Original Article

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Training indicators as predictors of the sport performance of the race walker Matej Tóth in YTC 2013/2014 to YTC 2015/2016

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Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract

Introduction: This paper shows the impact of effect of the training indicators to the sport performance of the Olympic and world champion in the men's 50-kilometer race-walk Matej Tóth in year training cycles YTC - year training cycles 2013/2014 to YTC 2015/2016. *Method:* The basis of the analysis were the training volume indicators and the annual sport performance. Nonparametric procedures were chosen according to the assessment of the normality of file layout. Differences between the completed volume were evaluated statistically (Z) and substantively ("r"). The nonparametric algorithm CART was used for the construction of the regression trees. *Result:* By the CART method were selected training indicators which showed in the individual YTC high tightness with racewalking performance. In the YTC 2013/2014 (50 km 3:36:21 h; 20 km: 1:19:48 h) indicators of tempo endurance, special intensive and extensive tempo endurance has enforced in the model. Peak of the YTC 2014/2015 (50 km 3:34:38 hod; 20 km 1:20:21 hod) were the World Championships in Beijing. Intense special endurance, intense aerobic endurance and extensive tempo endurance have been enforced between the predictors of the walking performance. The training loss in the Olympic YTC 2015/2016 (50km 3:40:58h) had caused the reduced volume of the total load and walk training indicators. The reduced volume was compensated by increased volume of the cross-country skiing, training adds and by the walking at an extensive aerobic rate. This fact was reflected in the low number of regression tree factors. Number of training units and extensive special endurance came to the fore for the 50 km performance. *Conclusion:* In all YTC the impact of special endurance on sport performance has been proved. The specific periodization YTC showed cumulative effect of rate and aerobic endurance or training units.

Keywords: athletics, racewalk, training indicators, performance, regression trees

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INTRODUCTION

Periodization of the training load content in the walker´s annual training cycle is dependent on type of the actual phase, conceptual models which are used in the sport preparation, preferred disciplines, numbers of peaks in the session, system of top events in the annual cycles, etc.

Gradual transition from the accumulation phase through the intensification phase to the transformation phase is the guarantee of the good sport performance with cumulation on planned sport event [1-3].

The accumulation period which is characterized by the continuous aerobic load should be followed by the intensification period focused on strength and endurance – force load. For next period of transformation is characteristic interrupting training with gradual transition to the maximum sport performance in cumulating competition period. These individual components do not exist separately. Their reversible ratio in periods is given by length of the period, volume and load intensity (figure 1). Conceptual basis in the preparation of walkers is formed by recommended load volume with possible deviations (table 1). Increasing performance requires adequate “narrowing” of the content corridor towards special tempo. Process of the walker´s qualitative transformation in some time horizon requires reconciliation of the aerobic and anaerobic training.

The importance of monitoring changes in the anaerobic threshold and efficiency of individual training periods in annual cycle is confirmed. Anaerobic threshold level changes subsequently require speed changes in every training means in individual bioenergetics zones [4].

From the perspective of the effective development of long-term and middle- term endurance is important to stimulate aerobic performance and aerobic capacity. The level of aerobic performance and aerobic capacity directly limits sport performance in the race walk. While we can increase the aerobic performance by 15-25%, in aerobic capacity there are greater possibilities. An optimal training impulse for development aerobic performance and aerobic capacity of the aerobic endurance is at the level of the anaerobic threshold (3-6 mmol.l^{-1}). From the perspective of sport practice, the intensity between the 90-100% VO_2max develops aerobic performance and lower intensity as the 90% VO_2max develops aerobic capacity.

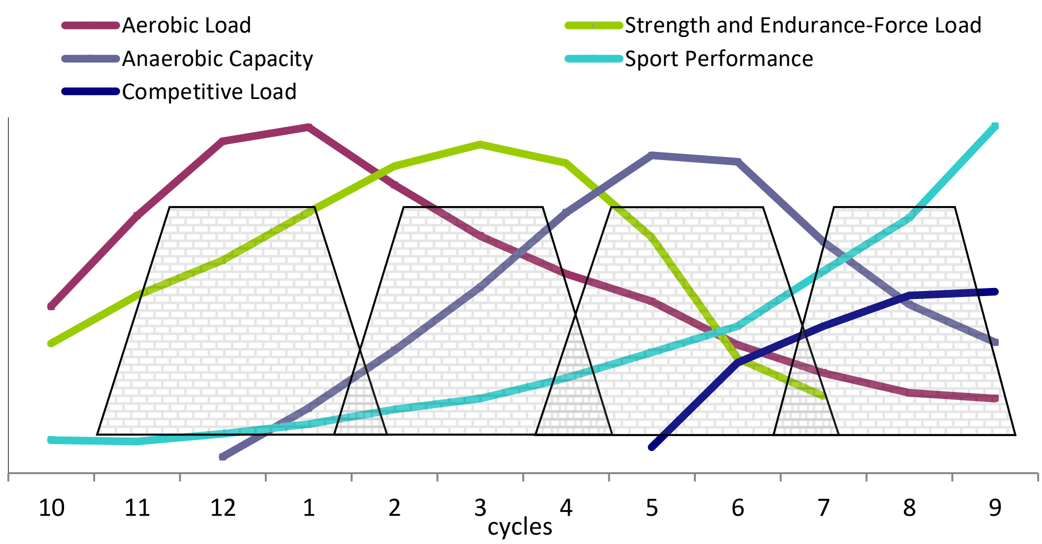

Figure 1. The concept model of the annual sport preparation of the racewalker in its individual stages [2,5,6].

Table 1. The structure of the training load and concept for creating training content of 20 and 50 km race walk.

		20 km	50 km
Bioenergetics share	**AEROBIC / ANAEROBIC** VO2max	**90:10%** 75-80	**95:5%** 80>
Aerobic load Rate 5:00 min·km^{-1} and above	**Tempo endurance 1** Lactate: 0-2 mmol·l^{-1}	25	30
	Tempo endurance 2 La: 2	30	**35**
Aerobic-anaerobic load Rate 5:00 - 4:05 min·km^{-1}	**Tempo endurance 3** La: 2-4	**35**	30
Anaerobic lactate Rate 4:05 min·km^{-1} and better	**Special endurance** La: 4-9	8	3-5
	Tempo speed La: 9>	3	-

Note: The pace of walking in individual bioenergetics zones has been adjusted according to Matej Tóth´s training diaries from 2013 [8].

Training methods determines the internal dynamics of the training load model. In the race walking, we use quantitative (continuous, fartlek, cyclic aimed to develop aerobic and anaerobic power) and qualitative methods (interval, repeating, cyclic). Their application in the structure system development of the aerobic capacity and performance has a wide variability and use. Diversity of variants develops in connection with specific adaptive changes and needs of competitive condition (different length, intensity changing, determined extensive and intensive lengths). The method of the modelling of the competitive load participate in the adaptation from the psychological point of view. From the perspective of training practice is necessary to combine all methods, means and forms so that they can complete the tasks of all components in the race walking. The decisive factor determining race walking performance is the reached degree of adaptation of the body to long-term intensive work [7].

The race walkers should complete 4000-6000 km annually [9,10]. The decisive motor skills in terms of sport performance in 20 km and 50 km race walking is special endurance which binds to a length of the racing distance. The special endurance in the 20 km race walk is realized by sport performance on the level of individual anaerobic threshold and in the 50 km race walk is load intensity at 93-97% of anaerobic threshold [11,12]. Load volume in special tempo is highly individual. Quantization needs complex and long-term approach which is reflected in specific impulse dosage in the time horizon, respecting the biological and pedagogical principles of adaptation and identification the athlete´s recovery processes [11, 13].

Reverse analysis of training plans allows to identify the training resources which were most involved in improving race walker´s performance. Their exact identification allows to rationalize periodization of the training process, coordinate conceptual backgrounds of the preparation and to improve the system of enhancement of sport performance. In our post we tried to point out "ex post facto" to the resources with the highest participation in sport performance of the Olympic and world champion in the men's 50-kilometer race walk Matej Tóth in years 2015 and 2016.

MATERIALS AND METHODS

Representative of the Slovak Republic in 50 km and 20km race walk - Matej Tóth (1983) has recorded from 1999 to 2016 progressive growth in sport performance (figure 2). Since the YTC 2013/2014 he trains under the guidance of coach Matej Spišiak and he won the title of world champion (Beijing 2015) and title of the Olympic champion (Rio 2016).

Training indicators (figure 2) are the starting points for detecting factors which determines the sport performance in YTC 2013/2014, YTC 2014/2015 and YTC 2015/2016. The basis of analysis was weekly – volume training indicators VTU 115-120, special training indicators STU 101-114 and the yearly sport performance SV recalculated to point values according to the IAAF tables (table 1). Length

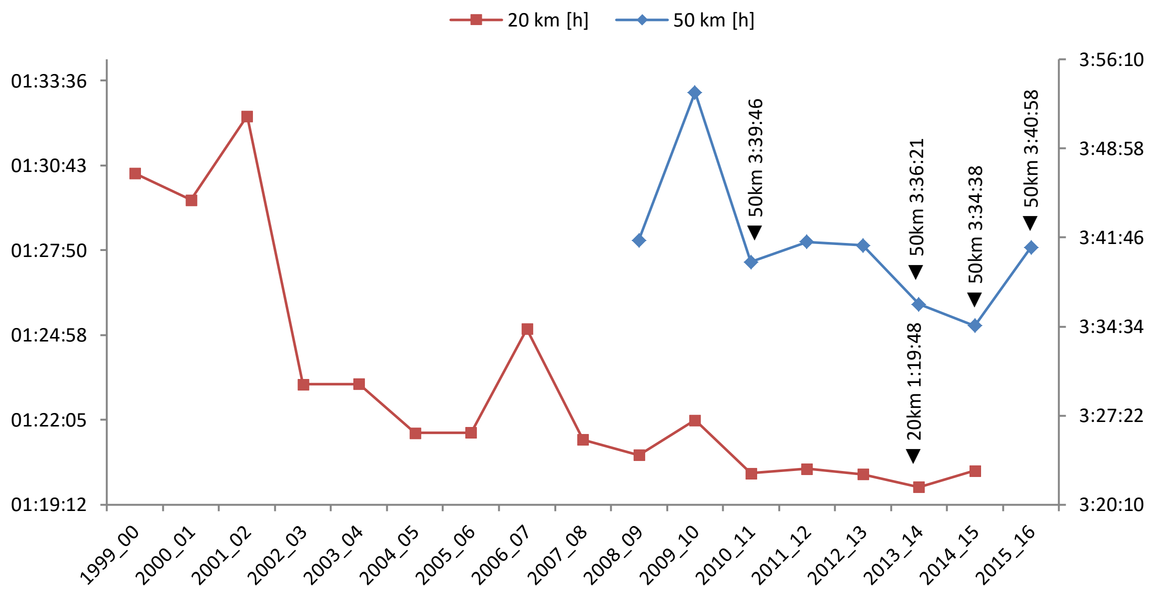

Figure 2. Dynamics of sport performance MT in years 1999-2016.

of time series of YTC = 52 weeks. Nonparametric procedures [14-16] were chosen according an assessment of the file layout normality (Kolmogorov-Smirnov test and Shapiro-Wilk test). Differences between the completed volume of training indicators in YTC were assessed statistically (Wilcoxon Z test) and by their value (effect size "r"). The nonparametric algorithm CART was used for the construction of the regression trees (classification and regression trees). Tree regression was preceded by a 5-factor factor analysis. Nonparametric algorithms are characteristic by their data obtaining from low-numbered files and files which do not meet the conditions of normality layout.

RESULTS

Volume of the training indicators in YTC 2013/2014 is the same in all indicators (p=ns - not significantly). In both annual cycles, the racewalker focuses on both disciplines. Sportsmen injury in Olympic YTC 2015/2016 in comparison with previous years caused total loss of load and some walk training indicators ($p<0.01$). By this reason he chooses only one-peak session with the peak at the 50 km racewalk at the Olympic Games. Missed trainings were a result of reduction in the sport performance score. Reduced volume of the walking and running load was compensated by increased volume of cross-country skiing and the other complementary activities such as stationary bicycle, bicycle, swimming ($p<0.01$; $r>0.30$), training supplements ($p<0.01$; $r>0.40$) and by walking in slow pace (STU 109; $p<0.05$) which was reflected in the increased number of training units ($p<0.01$; $r=0.30$) and in the total load time ($p<0.01$).

By factor analysis and CART method were selected training indicators which in the individual YTC showed up high tightness with racewalk performance. On pictures 3-5 we can see unerupted regression trees. Performances are predicted at point according to the IAAF tables. Training indicators forms node variables with indicating the boundary volume values for prediction of the number of performances by higher and lower load volume. Regression parameters are presented near the models (R, SD, ME, MAE). Using them, we can define the model predictive reliability as in linear regression. In year training cycle YTC 2013/2014 (50 km 3:36.21 h; 20 km: 1:19.48 h) the model of rate persistence has been applied to the model STU 105 ($p<0.01$) a STU 106 ($p<0.05$), intensive special endurance

Table 2. Volume comparison of general and special training indicators in YTC 2013/2014, YTC 2014/2015, YTC 2015/2016.

			YTC [SUM]			YTC 2013/2014 <> YTC 2014/2015			YTC 2013/2014 <> YTC 2015/2016			YTC 2014/2015 <> YTC 2015/2016		
		Training indicators	2013/14	2014/15	2015/16	Z	p	r	Z	p	r	Z	p	r
VTU	115	Load days [n]	325.0	342.0	322.0	1.79	0.07	0.18	0.37	0.71	0.04	1.22	0.22	0.12
	116	Training units [n]	437.0	466.0	516.0	1.64	0.10	0.16	3.06	0.00	0.30	2.34	0.02	0.23
	117	Race - Start [n]	14.0	10.0	3.0	0.47	0.64	0.05	2.00	0.05	0.20	1.90	0.06	0.19
	118	Total load time [min]	581.1	691.0	754.0	2.15	0.03	0.21	3.55	0.00	0.35	2.12	0.03	0.21
	119	Regeneration of forces [min]	285.1	347.0	486.0	0.75	0.45	0.07	4.94	0.00	0.48	3.66	0.00	0.36
	120	Days of illness and disability [n]	12.0	6.0	83.0	0.68	0.50	0.07	3.20	0.00	0.31	3.13	0.00	0.31
STU	101	Walk below 3:40 min·km-1 [km]	110.0	88.0	32.0	1.29	0.20	0.13	3.56	0.00	0.35	2.88	0.00	0.28
	102	Walk 3:41 - 4:05 min·km^{-1} [km]	261.0	258.0	56.0	0.38	0.70	0.04	3.36	0.00	0.33	3.52	0.00	0.35
	103	Walk 4:06 - 4:20 min·km^{-1} [km]	220.0	279.0	165.0	1.07	0.29	0.10	0.23	0.82	0.02	0.71	0.48	0.07
	104	Walk 4:21 - 4:40 min·km^{-1} [km]	541.0	698.0	451.0	0.88	0.38	0.09	0.25	0.81	0.02	0.99	0.32	0.10
	105	Walk 4:41 - 5:00 min·km^{-1} [km]	1185.0	1458.0	989.0	1.45	0.15	0.14	1.08	0.28	0.11	2.31	0.02	0.23
	106	Walk 5:01 - 5:20 min·km^{-1} [km]	1328.0	1296.0	1190.0	0.40	0.69	0.04	1.13	0.26	0.11	0.70	0.49	0.07
	107	Walk 5:21 - 5:40 min·km^{-1} [km]	358.0	295.0	298.0	1.04	0.30	0.10	0.23	0.82	0.02	0.27	0.79	0.03
	108	Walk 5:41 - 6:00 min·km^{-1} [km]	18.0	24.0	1.0	0.00	1.00	0.00	1.80	0.07	0.18	1.77	0.08	0.17
	109	Walk 6:00 and over min·km^{-1} [km]	241.0	294.0	384.0	0.63	0.53	0.06	2.01	0.04	0.20	1.88	0.06	0.18
	110	Total Walk [km]	4262.0	4685.0	3566.0	1.26	0.21	0.12	1.36	0.17	0.13	2.68	0.01	0.26
	111	Total Run [km]	656.0	740.0	429.0	1.09	0.27	0.11	2.29	0.02	0.22	4.06	0.00	0.40
	112	Sum of runs [km]	92.0	177.0	476.0	1.39	0.16	0.14	4.14	0.00	0.41	3.49	0.00	0.34
	113	Total volume [km]	5000.0	5602.0	4471.0	1.77	0.08	0.17	0.86	0.39	0.08	2.56	0.01	0.25
	114	Training accessories [h]	122.3	148.0	293.0	0.72	0.47	0.07	4.65	0.00	0.46	4.53	0.00	0.44
SV	Sports performance [points]		52519.59	51815.87	45285.73	0.72	0.47	0.07	2.24	0.03	0.22	1.62	0.11	0.16

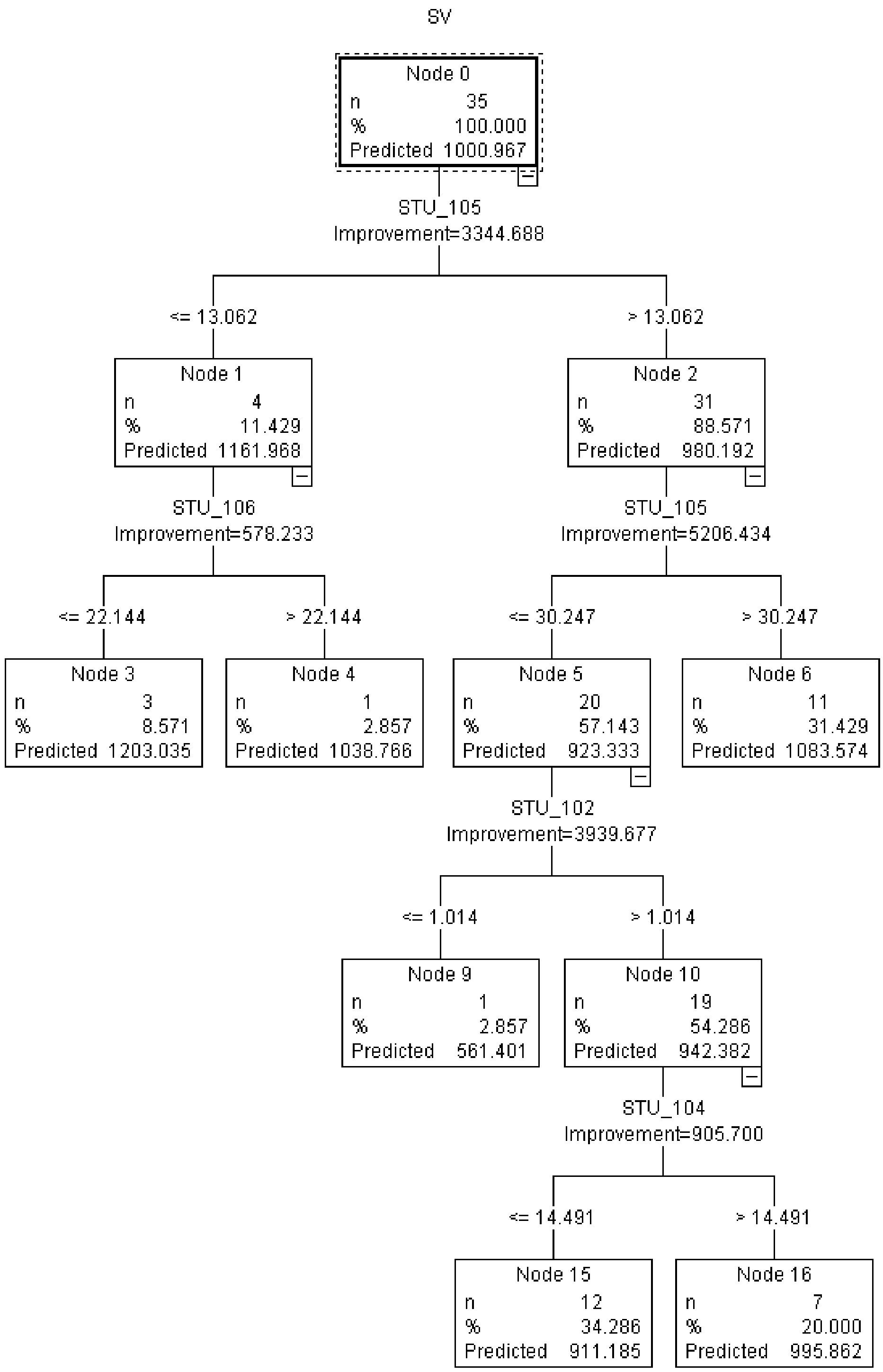

Figure 3. Regressive tree of selected training indicators of sport performance in YTC 2013/2014 (R = 0.89; SD = 61.37; ME: 9.74; MAE = 36.11).

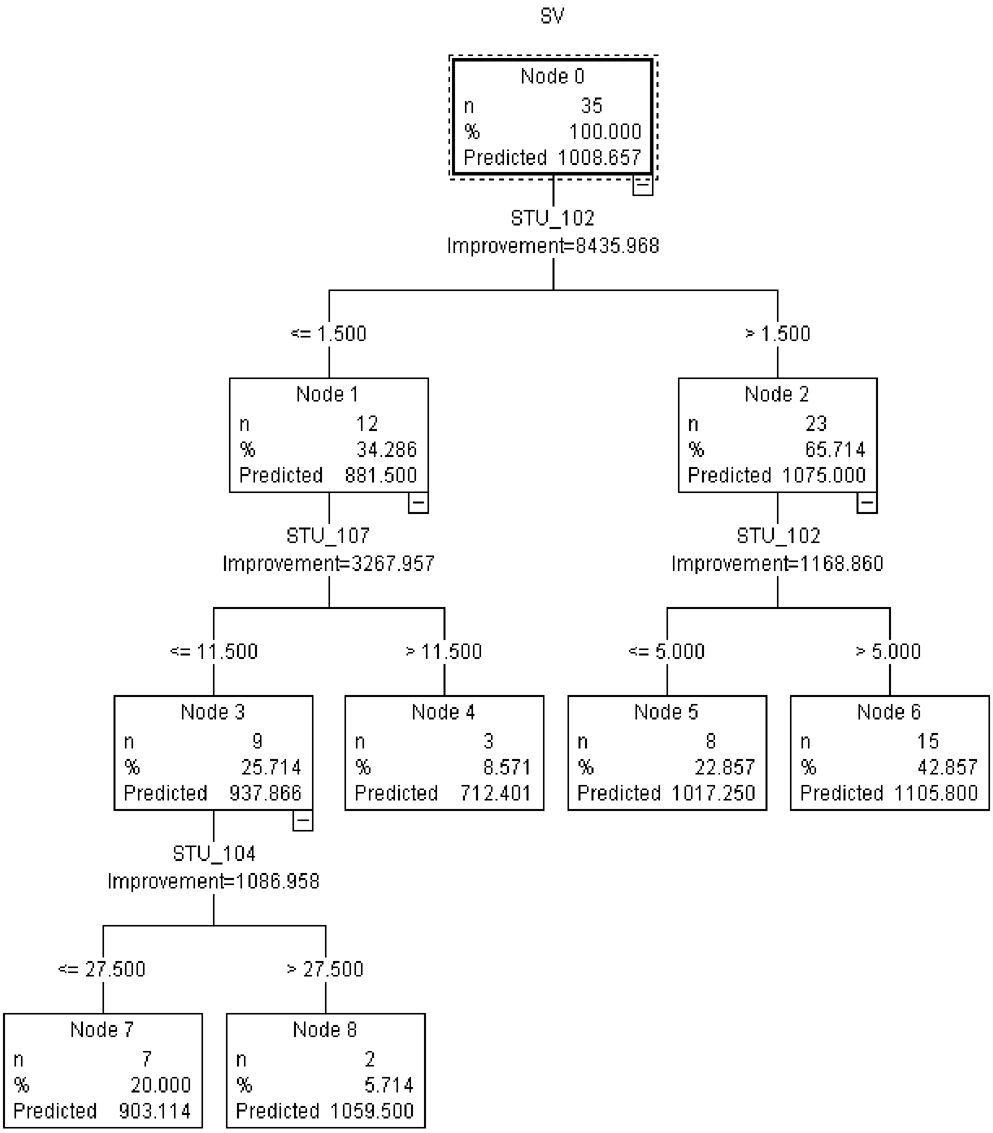

Figure 4. Regressive tree of selected training indicators for sport performance in YTC 2014/2015 (R = 0.79; SD = 82.76; ME: 6.45; MAE = 62.24).

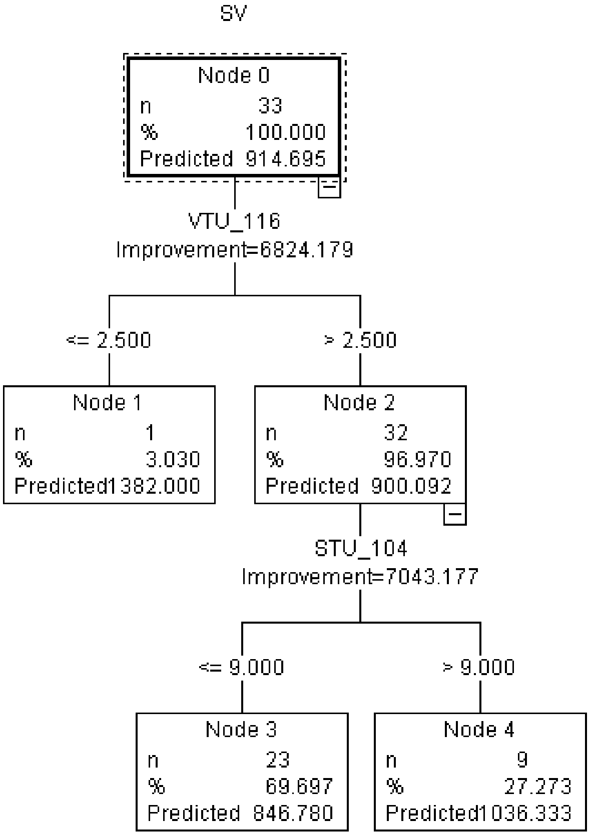

Figure 5. Regressive tree of selected training indicators for sport performance in YTC 2015/2016 (R = 0.72; SD = 139.17; ME: 2.99; MAE = 97.13).

STU 102 (p<0.01) and extensive special endurance STU 104 (p<0.01). In this case the reliability of the model is R = 89 which we can consider as reliable model. For the rest training indicators, the relationship with sport performance has not been established. The most prominent training indicator predicting training performance as 1161 points (10 km 39:17 min; 20 km 1:21:24 h; 50 km 3:50:20 h) is extensive tempo endurance STU 105 with boundary weekly volume 13.1 km (model for 4 performances) and the extensive tempo endurance STU 106 with boundary volume 22.15 km weekly, by predicted performance 1203 points (10 km 38:19 min; 20 km 1:19:27 h; 50 km 3:43:21 h). For performances lower than 1083 points, intensive tempo endurance STU 105 with boundary volume 30.25 km per week, intensive special endurance STU 102 with a volume lower than 1.014 km per week and extensive special endurance STU 104 with boundary volume load per week 14.50 km, has been established into the model.

World Championships in Beijing were the peak for the annual training cycle YTC 2014/2015 (50 km 3:34:38 hod; 20 km 1:20:21 hod). Among the predictors of racewalking performance (figure 4) have enforced the intensive special endurance STU 102 (p<0.01), intensive aerobic endurance STU 107 (p<0.05) and the extensive special endurance STU 104 (p<0.01). Even in this case, the reliability of the model is high R = 0,79 which we can consider as a reliable predictive model. In case of completing higher volume of kilometers of intensive special endurance (>5.0 km/week) is predicated sport performance 1105 points (10 km 40:36 min, 20 km 1:24:03, 50 km 3:59:51 h). For predicted performances weaker than 1059 points the training indicators with boundary volume per week STU 102 (1.5 km) STU 107 (11.5 km) and STU 104 (27.5 km) has been established into the regression model.

Missed trainings according to injury in the year training cycle YTC 2015/2016 had a cause of lowered load volume and some training indicators of racewalking (table 2). Racewalker tried to compensate the lowered volume by increasing volume of cross-country skiing, training complements and walking in the extensive aerobic tempo which was reflected in the increased number of training units and total load time. This fact was reflected in the low number of selected factors (n=2) of regression tree (figure 5). Number of the training units STU 116 ($p<0.05$) and extensive special endurance which is characteristic for the 50 km STU 104 ($p<0.01$) performance, has been pushed forward. By the predicted selection of 1036 points (10 km 42:15 min; 20 km 1:27:25 h; 50 km 4:11:54 h) the more as the 9.0 km per week is needed. The model reliability is R = 0,72 which we can consider as the reliable predictive model.

DISCUSSION

The decisive motor skill in terms of sport performance in 20 km and 50 km race walking is special endurance which binds to the length of racing distance. The special endurance in 20 km race walking is performed at the level of an individual anaerobic threshold [17]. Physiological parameters as maximal oxygen consumption (VO_2max), anaerobic threshold (AnT) reaches high values in top racewalkers at 20 km. There were detected values of VO_2max at the maximum load at the level of 79.8 $mmol \cdot l^{-1}$. VO2max percentage usage during the sport performance is 80-90%. Heart rate values at the ANP level range from 170 to 190 pulses min^{-1} in run tempo from 3.8 to 4.1 $m \cdot sec^{-1}$. The intra-individual variability of the lactate level ranges from 2 - 14 $mmol \cdot l^{-1}$. Energy consumption per minute ranges at the level of 105 kJ [11]. 50 km race walking is specific discipline with endurance character where the racer usually complete even 98% of distance in aerobic mode and load intensity is on 93 – 97% of anaerobic threshold level [11]. Estimated energetic expenditure is on the level at 3600 kcal by walking speed 13.8 $km \cdot hour^{-1}$ [18]. When modelling the training load in annual macrocycle in combination: two-peak session on 50 km and two top world race walking events, realization of high load in the accumulation period in 106–105 zones and gradually increasing the load intensity with lower load in the intensification period in 104–102 zones, is important. Long-term intensification with the high load in zones 104–101 appears to be ineffective [19]. Athletic preparation of M. T. points to high intra-individual patterns of special training indicators for race walking performance. Dynamics of the total load capacity and special training resources was based on the conceptual models of individual annual macrocycles, preferred disciplines in the corresponding macrocycle period, number of starts to 50 km and combination of both disciplines on the top athletic events [20-23].

The structure of training load in M. T. in the first two annual training cycles was based on the conceptual models for 20 km and 50 km racewalk. Realization of high load volume in the accumulating period in areas 107-105 and gradually increasing intensity of load with lower volume in the intensification period in areas 104 and 102 was reflected in selection of the training indicators (predictors) which affected the sport performance. The specific realization of Olympic cycle confirmed focus and importance of special tempo realized in area STU 104 for 50 km racewalk. Even thought that this is the example of high intra-individual periodization of load in relation to the monitored athlete, we can say that the obtained results correspond with findings from racewalking and professional practice [5-7, 9, 12, 13, 20-23].

CONCLUSION

In this paper we pointed to the specific impact of the training load on sport performance of the Slovak Republic racewalk representative during the last three years of Rio de Janeiro´s Olympic macrocycle. Using factor analysis and the construction of regressive trees was selected training load which shows higher tightness with sport performance in competent annual training cycle. The load has been characterized in terms of volume and intensity or more precisely by the variability of prediction of sport performance.

In all YTC the impact of the special endurance on sport performance has been proven. The specific periodization of annual training cycles shows cumulative effect of tempo and aerobic endurance and the cumulative number of training units in the Olympics cycle. The regression analysis points to the training resources which were most involved in the improvement of the sport performance. Their exact identification will allow the rationalization of the training process in the future, coordinate the conceptual bases of sport preparation and to improve the system of shaping the top condition towards the 2020 Olympics in Tokyo.

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