreation (here also referred to as *leisure time*) could, without making a bigger error, be assigned the attribute *health-related* due to the fact that the planning, programming and execution of any activity is based on the principle of health-related orientation. Naturally, the term *health* refers to the "total physical, psychological and social welfare, and not only the absence of disease or weakness" (according to Harel, 1996). Recreation does not deal with a cure (treatment), but primarily with prevention, that is, with correction and compensation (replacement) of the negative impact of the environment and of the working and living conditions (Active Living Leadership, 2004). Recreational medically programmed active rest (MPAR) is a type of protection and improvement of health and of protection and improvement of the way of life and it is to be found as a specific measure in Croatia's law on health protection. This variable also addresses, apart from the already mentioned MPAR, various fitness- and health-promoting procedures, corrective exercises, etc.

### **Outdoor sporting activities**

In contemporary living conditions, characterized, among other things, also by a high degree of urbanization, outdoor activities are of significant importance. This is particularly evident in those activities that do not require any special material conditions such as constructed sports grounds, expensive equipment, etc. The variable *outdoor sporting activities* encompasses all sporting activities done outdoors and that are such, according to their structure, that they may produce the transformations of anthropological characteristics. This group encompasses activities such as running, biking, orienteering, roller-blading, etc.

### **Outdoor non-sporting recreation activities**

In spite of the fact that activities that may produce transformations of motor abilities, cardio-respiratory fitness and anthropometric characteristics are commonly assigned a bigger

significance, the activities lacking this attribute should not be neglected. Such activities may be an excellent supplement of any other activity/sport; however, they have their own value as well. They contribute to the quality of leisure time, and they may help meet the need for movement in those people who dislike competition. This variable encompasses hiking, scouting, going on excursions, etc.

### Data processing methods

Each of the defined set of sporting and other recreation activities was mapped into the given set of criterion variables. This process was based on the opinions of experts qualified in leisure-time sport (lecturers, researchers and associates of the Chair of Kinesiological recreation at the Faculty of Kinesiology, University of Zagreb). Experts qualified each sporting and/or any other recreation activity in such a way as to fit into one of the criterion variables. The result was a binary matrix comprising 93 entities each valued at a value of zero or one. This data matrix, having sporting and other recreation activities as entities and criterion variables, was used as the basis for further analysis.

The data were processed in the Computer centre at the Faculty of Kinesiology University of Zagreb. The statistical package SPSS for Windows was employed. A statistical description by means of frequencies and percentages for each variable were calculated. Further, the correlation matrix between the variables was calculated. An exploratory factor analysis was employed under the principal components analysis model. The number of significant factors was determined according to the Guttman-Kaiser criterion. The eigenvalues

and the sizes of their partial contribution in the explanation of the total variance, the communalities of variables and the matrix of principal components were also calculated.

### Results

In order to describe statistically the set of criterion variables, also termed *characteristics*, the frequencies and the corresponding percentages for each variable were calculated. It was evident (Table 3) that the activities analysed were evenly distributed across the set, with variables *collective sporting and other recreation activities* and *attractive/extreme sporting activities* being the most represented, and the variable *outdoor non-sporting recreation activities* being the least represented one.

The correlation matrix (Table 4) shows a very low correlation between the variables; they fall within a range between .00 and .23. The variable *collective sporting and other recreation activities* correlates with the variables *individual indoor sporting and other recreation activities* (.23) and *individual outdoor sporting and other recreation activities* (.22). A low correlation of .10 between the variables *individual indoor sporting and other recreation activities* and *individual outdoor sporting and other recreation activities* is noticed. The low correlation between the other variables was expected since the classification supposed mutually exclusive groups.

The 10 criterion variables were subjected to a factor analysis to determine their latent structure. So, by means of the Guttman-Kaiser criterion the ten criterion variables were reduced to nine factors, that explained 95.5% of the total variance (Table 5).

Table 3. Frequencies and percentages of sporting and other recreation activities (entities) in the set of criterion variables

Variable	Frequencies	%
Collective sporting and other recreation activities	13	14.0
Martial arts	11	11.8
Individual outdoor sporting and other recreation activities	11	11.8
Attractive/extreme sporting activities	13	14.0
Individual indoor sporting and other recreation activities	11	11.8
Recreationally beneficial sporting and other recreation activities	7	7.5
Leisure-time sporting and socializing activities	10	10.7
Leisure-time medically controlled recreation activities	6	6.5
Outdoor sporting activities	6	6.5
Outdoor non-sporting recreation activities	5	5.4
<b>Total</b>	<b>93</b>	<b>100</b>

The communalities (Table 5) amounting to values from .84 up to .99 should be considered as very high, and, accordingly, the variables can be interpreted as well-defined with regard to their common variance.

Partial contributions of the explained variance (Table 5) were very evenly distributed. The explained variance ranged from 12.9% in the first factor to 10.0% in the ninth. This evidence implies, together with the communalities mentioned, that such a solution, namely, the obtained factors are expected to be maximally parsimonious.

The final factors solution discerned in Table 6 displays the expected parsimonious features. Namely, most of the factors are *single* factors, weighted by just one high loading. The first factor was defined by the characteristic (variable) *collective sporting and other recreation activities* (-.91). The variables *individual indoor sporting and other recreation activities* (.44), *individual outdoor sporting and other recreation activities* (.40) and *martial arts* (.22) are also present to a somewhat lower level.

The second factor was bipolar and it was defined by the variables *individual indoor sporting and other recreation activities* (-.75) and *individual outdoor sporting and other recreation activities* (.73), whereas all the other variables had almost no connection with this factor. The third factor was highly defined by the variable *martial arts* (.79), and to a much lower extent by the variables *individual outdoor sporting and other recreation activities* (-.44) and *individual indoor sporting and other recreation activities* (-.36). The fourth factor was almost evenly defined by the variables *recreationally beneficial sporting and other recreation activities* (.64), *martial arts* (-.51) and *outdoor sporting activities* (.45) and to a much lesser extent by the variable *leisure-time medically controlled recreation activities* (.29). The fifth factor was dominated by the variable *outdoor sporting activities* (.75) on the positive pole, and by the variable *recreationally beneficial sporting and other recreation activities* (-.66) on the negative pole. The sixth factor was defined by the variable *leisure-time medically*

Table 4. Correlation among variables

Collective sporting and other recreation activities	1.00	;	;	;	;	;	;	;	;	;
Martial arts	-0.15	1.00	;	;	;	;	;	;	;	;
Individual outdoor sporting and other recreation activities	-0.22	-0.07	1.00	;	;	;	;	;	;	;
Attractive/extreme sporting activities	-0.04	-0.01	-0.02	1.00	;	;	;	;	;	;
Individual indoor sporting and other recreation activities	-0.23	-0.07	-0.10	-0.02	1.00	;	;	;	;	;
Recreationally beneficial sporting and other recr. activities	-0.11	-0.03	-0.05	-0.01	-0.05	1.00	;	;	;	;
Leisure-time sporting and socializing activities	-0.04	-0.01	-0.02	0.00	-0.02	-0.01	1.00	;	;	;
Leisure-time medically controlled recreation activities	-0.09	-0.03	-0.04	-0.01	-0.04	-0.02	-0.01	1.00	;	;
Outdoor sporting activities	-0.10	-0.03	-0.05	-0.01	-0.05	-0.02	-0.01	-0.02	1.00	;
Outdoor non-sporting recreation activities	-0.06	-0.02	-0.02	0.00	-0.03	-0.01	0.00	-0.01	-0.01	1.00

Table 5. Communalities, eigenvalues, percentage and cumulative percentage of explained variance

Variable	communalities	Eigenvalues	Percentage	Percentage Cumulative
Collective sporting and other recreation activities	0.843	1.29361	12.9	12.9
Martial arts	0.953	1.10227	11.0	24.0
Individual outdoor sporting and other recreation activities	0.919	1.06222	10.6	34.6
Attractive/extreme sporting activities	0.996	1.03325	10.3	44.9
Individual indoor sporting and other recreation activities	0.914	1.02305	10.2	55.1
Recreationally beneficial sporting and other recreation activities	0.974	1.01842	10.2	65.3
Leisure-time sporting and socializing activities	0.997	1.00723	10.1	75.4
Leisure-time medically controlled recreation activities	0.981	1.00403	10.0	85.4
Outdoor sporting activities	0.977	1.00287	10.0	95.5
Outdoor non-sporting recreation activities	0.993	.45305	4.5	100.0

Table 6. Matrix of principal components loadings

Variable /Factor	1	2	3	4	5	6	7	8	9
Collective sporting and other recreation activities	-0.91	-0.02	-0.08	-0.05	-0.01	-0.01	-0.02	-0.01	-0.01
Martial arts	0.22	0.05	0.79	-0.51	-0.06	-0.06	-0.06	-0.04	-0.02
Individual outdoor sporting and other recreation activities	0.40	0.73	-0.44	-0.17	-0.03	-0.03	-0.04	-0.02	-0.01
Attractive/extreme sporting activities	0.05	0.01	0.05	0.07	0.02	0.03	0.19	0.92	-0.31
Individual indoor sporting and other recreation activities	0.44	-0.75	-0.36	-0.16	-0.03	-0.03	-0.04	-0.02	-0.01
Recreationally beneficial sporting and other recreation activities	0.15	0.02	0.21	0.64	-0.66	-0.22	-0.11	-0.05	-0.03
Leisure-time sporting and socializing activities	0.04	0.01	0.04	0.06	0.02	0.03	0.13	0.27	0.95
Leisure-time medically controlled recreation activities	0.12	0.02	0.14	0.29	0.14	0.90	-0.15	-0.07	-0.03
Outdoor sporting activities	0.14	0.02	0.18	0.45	0.75	-0.38	-0.12	-0.06	-0.03
Outdoor non-sporting recreation activities	0.07	0.01	0.07	0.10	0.03	0.06	0.95	-0.25	-0.08

controlled recreation activities (.90) and by the small contribution of the variable *outdoor sporting activities* (-.38). The seventh factor was defined by the variable *outdoor non-sporting recreation activities* (.94), the eighth factor by the variable *attractive/extreme sporting activities* (.92) and by the small contribution of the variables *leisure-time sporting and socializing activities* (.27) and *outdoor non-sporting recreational activities* (-.25). The ninth factor was dominated by the variable *leisure-time sporting and socializing activities* (.95) and to a lesser extent by the variable *attractive/extreme sporting activities* (-.31).

## Discussion and conclusion

The correlation matrix between the criterion variables (characteristics) (Table 4) shows, in general, very low correlations, as expected, since the classification hypothesizes mutually exclusive groups. In the factor analysis the results showed and confirmed this score. Namely, in the first factor the variable *collective sporting and other recreation activities* had the largest contribution, and was consequently defined as the factor of collective sports. The second factor axis differentiated between individual sports that are done indoors from individual sports that are done outdoors. This factor defined individual sports regardless of the place where they are practised/done. In the third factor all three variables (characteristics) belong to an area of sport and are basically executed individually, so that their interconnection is acceptable. Namely, the variable *martial art* was extracted from the group of individual sports due to its special features, both as regards the activities themselves and as regards the people that participate in them. This characteristic of martial arts does not relate only to leisure-

-time sport, but also to individual sports, which is evident from the opposite direction of the contributions of variables (characteristics) in the structure of this factor. Thus, this factor was defined as the *martial arts* factor. The following factor, defined as *recreationally beneficial sporting and other recreation activities*, was accompanied by *outdoor non-sporting recreation activities*. Their common denominator was the list of the following sporting and recreation activities: aerobics, exercising for fitness, non-competitive biking and running, i.e., none of them implies either any danger or competition. In contrast, the variable *martial arts* refers to combat in direct physical contact with an opponent. The fourth factor, therefore, emphasised the difference between leisure-time sporting activities and martial arts. The fifth factor was dominated by the characteristics (variables) that differ as regards the place where the activities are practised, the degree of organisation and the level of control. *Recreationally beneficial sporting and other recreation activities* are almost always carried out indoors (sports halls, fitness centres, swimming pools) as programmed and controlled leisure-time sporting activities, whereas the *outdoor sporting activities* are carried out exclusively outdoors and at one's own initiative. Due to the size of the contribution of variables it is difficult to choose only one variable and name the whole factor accordingly, especially because both variables have their loadings on the fourth factor as well. In the sixth factor, the most parsimoniously defined variable *leisure-time medically controlled physical activities* was dominant. Similarly, in the seventh factor, the variable *outdoor non-sporting recreation activities* was dominated by the group of unconventional activities carried out in nature, for example, hiking, walking, etc., and this is

something that clearly distinguishes it from the other groups of activities. The eighth factor was dominated by the *attractive/extreme sporting activities*. Finally, the ninth factor was dominated by the variable *leisure-time sporting and socializing activities* in contrast to the eighth factor that comprised the most risky or dangerous sporting activities. The variable *leisure-time sporting and socializing activities* included activities such as croquet, swing bowls, miniature golf, etc., whereas the variable *attractive/extreme sporting activities* encompassed activities such as speleology, motorcycle racing, paragliding, etc.

An attempt to determine the latent structure of the ten variables (characteristics) on the basis of their position in relation to the 93 entities was not successfully accomplished because the factor analysis did not result in the expected sufficient number of interpretable factors. The factors were, as a rule, defined by only one criterion variable each. Therefore, the expected

latent structure of the variables describing leisure-time and other recreation activities was not obtained. Yet, this does not mean that these characteristics do not exist at the manifest level of characteristics of leisure-time sporting and other recreation activities. So, recreation activities practised in Croatia may be observed as: collective sporting and other recreation activities; individual sporting and recreation activities; martial arts; recreationally beneficial sporting and other recreation activities; outdoor non-sporting recreation activities; leisure-time medically controlled recreation activities; outdoor sporting activities; attractive/extreme sporting activities and leisure-time sporting and socializing activities. Due to the nature of the obtained results it would be useful to proceed with the research, but this time the entities should be better defined and the variables describing leisure-time sporting and other recreation activities should be more carefully selected.

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# POKUŠAJ DEFINIRANJA LATENTNE STRUKTURE KARAKTERISTIKA SPORTOVA I SADRŽAJA SPORTSKE REKREACIJE

## Sažetak

### Uvod

U radu se polazi od činjenice da postoji veliki broj različitih sportova i sadržaja sportske rekreacije kojima se ljudi bave. Njihova brojnost nameće problem racionalne klasifikacije, što je predmet istraživanja kako u svijetu tako i u nas. Primjerice, COMPASS je europski projekt sa svrhom da se klasificira, standardizira i prati sudjelovanje ljudi u redovitim oblicima vježbanja. Hrvatska (još) nije formalni član COMPASS-a, ali se poduzimaju neke akcije u tom smjeru.

Ovaj rad ima dva cilja. Prvi cilj je napraviti listu (popis) sportova i sadržaja sportske rekreacije kojima se bave građani Republike Hrvatske. Drugi je cilj odrediti latentnu strukturu karakteristika tih sportova i sadržaja sportske rekreacije i tako ih klasificirati, odnosno, svrstati u manji broj skupina. Pored toga, ovakvo istraživanje može doprinijeti usklađivanju hrvatskih standarda s onima deklariranim u Europi.

### Metode

Putem anketnog upitnika otvorenog tipa, prikupljeni su podaci od 1.126 odraslih osoba, građana Republike Hrvatske. Na osnovi odgovora ispitanika registrirana su 93 različita sporta i/ili sadržaja sportske rekreacije kojima su se ispitanici nekada bavili ili se sada bave. U ovome radu, upravo ta 93 sporta i/ili sadržaja sportske rekreacije čine uzorak entiteta. Tako definiran uzorak entiteta ne pokriva sve moguće sportove i sadržaje sportske rekreacije kojima bi se ljudi mogli baviti niti ima ambiciju biti potpun i iscrpan, već je odraz onoga čime se ljudi u Hrvatskoj bave.

Definiranje varijabli (kriterija) za utvrđivanje latentne strukture temelji se na postojećim teorijama u kineziologiji te na metodičkom pristupu u planiranju, programiranju, provedbi i kontroli tih sadržaja u području sportske rekreacije. Primijenjeno je 10 varijabli kojima su obuhvaćene osobine sportsko-rekreacijskih sadržaja kao: *kolektivno, borilački, individualno, na otvorenom prostoru, u zatvorenom prostoru, u prirodi, atraktivno/ekstremno, transformacijski, rekreacijski, društveno-zabavno, medicinski (zdravstveno)*.

Svaki od 93 entiteta je, temeljem procjene eksperata, svrstan u jednu od varijabli.

Za obradu podataka upotrijebljen je statistički paket SPSS za Windows. Primijenjena je faktorska analiza pod komponentnim modelom, a broj značajnih faktora određen je prema Guttman-Keiserovu kriteriju.

### Rezultati, rasprava i zaključak

Faktorskom analizom dobiveno je devet faktora koje objašnjavaju 95,5% ukupnog varijabiliteta. Komunaliteti potvrđuju dobru zastupljenost svih varijabli. Svaki od dobivenih faktora zastupljen je ravnomjerno (parcijalno nose podjednaku količinu zajedničkog varijabiliteta u ispitivanom prostoru), što upućuje na visoku kompleksnost strukture. Prvi faktor razlikuje *kolektivne* od svih ostalih u ovome radu opisanih sportova i sadržaja sportske rekreacije. Drugi faktor je bipolaran. Definiraju ga varijable *individualnih* sportova i sadržaja sportske rekreacije koji se provode kako *u zatvorenom* tako i *na otvorenom prostoru*. Treći faktor definiraju tri varijable koje pripadaju području sporta, a u osnovi se provode individualno. Unatoč tome može se reći da pokriva prostor borilačkih sportova. Četvrti faktor naglašava razliku između redovitih *rekreacijskih programa* koji se primjenjuju *u svrhu transformacije* antropoloških obilježja i njima bliskih sportova i sadržaja sportske rekreacije. Peti faktor definiraju dvije varijable kojima je zajednička karakteristika potencijala moć *u transformaciji* antropoloških obilježja, iako se razlikuju prema mjestu provođenja, stupnju organiziranosti i razini upravljanja. Šesti, sedmi, osmi i deveti faktor su "singl" faktori. Njih dominantno definira jedna varijabla, dok su doprinosi ostalih varijabli vrlo mali ili zanemarivi. Šesti faktor je definiran kao *medicinski kontrolirani* sadržaji sportske rekreacije, sedmi kao *rekreacijski sadržaji koji se provode u prirodi*, osmi kao *atraktivne/ekstremne sportske aktivnosti*, a deveti kao *rekreacijski i društveno-zabavni sadržaji*. S obzirom na to da je veći broj faktora, u pravilu, bio definiran samo jednom kriterijskom varijablom nije dobivena očekivana latentna struktura varijabla koje opisuju sportske i druge sadržaje sportske rekreacije.

# PHYSIQUE, ANAEROBIC POWER AND PULMONARY MEASURES OF BOTSWANA TRACK ATHLETES

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## Abstract:

This study profiled the physique (anthropometry, body composition and somatotypes), leg power and pulmonary measures of Botswana track athletes gathered in a sports camp for the All Africa Games held in Johannesburg, South Africa. The intention was to provide coaches and trainers with the necessary data that enabled them to adjust their training programmes to improve the performance parameters in which shortfalls were noticed. The sample of participants comprised thirteen (13) male athletes, who competed in the sprinting and relay events at the All Africa Games. Their mean age was  $24.3 \pm 2.8$  years. The components of physique assessed included stature, body mass, body fat percentage, body mass index and somatotype ratings of endomorphy, mesomorphy and ectomorphy. Anaerobic power measurements included peak, minimum and average power (W) and power drop (W/s). The pulmonary functions test included vital capacity (VC), forced expiratory volume ( $FEV_1$ ),  $FEV_1$  percentage, maximum expiratory flow (PEF), forced vital capacity (FVC) and forced expiratory flow (FEF) at 25, 50 and 75% of FVC. Data were analysed using descriptive statistics. The results for physique revealed a mean body mass value of  $65.3 \pm 9.2$  kg, mean stature of  $174.2 \pm 8.1$  cm, mean body density (BD) value of  $1.08643 \pm 3.9$  gm/cc, a mean body fat percentage value of  $5.6 \pm 1.6\%$ , a mean body mass index value of  $21.5 \pm 2.7$  kg·m<sup>-2</sup> and mean somatotype value of  $1.36 \pm 0.6$ ,  $3.81 \pm 1.4$  and  $3.21 \pm 1.3$  for endomorphy, mesomorphy and ectomorphy, respectively, indicating that the athletes were ectomorphic-mesomorphs. The athletes' mean leg power outputs were  $651.75 \pm 1.4$ W,  $313.68 \pm 1.06$ W,  $486.84 \pm 1.34$ W,  $-1.92 \pm 0.6$ W/s for peak power, minimum power, average power and power drop, respectively. The athletes' mean pulmonary measures were  $3.2 \pm 0.67$ ,  $1.92 \pm 0.78$ ,  $59.12 \pm 1.2$  and  $3.07 \pm 0.93$  for VC,  $FEV_1$ ,  $FEV_1\%$  and FVC, respectively. It was concluded that the physique values were typical of similar athletes involved in sprint events. However, the athletes' pulmonary and peak leg power outputs were very low compared to values from athletes in similar events, hence requiring training adjustments.

**Key words:** Botswana athletes, anthropometry, body composition, somatotypes, pulmonary functions test, power output

## KÖRPERBAU, ANAEROBE KAPAZITÄT UND ATMUNGSMESSUNGEN BEI BOTSWANISCHEN LÄUFERN

### Zusammenfassung:

Diese Studie untersuchte den Körperbau (die Anthropometrie, die Körperzusammensetzung und die Somatotypen), die Beinkraft und Atmungsmessungen bei botswanischen Läufern, die am Trainingslager für die in Johannesburg, Süd Afrika, stattfindenden All Africa Games teilnahmen. Die Absicht dieser Studie war, sowohl den Trainern als auch den Konditionstrainern die erforderlichen Daten verfügbar zu machen, damit sie ihre Trainingsprogramme ändern und die niedrigen Leistungsparameterwerte verbessern können. Die Studie umfasste dreizehn (13) Sportler, die an Sprints und Staffelläufen in All Africa Games teilnahmen. Ihr Durchschnittsalter betrug  $24,3 \pm 2,8$  Jahre. Die gemessenen Körperbaueigenschaften bezogen sich auf Körperhöhe, Körpergewicht, das Prozent des Körperfetts, Körpermassenindex und die Einschätzung von Somatotypen, d.h. ob es sich um einen endomorphen, mesomorphen oder ektomorphen Typ handelt. Die Messungen von anaeroben Kapazität wurden in der höchsten, minimalen und durchschnittlichen Schnellkraft (W), sowie im Krafrückgang (W/s) gegliedert. Der Test der Atemfunktionen umfasste Vitalkapazität (VC), Atemvolumenstoßtest ( $FEV_1$ ), Prozent des  $FEV_1$ , maximalen Ausatmungsdurchfluss (PEF), Vitalkapazitätstoßtest (FVC) und Ausatmungsdurchfluss-Stoßtest (FEF) bei 25%, 50% und 75% des Vitalkapazitätstoßtest. Die Datenanalyse wurde mit Hilfe der deskriptiven Statistik vorgenommen. Die Ergebnisse der Körperbaumessungen zeigten den durchschnittlichen Körpergewicht von  $65,3 \pm 9,2$

kg, die durchschnittliche Körperhöhe von  $174,2 \pm 8,1$  cm, den durchschnittlichen Körperdichte (BD) von  $1,08643 \pm 3,9$  gm/cc, das durchschnittliche Prozent des Körperfetts von  $5,6 \pm 1,6$  %, den durchschnittlichen Körpermassenindex von  $21,5 \pm 2,7$  kg·m<sup>-2</sup> und den durchschnittlichen Somatotypen-Wert von  $1,36 \pm 0,6$ ,  $3,81 \pm 1,4$  und  $3,21 \pm 1,3$  d.h. für den Endomorphen, Mesomorphen und Ektomorphen; daraus folgt, dass die Sportler Ektomorphen-Mesomorphen sind. Der durchschnittliche Beinkraft-Output betrug  $651,75 \pm 1,4W$ ,  $313,68 \pm 1,06W$ ,  $486,84 \pm 1,34W$ ,  $-1,92 \pm 0,6W/s$  für die höchste, minimale und durchschnittliche Schnellkraft, sowie für den Krafterückgang. Die durchschnittlichen Atemmessungen waren  $3,2 \pm 0,67$ ;  $1,92 \pm 0,78$ ;  $59,12 \pm 1,2$  und  $3,07 \pm 0,93$  für VC, FEV<sub>1</sub>, FEV<sub>1</sub>% und FVC. Daraus lässt sich folgern, dass die Körperbauwerte typisch für ähnliche Sportler waren, die an Sprint-Disziplinen teilnahmen. Die Atemvolumenwerte und die höchsten Beinkraft-Werte dagegen waren sehr niedrig im Vergleich zu Sportlern in ähnlichen Sportdisziplinen; deshalb sind Änderungen im Trainingsprogramm erforderlich.

**Schlüsselwörter:** *botswanische Sportler, Anthropometrie, Körperzusammensetzung, Somatotypen, Atemtest, Kraft-Output*

## Introduction

The superior performance of today's athletes is the result of an intricate and useful blend of many factors and considerations. This blend, according to MacDougall and Wenger (1991), involves genetic endowment, selection criteria, training and favourable health status, carefully and deliberately integrated through the application of sport science disciplines like physiology, psychology, nutrition, biomechanics to mention just a few. Profiles of top elite athletes are the target of other aspiring athletes who try to reach them through training (Meckel, Atterbom, Grodjinovsky, Ben-Sira, & Rotstein, 1995; Sharma & Dixit, 1985; Thorland, Johnson, Cisar, Housh, & Tharp, 1987). Similarly, physical-performance profiles have also been used to predict performances in various sports, based on established relationships (Blazevich & Jenkins, 1998; Brandon, 1999; Nummela & Rusko, 1995). Apart from using these characteristics to predict performance in competitions, they have also been used to select athletes into sports camps for further training towards competitions.

Various levels of physical and performance characteristics have been used as indicators of success in sport. One of the typical changes arising from regular physical training, particularly for competitive sports, is a higher ratio of active body mass (fat-free mass) in comparison to fat tissue (Pavlik, 2000; Strojnik, Apih, & Demsar, 1995; Tilinger, 1997). This was corroborated by a study on young ice hockey players, in which Dzurenkova, Novotna, Hajkova and Marcek (2000) reported a positive influence of physical activity on body composition. In most cases the increased muscle mass is reflected in predominant mesomorphy. Elite and successful male sprinters range in height from 157 cm to 190 cm and in weight from 63.4 to 90.0 kg (Radford, 1990). Majority of

successful sprinters have tended to be predominantly mesomorphic. However, the high muscle mass found in sprinters may be due to a genetic predisposition or training effects or a combination of both (Boros-Hatfaludy, Fekete, & Apor, 1986; Owolabi & Oduyale, 1989; Strojnik, Apih, & Demsar, 1995; Torok, Duey, Bassett, Howley, & Mancuso, 1995). It is generally acknowledged that while heredity may predispose an athlete to certain physiological capacities, the realisation or manifestation of these potentials in the phenotype is highly dependent on favourable environmental factors and training (Mero, Jaakkola, & Komi, 1991; Mero, Komi, & Gregor, 1992).

Generally, athletes tend to carry a smaller percentage of body fat than their non-athletic counterparts. Indeed, the established inverse relationship between the percentage of body fat and athletic performance has necessitated the inclusion of a body fat assessment in the physiological preparation and evaluation of athletes. Meckel, Atterbom, Grodjinovsky, Ben-Sira and Rotstein (1995), in a study on the physiological characteristics of 100-metre sprinters being classified into fast, average and slow groups, found the fast group to be significantly superior in the Wingate anaerobic test performance and to carry a significantly lower percentage of body fat than the slow group.

Any physical performance output that involves maximum muscular contraction within 2 to 60 seconds is primarily dependent on the anaerobic energy system. The anaerobic energy system is the energy pathway that does not depend on oxygen to provide the energy for an on-going physical exertion. The anaerobic energy system is dependent on the muscles store of ATP – PC (phosphagens) (alactic energy) and muscle glycogen (lactic energy). The two acknowledged indicators of

anaerobic performance are anaerobic power (maximal muscular contractions completed in up to 10 seconds) and anaerobic capacity (maximal muscular contractions sustained and completed in up to 60 seconds). While anaerobic power determines the alactic capacity of the athlete, anaerobic capacity determines the lactic capacity of the athlete.

Although pulmonary ventilation and diffusion may not be a limiting factor in the track performance of athletes with healthy lungs, the functional lung capacities may be limited by factors such as airway obstruction or impairment and inappropriate training. Successful performance in competitive track events is also dependent on the optimum presence of specific physical and motor performance attributes. These include stature, anthropometry, body weight and composition, somatotype, muscle strength and flexibility. Particularly in track events, where the body has to be moved over a space in a minimum time, the importance of muscle mass, body anthropometry, percentage of body fat, flexibility and strength cannot be over emphasised.

Botswana, to date, has not made a significant mark on the world-map of track-and-field athletics. There was a need to carry out a profile study of this nature with the main objective being that coaches and trainers design and re-design their training programmes in preparation for the All Africa Games held in Johannesburg, South Africa. It was therefore a modest scientific beginning of pre-camp assessments of the physique, anaerobic power and pulmonary functions of Botswana's elite track athletes. Also, these much-needed data enriched the country's track-and-field athletics data bank. Finally, it was believed that the data from this study would be used, for international comparative studies on similar athletes, by other researchers.

## Methods

### Subjects

Thirteen male athletes, aged  $24.3 \pm 2.8$  years, participated in the study. They were selected into the national team based on their previous performance records at national, regional and continental athletic championships. The evaluation was done at the invitation of the Botswana National Sports Council in preparation for the All Africa Games in Johannesburg, South Africa.

### Testing protocol

The tests administered on the athletes were kinanthropometry / anthropometry (including somatotypes), anaerobic power and pulmonary function tests. These tests were administered to ascertain the level of readiness of the athletes within the preparation program for the continental athletic championship. All the athletes were involved in sprint races (100m, 200m and relay sprinting events). The kinanthropometric assessments involved the use of restricted profiles (Norton, Whittingham, Carter, Kerr, Gore, & Marfell-Jones, 1996) which, in addition to stature and body mass, consisted of nine skinfolds (triceps, subscapula, biceps, iliac-crest, supraspinale, abdominal, front thigh, medial calf and mid-axilla), five girths: arm-relaxed and arm-flexed, waist (minimum), gluteal (hip) and calf (maximum) and two breadths (humerus and femur). These profiles were assessed according to the protocol of the International Society for the Advancement of Kinanthropometry (1999). For the same-day test-retest reliability, three successive measurements, per site, were taken on each athlete. The athletes' anaerobic power output was assessed using the short-term Wingate Anaerobic Test (Wan T) described by Bar-Or (1981). Pulmonary (lung) functions in the athletes were assessed with the single-breath spirometry, using the standardized procedure by the American Thoracic Society (ATS) (1995).

### Data collection

Prior to reporting at the sports training camp, the participants were measured for all the tests at the Human Performance Laboratory, University of Botswana. They were duly informed of all the test protocols and evaluation procedures prior to the assessment. They then signed the informed consent forms. Their ages (in years), stature (in cm) and body mass (in kg) were recorded, followed by measurements of skinfolds, skeletal diameters and circumferences (in cm). Skinfolds were taken at carefully designated sites with a Harpenden skinfold caliper model 203, with a constant tension of  $10.1\text{g}\cdot\text{mm}^{-2}$  at all thicknesses. Skeletal diameters were measured to the nearest millimetre at the designated sites using a broad-blade anthropometer, whereas the circumferences were measured to the nearest centimetre using the 2-meter-long, retractable, flexible steel tape.

The Withers, Craig, Bourdon and Norton's (1987) equation was used to compute body

density (BD) from the anthropometric data, while lean body mass was determined using the equation by Withers, Laforgia, Heymsfield, Wang, and Pillans (1996). Percentage of body fat was derived from the equation proposed by Siri (1961), while body mass index (BMI) was determined from the measures of stature and body mass using the equation developed by Abernethy, Olds, Eden, Neill, and Baines (1996). The Heath-Carter method of somatotyping, in which anthropometry is used to estimate the criterion somatotype was used to determine the somatotypes of the athletes. The three components of somatotypes were compared using the equations for a decimalised anthropometric somatotype (Carter & Heath, 1990). The resulting somatotype values were then displayed on a standard somato-chart.

The Wingate Anaerobic Test (Wan T) was used to determine leg power over a 30-second period of super-maximum bicycle riding. Anaerobic power output variables of peak power, minimum power, average power and power drop were determined over six 5-second periods (Amusa, Toriola, Dhaliwal, & Mokgwathi, 1998; Bar-Or, 1981; Dotan & Bar-Or, 1983). For the determination of the athletes' lung function, the Erich Jaeger Masterscope Spirometry / flow volume model 780854 was used for the measurement of slow and forced expiration values as well as maximum voluntary ventilation (Jaeger News, 1996). The standardized diffusion capacity method advanced by the American Thoracic Society (ATS) (1995) was used to determine lung function variables of vital capacity (VC), forced vital capacity (FVC), forced expiratory volume after one second ( $FEV_1$ ), forced expiratory volume after one second in a percentage of VC ( $FEV_1^0$ ) and forced expiratory flow at 25%, 50% and 75% of FVC.

**Data analyses**

Data were analysed using simple descriptive statistics of mean, range and standard deviation.

**Results**

Data on the age, stature, body mass, lean body weight, body density, percentage of body fat, body mass index and somatotype values are shown in Figures 1 and 2.

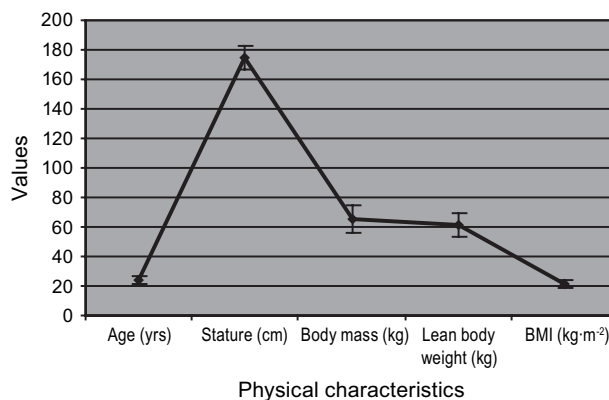


Figure 1. Mean ± SD of selected physical characteristics of the athletes (N=13).

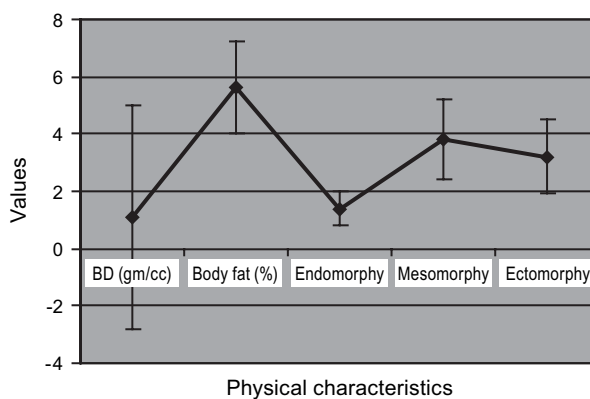


Figure 2. Mean ± SD of selected physical characteristics of the athletes (N=13).

Shown in Figures 3 and 4 are the data on the anaerobic (leg) power of the athletes.

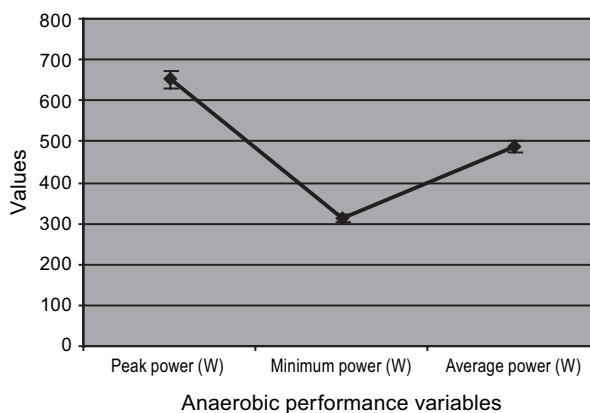


Figure 3. Mean ± SD of selected anaerobic power output of the athletes (N=13).

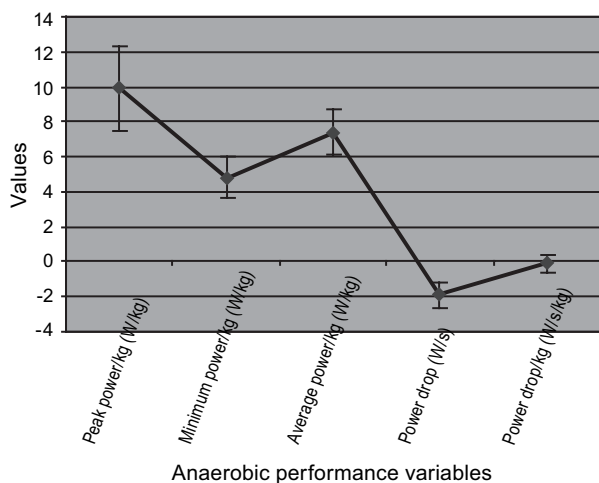


Figure 4. Mean  $\pm$  SD of selected anaerobic power output of the athletes (N=13).

Shown in Figures 5 and 6 are data on the selected single breadth variables of the athletes.

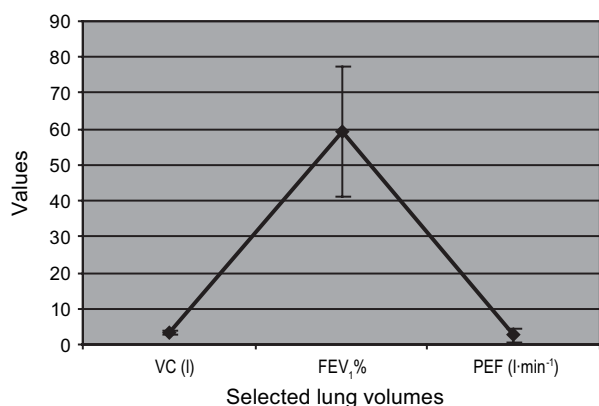


Figure 5. Mean  $\pm$  SD of selected single breath variables of the athletes (N=13).

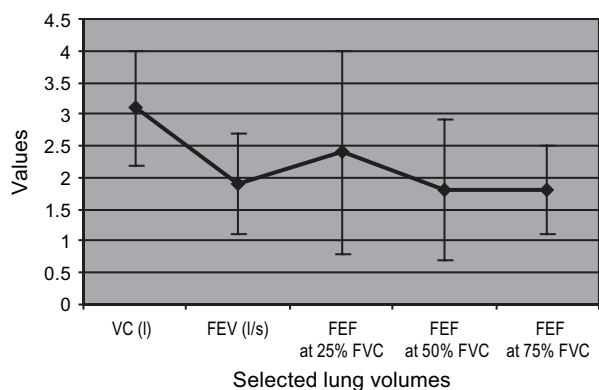


Figure 6. Mean  $\pm$  SD of selected single breath variables of the athletes (N=13).

## Discussion and conclusions

This is a descriptive study intended to ascertain the level of preparedness of thirteen Botswana sprint athletes for the All Africa Games, in terms of the various performance parameters required for success at the Games. Additionally, since they were to move into an intensive training session in the sports camp, the assessment was necessary to enable the coaches and trainers to focus on the possible performance characteristics requiring improvement, before the commencement of the Games. It was intended that the design and re-design of training programmes would be influenced by the outcome of this study. However, where possible, reference was made on how these athletes compared with their counterparts elsewhere in terms of the variables assessed.

The athletes' mean age of  $24.3 \pm 2.8$  years compares favourably with the  $25.6 \pm 6.5$  years for other African athletes studied during the 6<sup>th</sup> All Africa Games (De Ridder, Monyeke, Amusa, Toriola, Wekesa, & Carter, 2000) and athletes elsewhere (Norton, Olds, Olive, & Craig, 1996). Age is a crucial factor in physical fitness and performance. The younger the athletes, the fitter they are likely to be and the better their performances in comparison to older athletes in the same sport. The importance of stature in the determination of ultimate success in elite sports has been well substantiated (Ackland, Schreiner, & Kerr, 1997; Cox, Miles, Verde, & Rhodes, 1995; Norton, Olds et al., 1996; Khosla & McBroom, 1988).

The mean height of 174.2 cm reported for the athletes also compares favourably with the 174 cm reported for athletes in different events at the 1972 and 1976 Olympics (Norton, Olds et al., 1996) and the 173.5 cm for elite African athletes (De Ridder et al., 2000). Height may play an important role in athletic success. For example, shortness in stature is particularly advantageous in acceleration when changing direction. This favours shorter sprinters with a relatively lower moment of inertia or movement resistance. The minimum height of 157.0 cm reported for the athletes in this study may perhaps be a favourable factor.

Again, the mean body mass of  $65.3 \pm 9.2$  kg reported for the athletes in this study compares favourably with values reported for similar sprint athletes elsewhere (De Ridder et al., 2000; Ford, 1984; Khosla, 1968; Norton, Olds et al., 1996). These athletes had a mean body fat percentage of  $5.6\% \pm 1.6$ . Body fat is



related to body mass. Track events, in general, involve athletes for whom low body fat mass is a norm. This low body fat mass is considered desirable for athletic competition since higher fat values negatively affect success in track events. The observed athletes were involved in events requiring speed and explosive power. Therefore, excess body fat could increase body mass and decrease acceleration (Norton, Olds et al., 1996; Quinney, 1990). The athletes were within the weight and body fat limits that allowed for optimum mobility.

Body mass index (BMI) has been referred to as the traditional measure of obesity and also as an index of weight relative to stature (Abernethy, Olds, Eden, Neill, & Baines, 1996; Pounder, Carson, Davison, & Orihara, 1998). BMI is influenced, to an equal degree, by the body's lean and fat components (Hawe, 1996), suggesting that it is as much a measure of lean tissue as it is of fat. Whatever the views are about BMI, the fact remains that excessive BMI could have serious health and performance implications (Amusa & Onyewadume, 2001). The athletes in this study had a mean BMI of  $21.5 \pm 2.7 \text{ kg}\cdot\text{m}^{-2}$ . This was an expected BMI result as these were elite national athletes.

The technique of somatotyping has been employed in appraising the profile of athletes in various sports (Carter, 1996). In employing this technique, the magnitude of each of the three components of physique is always expressed in a three-number rating, representing endomorphy, mesomorphy and ectomorphy in that order. With the mean somatotype rating of  $1.4 \pm 0.6 - 3.8 \pm 1.4 - 3.2 \pm 1.3$ , the observed athletes may be referred to as low on endomorphy and moderate on mesomorphy and ectomorphy. These values are similar to the  $1.5 \pm 0.5 - 3.4 \pm 0.9 - 4.1 \pm 0.9$  reported for athletes in similar events by De Ridder and associates (2000). These athletes could be described as being ectomorphic-mesomorphs.

Track athletes are frequently required to generate high power output during a performance. The peak power (W) represents the phase of the activity when the athletes are at their peak performance. In some instances, they are expected to sustain this high power output a bit longer. Indeed, successful sprinters are characterised by their ability to produce very large power outputs very rapidly (Radford, 1990). This ability may be due to their possession of a high percentage of fast twitch (type II) fibres in their running muscles (Mero, 1985; Sadoyama, Masuda, Miyata, & Katsuta, 1988;

Torok et al., 1995). High anaerobic power (alactacid) and capacity (lactacid) thus seem very crucial in successful track performance. This is because these functional capacities are related to the metabolic and contractile properties of the contracting muscles.

With a mean peak leg power output of  $651.75 \pm 1.4\text{W}$  and a range of 304.3 - 972.10W, the majority of the athletes reached their peak power output too soon at the 20-second point of the test. While this may be desirable for athletes with the highest value, it was proper that athletes recording low values should be given extra strength and speed training in order to improve their peak power. Peak power was expected between the 15<sup>th</sup> and the 20<sup>th</sup> second points of the test, thereby causing the power-drop (the difference between the highest and lowest power outputs) to be very minimal. As the low trend was also manifested in the minimum power, average power, power drop and power drop per kilogram values, coaches and trainers must make modifications in their training programmes. To improve the performance variables, the maximum power generated between the 20<sup>th</sup> and 25<sup>th</sup> second points of the test should be sustained over the next few seconds to ensure the running speed does not drop too sharply. This must be the target of the remedial training if both coaches and athletes desire improvement and success at competitions.

The degree of leg strength that backs up leg speed directly determines the capability of an athlete to accelerate during sprinting events. The decrease in speed, often associated with the last phase of sprinting events, is largely due to local muscular fatigue. According to Nossek (1982), the decrease in speed as a result of muscular fatigue, manifests itself in low-level performers soon after short intensive performances of about 10s duration and indicates a lack of speed endurance quality. Therefore, to improve this anaerobic endurance capacity, coaches and trainers must adjust their training programmes to ensure repetitions of fast sprints.

There is a need to evaluate and monitor respiratory functions and their capacities as athletic events and training have been reported to elicit characteristic changes in trained athletes (Veda, Yanagidaira, Takeoka, Koshihara, & Yonemura, 1980). Measurement of lung volumes has proven to be a valuable guide in establishing the pulmonary functions as well as being a diagnostic tool in determining cases of abnormal lung functioning in individuals (McArdle,



Katch, & Katch, 1996). This information can guide coaches, trainers and athletes as to which sport, or competitions athletes are best suited, or prepared, for respectively. Vital capacity can be a good indicator of the preparedness of an athlete for competitions. For most sports, high values of vital capacity are beneficial (McArdle et al., 1996). Wilmore and Haskell (1972) reported vital capacities as high as 7.6 L for a professional football player and 8.1 L for an Olympic gold medallist in cross-country skiing. Therefore, the maximum values of 4.4 L and 4.4 L, for VC and FVC, respectively, for the observed athletes were not encouraging. Higher vital capacity values are required as athletes would then have an excellent ability to move large volumes of oxygen through air passages. In sprinting track events, this large volume can be a very beneficial reserve as the athletes might have the opportunity of breathing only a few times before the end of the race. Low values, as obtained in this study, can reflect, not only airway resistance but also, poorly conditioned or poorly functioning ventilatory muscles (Plowman & Smith, 1997). The FEV<sub>1</sub>

and FEV<sub>1</sub>% values provide information, not only on the total volume of air moved through the lungs, but also on the rate of flow of that movement. The advantage of these variables (FEV<sub>1</sub>, FEV<sub>1</sub>%, VC and FVC) is that their values can be used as screening tests prior to any serious competition or even selection for sports camps. Hence, for the observed athletes, it was strongly recommended that the coaches and trainers plan and execute a training programme designed for the development of the lung function variables.

The assessment of various performance parameters of the athletes in this study, was not just to evaluate their present physical fitness levels and readiness for pending competitions, but also to provide useful information to coaches and trainers in the design and re-design of training programmes used during the sports camping period. It was evident in this study that the athletes exhibited very low pulmonary function and peak leg power outputs. Recommendations were given to their coaches and trainers to re-design their training programmes for optimal benefits.

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# TJELESNA GRAĐA, ANAEROBNA SNAGA NOGU I RESPIRACIJSKI PARAMETRI TRKAČA IZ BOCVANE

## Sažetak

### Uvod

Vrhunska sportska postignuća današnjih sportaša rezultat su djelovanja mnogih, vrlo različitih faktora: genskih predispozicija, selekcije, treninga, zdravstvenog statusa, primjene znanstvenih spoznaja (primjerice, fiziologije, psihologije, nutricionistike, biomehanike, da spomenemo samo neke). Profili uspješnih sportaša modeli su koje treningom žele dosegnuti drugi. Ti se profili očituju u različitim razinama razvijenosti tjelesnih karakteristika i sportskih rezultata. Cilj je ove deskriptivne studije dati profil tjelesne građe (antropometrija, sastav tijela i somatotip), snage nogu i respiracijske parametre trkača iz Bocvane koji su se pripremali za Sveafričke igre. Namjera je bila pružiti trenerima podatke na temelju koji bi oni mogli planirati i programirati trening u pripremnom razdoblju kako bi poboljšali sportske rezultate svojih sportaša.

### Metode

Uzorak ispitanika činilo je 13 sprintera (muškaraca), članova reprezentacije Bocvane, prosječne dobi od  $24,3 \pm 2,8$  godine. Komponente tjelesne građe procijenjene su sljedećim antropometrijskim mjerama: tjelesna visina, tjelesna težina, postotak potkožnoga masnog tkiva (devet kožnih nabora, pet opsega i dva promjera), a izračunat je i indeks tjelesne mase (BMI) te je procijenjen somatotip. Mjere anaerobne snage obuhvatile su maksimalnu, minimalnu i prosječnu snagu ( $W$ ) te pad snage ( $W/s$ ). Testovi plućnih funkcija obuhvatili su mjere vitalnoga kapaciteta ( $VC$ ), forsiranog

ekspiracijskog volumena u 1 s ( $FEV_1$  i  $FEV_1\%$ ), vršni ekspiracijski protok ( $PEF$ ), forsirani vitalni kapacitet ( $FVC$ ) i forsirani ekspiracijski protok ( $FEF$ ). Za analizu podataka upotrijebljena je deskriptivna statistika.

### Rezultati

Podaci o dobi, visini, težini, mišićnoj tjelesnoj masi, tjelesnoj gustoći, postotku masnoga tkiva, indeksu tjelesni mase i somatotipske vrijednosti prikazane su na slikama 1 i 2. Podaci o anaerobnoj snazi nogu prikazani su na slikama 3 i 4. Parametri jednog respiracijskog ciklusa prikazani su na slikama 5 i 6.

### Rasprava i zaključak

Podaci o bocvanskim sprinterima promatrani su kao apsolutne vrijednosti, ali su i uspoređeni s podacima o drugim vrhunskim atletičarima. Nema razlike između bocvanskih i drugih sprintera u dobi, tjelesnoj visini, tjelesnoj težini, postotku masnoga tkiva, BMI, a slični su i po somatotipu. Bocvanski su atletičari postigli puno lošije rezultate u mjerama anaerobnog kapaciteta od poželjnih i očekivanih, a osobito su bili loši rezultati u mjerama pada snage. Stoga su treneri upozoreni da posvete osobitu pozornost treningu jakosti, brzine i brzinske izdržljivosti. Nisu bile ohrabrujuće ni vrijednosti postignute u mjerama respiracijskih funkcija, što je govorilo o slaboj kondicijskoj pripremljenosti sprintera. Na temelju dobivenih rezultata trenerima je preporučeno kako da prilagode program treninga ne bi li poboljšali pripremljenost svojih sportaša.