Journal of Physical Education and Sport ® (JPES), Vol. 23 (issue 10), Art 311, pp. 2718 - 2727, October 2023
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Training load determining sports performance in swimming

MATÚŠ GUZMAN[1], JAROSLAV BROĎÁNI[2]
[1,2]Department of Physical Education and Sports, Constantine the Philosopher University in Nitra, SLOVAKIA

Published online: October 31, 2023
(Accepted for publication : October 15, 2023)
DOI:10.7752/jpes.2023.10311

Abstract
The representative from Slovak Republic, T.P., documented a noteworthy progression in sports performance within swimming disciplines during ATC 2020-2021. Notably, the 400 freestyle event showcased an impressive performance 3:49.03. In the analysis of the data, we used the method of studying the training diaries of the athlete from the annual training cycle 2022. From the point of view of general training indicators, we focused on days of loading (GTI 110), 111 training units (GTI 111), competitions / starts (GTI 112), load time (GTI 113), regeneration time (GTI 114) and days of medical incapacity (GTI 115). Of the special training indicators, we focused on total flown (STI 101), warm-up and swim-out (STI 102), aerobic endurance (STI 103), anaerobic endurance (STI 104), swim in race pace (STI 105), elemental arm swimming (STI 106), elemental leg swimming (STI 107), technical exercises (STI 108). A retrospective analysis delved into the classification of specialized and general training resources, pinpointing those with the highest correlation to sports performance in swimming. Employing non-parametric techniques, such as the Spearman correlation coefficient and decision trees of CHAID, facilitated the identifications of interactions and predictions. Among the special training indicators, factors influencing sports performance encompassed the volume of load swum at race pace (STI 105), the volume of warm-up and swim-out (STI 102), as well as the volume of aerobic and anaerobic endurance (STI 103 and STI 104). General training indicators also played a crucial role, with indicators such as the number of starts (GTI 112), occurrences of sick days (GTI 115), total load time (GTI 113), and number of training units (GTI 111) being key determinants of year-round athletic performance. The precise identification of training parameters in terms of volume and intensity the stage for rationalizing the periodization of the training process. This approach aims to align conceptual foundations enhance the tuning system for the observed swimmer's sports form, preparing them for upcoming top-tier world events.
Key Words: Swimming. Performance. Training load. Prediction. Regression trees.

Introduction

Changes in levels in the area of sports performance are unthinkable without purposeful use and manipulation of the training load. That is why sports performance is limited by factors that can be more or less influenced in the training process. Also, the load in sports training and subsequent coping with it has a decisive role in increasing the level of abilities or characteristics (Gussakov et al. 2023; Yakovlev et al. 2018).

As a result of properly adjusted periodization of the training load, athletes are able to achieve their highest state of readiness at the top events (Platonov, 2019). By evaluating the training load, we are able to identify and evaluate general and special training indicators. With this obtained data, coaches are able to predict and forecast the sports performance of their trainees during the entire training. Therefore, the training process should be constantly monitored (Pretorius, 2020; Makar et al. 2023).

For top swimmers, the most important thing is to swim faster and have better times than their competitors, or to be the fastest swimmer ever and to break personal, national or even world records (Kachaunov & Petrov, 2020).

Over the last few decades, we have seen a steady rise in the performance of swimmers. In the period between 2008 and 2009, we recorded a total of more than 130 world records broken. The sports public has attributed such a number of broken records mainly to swimsuits, which have undergone significant changes. These swimsuits were subsequently banned by the international swimming federation FINA, and the sports public thought that the records swum in these swimsuits would remain unbroken for a long time. In fact, many of these records have been broken to date.

It is the constant improvement in swimming performance that puts pressure on swimming coaches, and coaches are thus forced to invent new training methods or optimize existing training methods.

According to Bompa (1999), the training process is characterized by its complexity and versatility, as it is constantly changing as a result of applying the chosen load. The main task of the training load is to improve the level of given activities, abilities and characteristics (Pla et al. 2019).

Each of the disciplines in swimming is characterized by its specificity of training load, volume swum in the aerobic zone, anaerobic zone and especially the volume at a special (race) pace. The volumes of the different

Corresponding Author: MATÚŠ GUZMAN, E-mail: matus.guzman@ukf.sk

characteristics can also vary considerably among swimmers with the same specialization of disciplines. The task of the race pace is to prepare the athlete for the course of the discipline itself. In the literature, we can find many recommendations for the weekly volume of training load, such as: Chatard & Stewart (2011); Hellard et al. (2019); Pollock et al. (2019) Solonenco et al. (2021); Gonzalez Rave et al. (2021); Hermosilla et al. (2021); Ravé et al. (2022).

Based on recommendations from individual literature, we can develop a precise training load structure for the microcycle. However, it is necessary to pay attention to the fact that the given recommendations and the ratio of individual characteristics will not suit every swimmer, and the volume of the special (race) pace will be different for each of them. There is therefore no exact template or recipe for the unambiquous application of the training loads in sport training that is generally valid. So far, knowledge and information we are aware is only generalized.

Problem

The identification of the training load, which limits the sports performance in swimming to 400 m Freestyle, belongs to the necessary components in the field of management and rationalization of the training load for the purpose of improving the quality of sports training and the system of tuning sports form for top world events such as the European Championship, the World Cup and the Olympic Games.

Objective

The aim of the work is to highlight the intraindividual periodization of training load in the Slovak national swimming representative (T.P.) and to identify the training indicators that determined the year-round level of sports performance in the annual training cycle 2022.

Material & Methods

Representative of the Slovak Republic T.P. (born 2002) recorded a progressive growth of sports performance in swimming disciplines between 2012 and 2019. In the annual training macrocycle 2020 - 2021, T.P. so far his best personal performance in the discipline of 400 m Freestyle - 3:49.03 (February 19, 2021 Šamorín).

General and specific training indicators from the training diary (tab. 1) are the starting point for the detection of determinants of sport performance in the RTC 2022 annual training cycle. The basis of the analysis was the weekly - volume training indicators GTI 110-115, STI 101- 108 and year-round sports performance (SP) converted to point values according to FINA tables (tab. 1). The length of the annual time series was 52 weeks. Sports performance in individual weekly microcycles was converted to point values from swimming performances and tests for 50 m, 100 m, 200 m and 400 m.

Table 1. Volume of general and special training indicators in the annual training cycle 2022

Code		Training indicators	Sum	Min	Max	M	SD
SP		Sport performance (points)	32023.00	460.00	779.00	615.83	99.24
GTI	110	Days of loading (n)	286.00	3.00	7.00	5.50	0.90
	111	Training units (n)	490.00	5.00	13.00	9.42	1.83
	112	Competitions / Starts (n)	102.00	0.00	14.00	1.96	3.40
	113	Load time (h)	853.00	8.00	25.00	16.40	3.16
	114	Regeneration time (h)	271.00	4.00	8.50	5.21	0.99
	115	Days of medical incapacity (n)	11.00	0.00	2.00	0.21	0.57
STI	101	Total flown (km)	2410.95	24.10	74.95	46.36	12.29
	102	Warm-up and swim-out (km)	481.85	3.90	14.55	9.27	2.22
	103	Aerobic endurance (km)	974.05	8.20	39.80	18.73	6.54
	104	Anaerobic endurance (km)	38.25	0.00	1.55	0.74	0.38
	105	Swam in race pace (km)	180.53	0.18	6.90	3.47	1.85
	106	Elemental arm swimming (km)	322.85	0.90	16.30	6.21	4.11
	107	Elemental leg swimming (km)	316.80	2.60	10.50	6.09	2.07
	108	Technical exercises (km)	94.00	0.00	5.70	1.81	1.39

Nonparametric procedures (Breiman et al. 1984, Lehmann 1975) were selected based on an assessment of the normality of the distribution of the sets. The interaction between sports performance and training indicators has been assessed by the Spearman correlation coefficient r^s. (Cohen 1988).

The non-parametric algorithm CHAID - Chi-squared Automatic Interaction Detector and Trees (Breiman et al. 1984) was used to construct decision trees. This technique can be used for prediction (an alternative to parametric multiple regression), classification and detection of interactions between variables.

Results are obtained by automatically detecting relationships between independent variables based on chi-square tests. The advantage of the CHAID (Classification and Regression Trees) technique is in a better summary, interpretation and presentation of binary trees. CHAID creates trees that tend to have multiple branches (options). In each step of the analysis, it searches for one predictor that has the greatest influence on the dependent variable categories (Camp & Slattery, 2002).

However, CHAID may not always find an optimal distribution for the variables. Once it finds that all remaining categories are statistically different, it stops merging categories. For the models, we also present the regression parameters (Linear Correlation R, Standard Deviation SD, Mean Absolute Error MAE; Mean Error ME). Using them, we can define the prediction reliability of a non-parametric model as in linear regression. The results were processed in MS Excel and IBM SPSS Modeler. The findings and conclusions are formulated on the basis of objective and logical evaluation of the obtained results.

Results

The intraindividual periodization of the training load allowed the Slovak representative in swimming (T.P.) to achieve the highest scoring performance in RTC 2022 with a value of 779 points in a discipline of 400 m VS with a achieved time of 3: 59.10. In the annual training cycle 2022, the swimmer had a total flown of 2410.95 km, which represents an average of 26.36 km per week (Min 24.10 km; Max 74.95 km). The number of training units reached 490 at 286 days (Min 5; Max 13 training units per week). During the training cycles, the swimmer spent 271 hours regenerating, which represents 31.77% of the total load time.

Out of the total load, the volume of warm-up and swim-out (STI 102) reached 481.85 km (19.98%) in the calendar year. The largest volume of the swimmer was realized in aerobic endurance (STI 103) at the level of 974.05 km (40.40%). Anaerobic endurance (STI 104) with its volume of 38.25 km was the smallest part of the load (1.58%).

The load volume swum in the race pace zone (STI 105) reached 180.53 km (7.48%). The elemental swimming of the arm (STI 106) reached the level of swimming volume of 322.85 km (13.39%) and the elemental swimming of the leg (STI 107) had the level of 316.80 km (13.14%). The last integral part was technical exercises (STI 108) at the level of 94.00 km (3.89%).

Table 2. Correlation of sports performance and training indicators

Code		Training indicators	r^s	p
GTI	110	Days of loading (n)	0.588	0.000
	111	Training units (n)	-0.120	0.398
	112	Competitions / Starts (n)	0.792	0.000
	113	Load time (h)	-0.277	0.046
	114	Regeneration time (h)	0.425	0.002
	115	Days of medical incapacity (n)	-0.129	0.362
STI	101	Total flown (km)	0.014	0.919
	102	Warm-up and swim-out (km)	0.180	0.201
	103	Aerobic endurance (km)	-0.139	0.325
	104	Anaerobic endurance (km)	0.355	0.010
	105	Swam in race pace (km)	0.655	0.000
	106	Elemental arm swimming (km)	-0.120	0.395
	107	Elemental leg swimming (km)	0.116	0.412
	108	Technical exercises (km)	-0.053	0.707

Through non-parametric procedures, we have been able to classify the interactions between sport performance and training indicators or to detect the predictors that most significantly affected the average sport performance of a swimmer in the annual training cycle 2022.

Statistically significant correlations (Tab. 2) of general training indicators with sports performance were demonstrated with the number of loading days (GTI 110, $r^s = 0.588$, $p<0.01$), the number of competitions/starts (GTI 112, $r^s = 0.792$, $p<0.01$), total loading time (GTI 113, $r^s = -0.277$, $p<0.05$) and regeneration time (GTI 114, $r^s = 0.425$, $p<0.01$). Of the special training indicators, the swimming volume of anaerobic endurance (STI 101, $r^s = 0.355$, $p<0.01$) and volume swam in race pace (STI 105, $r^s = 0.655$, $p<0.01$) correlated with sports performance.

The non-parametric CHAID algorithm built prediction models that achieve high reliability with reasonable prediction error (Figs. 2 and 3, Tab. 3 and 4). The models included training indicators that showed a low to high degree of tightness with sport performance in swimming. Training indicators shall consist of nodal variables with limits on volume values for the ability to predict the number of performances at higher and lower load volumes.

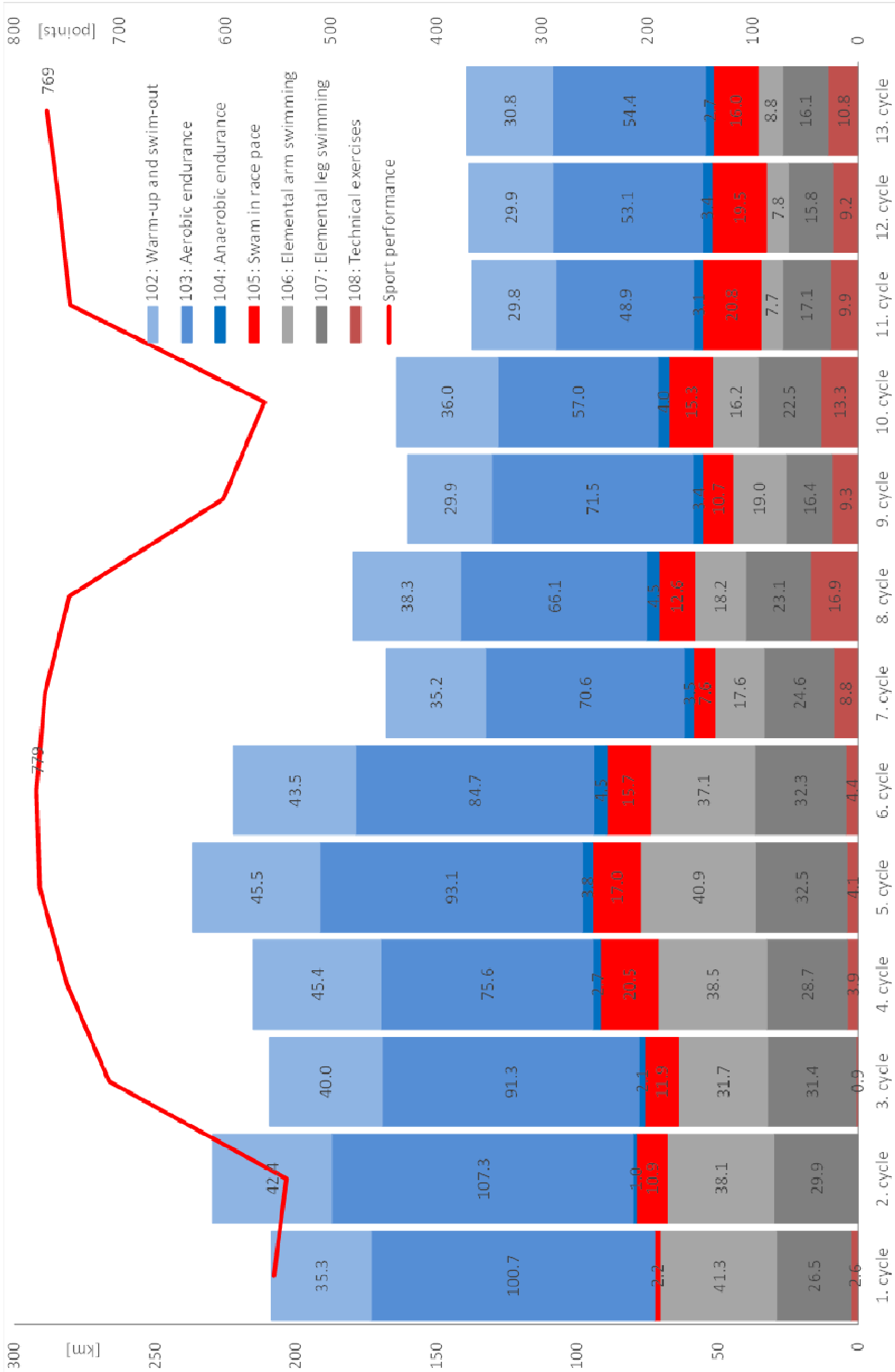

Fig. 1. Periodization of training load in annual training cycle 2022 (mesocycles)

Third branch: Among the predictors of swimming performance (Fig. 2, Tab. 3), **special training indicators** were selected: volume swum at race pace (STI 105), warm-up and swim-out (STI 102), aerobic endurance (STI 103) and anaerobic endurance (STI 104).

The predicted average sports performance of 615 points (for n = 52 performances) is determined by the volume swum at a racing pace with a weekly volume higher than 4.7 km (STI 105, F= 24.927; p<0.01; 721 points; n = 15), aerobic endurance with load variability from 13.25 km to 14.4 km (STI 103, F= 92.024; p<0.01; 592 points; n = 2), warm-up and swim-out with a load volume lower than 5.85 km (STI 102, F = ∞; p<0.01; 606 points; n = 1). If aerobic endurance in a week varies from 14.4 km to 21.3 km, we can expect a sports performance with 760 points (STI 103, F = 93.024; p<0.01; n = 7).

Second branch: For a lower predicted sports performance, the volume of the race pace from 1.6 to 4.7 km is sufficient (STI 105, F = 24.927; p<0.01; predicted sports performance 587 points; for n = 27 performances), volume of warm-up and swim-out lower than 9.8 km (STI 102, F = 12.154; p = 0.015; 556 points; n = 17), aerobic endurance volume higher than 11.6 km (STI 103, F = 21.951; p = 0.002; 544 points; n = 16) and anaerobic endurance volume higher than 0.8 km (STI 104, F = 17.640; p = 0.005; 574 points; n = 8). In the case of aerobic endurance at a volume lower than 11.6 km we can expect (F = 21.951; p = 0.002; 743 points, n = 1). If the warm-up and swim-out will be at a level higher than 9.8 km, then the expected performance (F = 12.154; p = 0.015; 639 points, n = 10).

From the point of view of **general training indicators** (Fig. 3), predictors of sports performance were selected: competitions/starts (GTI 112), days of medical incapacity (GTI 115), number of training units (GTI 111) and load time (GTI 113).

Second branch: The predicted average sports performance of 615 points (for 52 performances) is determined by at least one start per week (GTI 112; F = 132.171; p<0.01; 735 points; n = 17) and the minimum number of days of medical incapacity (GTI 115; F = 17.830; p = 0.001; 744 points; n = 16). If the number of days of medical incapacity were higher, we can expect sports performance at the level of 606 points (F = 17.830; p = 0.001; n = 1).

First branch: The second possibility of achieving an average swimming performance of 615 points is conditional on the swimmer not having a competitive start or test every week (GTI 112; F = 132.171; p<0.01; 557 points; n = 35), with a maximum of 1 day of medical incapacity (F = 5.401; p = 0.010; 643 points; n = 3) and a higher number of training units per week than > 8 (GTI 111; F = ∞; p<0.01; 726 points for n = 1).

Dicussion

The swimmer's training load structure was based on a two-peak model. Hermosilla et al. (2021) recommend the most frequently used pyramid model of the periodization with subsequent volume reduction leading up to the event. In our case, we can point to the individual periodization of the training load, which includes adapting the training load to the swimmer's specific needs or goals. It can include a combination of several types of periodization that are adjusted based on the swimmer's progress or recovery needs (Bompa & Haff, 2009).

From the general training indicators, the swimmer completed a number of 490 training units with a total load time of 853 hours in the annual training cycle 2022 and a total of 2410, 95 km flown. Czech elite swimmers have completed 423 training units with a total load time of 780 hours and a volume of 2511.7 km (Vaňková, 2010). In the case of the Olympic swimmer, the number of training units was 518 in the annual cycle with a total volume of 2873 km. (Krčková, 2013).

In the weekly microcycle, the swimmer had min. 5 and max. 13 training units, for this issue Finney (2003) gives recommendations of 10-11 training units per week, and in the case of British swimmers, training units were reduced to 9 in order to avoid overtraining (Meeusen et al. 2013). In the case of the total load time in the microcycle, the values range from min. 8 and max. 25 hours. In the publication Finney (2003) describes a weekly microcycle with a load of max. 23 hours.

The issue of sports training in swimming, or the influence of training load on sports performance was discussed by Chatard & Stewart (2011); Hellard et al. (2019); Solonenco et al. (2021); Gonzalez Rave et al. (2021); Hermosilla et al. (2021); Ravé et al. (2022); Rushall, 2018; Sylta et al. (2016). Pollock et al. (2019) concluded on the periodization of the training load in relation to VO2 max (p = 0.204), the training load relation to AEP (p < 0.01), the training load relation to ANP (p = 0.004) and the training load relation to the racing rate (p < 0.01).

From the point of view of the volume of the training load, we compared our achieved results with the recommendations in the literature. Chatard & Stewart (2011) recommends a total microcycle load of 45-60 km. A weekly load volume of 50–60 km has been established for the Italian national team (Bonifazi et al. 2000) and the Australian Olympic team (Mujika et al. 2002). Rădulescu et al. (2017) recommend a maximum training load of 80 km in the microcycle.

For British swimmers, the volume was set at a range of 43-53 km to reduce the risk of training (Meeusen et al. 2013). Compared to Gonzalez Rave et al. (2021) recommending a total load of 25-90 km in the microcycle for swimmers with a sport performance of 850-900 points (FINA).

After several or months of high-volume training, there is a brief period of gradual reduction in the amount of training load to four weeks, leading to a significant improvement in sport performance in order for the swimmer to reach peak performance at the required moment (Chatard & Stewart, 2011), which corresponds to our results before the top competition at the end of the year. Bompa & Haff (2009) describe that the phase of aerobic endurance

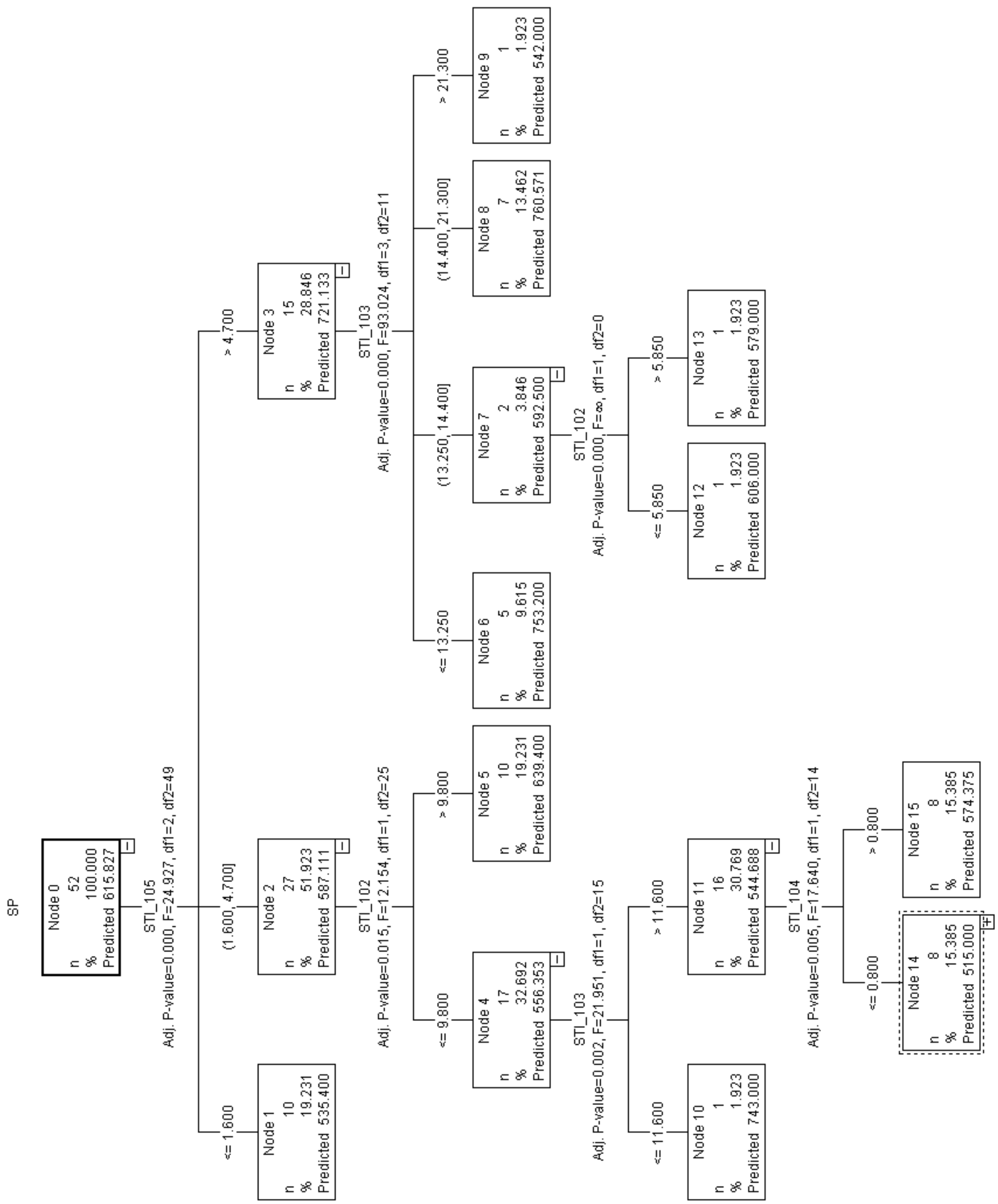

Fig. 2 Regression tree of selected special training indicators STI 101-108 to sports performance by the CHAID method
(R: 0.93; SD: 36.59; MAE: 26.07; ME -0.0)

Legend to special training indicators: SP Sport performance, **STI_102** Warm-up and swim out (km), **STI_103** Aerobic endurance (km), **STI_104 Anaerobic endurance** (km), **STI_105 Swam in race pace** (km)

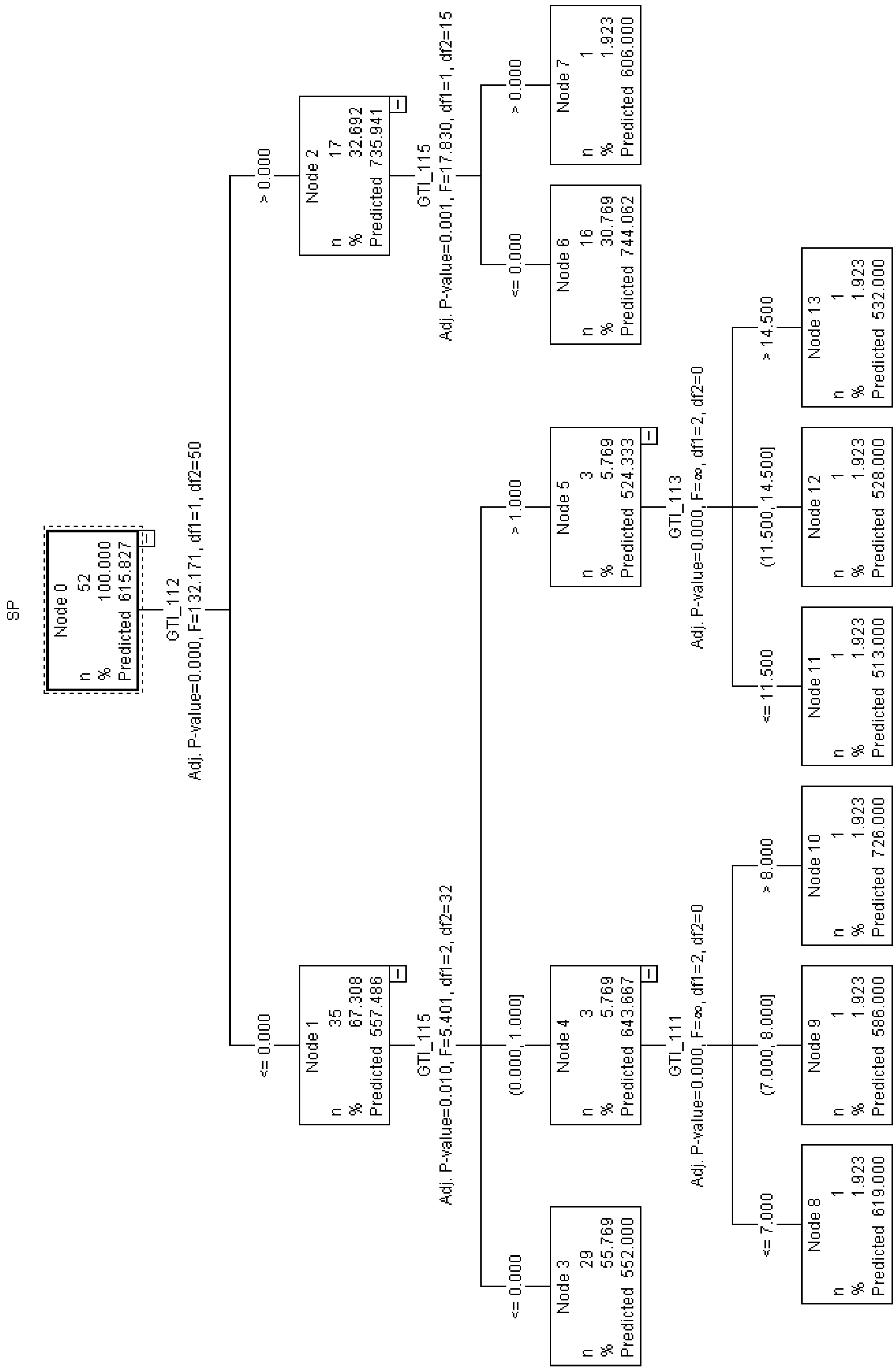

Fig. 3: Regression tree of selected general training indicators GTI 110-115 to sports performance by the CHAID method
(R: 0.914; SD: 40.231; MAE: 30.322; ME 0.0)

Legend to general training indicators: SP Sport performance, **GTI_111** Training units (n), **GTI_112** Competitions/Starts (n), **GTI_113** Load time (h), **GTI**_115 Days of medical incapacity (n)

Table 3: Prediction model of special training indicators for sports performance in swimming using the CHAID method

Node	Criterion	Prediction	Effect	N	%
1	STI_105 <= 1.6	535.4	-80.427	10	19.231
2	STI_105 > 1.6 and STI_105 <= 4.7	587.111	-28.716	27	51.923
4	STI_102 <= 9.8	556.353	-30.758	17	32.692
10	STI_103 <= 11.6	743	186.647	1	1.923
11	STI_103 > 11.6	544.688	186.647	16	30.769
14	STI_104 <= 0.8	515	-29.688	8	15.385
15	STI_104 > 0.8	574.375	29.688	8	15.385
5	STI_102 > 9.8	639.400	52.289	10	19.231
3	STI_105 > 4.7	721.133	105.306	15	28.846
6	STI_103 <= 13.25	753.200	32.067	5	9.615
7	STI_103 > 13.25 and STI_103 <= 14.4	592.500	-128.633	2	3.846
12	STI_102 <= 5.85	606	13.5	1	1.923
13	STI_102 > 5.85	579	-13.5	1	1.923
8	STI_103 > 14.4 and STI_103 <= 21.3	760.571	39.438	7	13.462
9	STI_103 > 21.3	542	-179.133	5	1.923

Table 4: Prediction model of general training indicators for sports performance in swimming using the CHAID method

Node	Criterion	Prediction	Effect	N	%
1	GTI_112 <= 0	557.486	-58.341	35	67.308
3	GTI_115 <= 0	522.00	-5.486	29	55.769
4	GTI_115 > 0	643.667	86.181	3	5.769
8	GTI_111 <= 7	619	-24.667	1	1.923
9	GTI_111 > 7 and GTI <= 8	586	-57.667	1	1.923
10	GTI_111 > 8	726	82.333	1	1.923
5	GTI_115 > 1	524.333	-33.152	3	5.769
11	GTI_113 <= 11.5	513	-11.333	1	1.923
12	GTI_113 > 11.5 and GTI <= 14.5	528	3.667	1	1.923
13	GTI_113 > 14.5	532	7.667	1	1.923
2	GTI_112 > 0	735. 941	120.114	17	32.692
6	GTI_115 <= 0	744.062	8.121	16	30.769
7	GTI_115 > 0	606	-129.941	1	1.923

should last between 1-3 months in order to build a high aerobic potential, which will subsequently transform into special endurance and later race pace, as we can see in Figure 1.

In the results section, we state that if the volume of the race pace is at a level higher than 4.7 km in the microcycle, the predicted sports performance will be 721 points (FINA). Pollock et al. (2019) in their publication gives race pace recommendations for middle distance swimmers at 17.3 ± 4.6 km, which is significantly higher than the values in our results. From the point of view of the annual cycle, the swimmer swam 180.53 km at a racing pace. In the work of Krčkova (2013), the annual volume of a swimmer at a race pace is reported in the analysis at the level of 70 km, which is a significantly lower value than in our results.

Despite the fact that this is an example of a highly intraindividual periodization of the training load in relation to the observed athlete, we can state that the obtained results correspond to recommendations from swimming and professional practice, such as Chatard & Stewart (2011); Gonzalez Rave et al. (2021); Hermosilla et al. (2021). However, Pollock et al. (2019) recommends even higher weekly training load volumes compared to ours. Nevertheless, the selection of the abovementioned training indicators into the prediction models was logical and justified from the point of view of the continuity of the training means.

Conclusions

In the article, we pointed out the intraindividual periodization of the training load of the Slovak national swimmer (T.P.) in the annual training cycle 2022. Using regression trees with the CHAID method, training indicators were selected that showed high tightness with year-round sports performance. The optimal load was characterized in terms of volume and intensity, or variability of sports performance prediction.

The influence of the volume of the load swum at race pace was demonstrated (STI 105) and a significant role in the preparation was played by the warm-up and swim-out (STI 102), aerobic endurance (STI 103) and anaerobic endurance (STI 104). Among the general training indicators, the influence of the number of competitions/starts (GTI 112), the number of days of medical incapacity (GTI 115), the number of training units (GTI 111) and the load time (GTI 113) was proven.

Retrospective analysis classified the training means that were most involved in improving the swimmer's sports performance. Their accurate identification will make it possible to rationalize the periodization of the training process, harmonize the conceptual starting points of sports training and improve the system of tuning the sports form of the swimmer himself towards the top competitions.

References

Bompa, O. T. (1999). Periodization: Theory and Methodology of Training. *Human Kinetics*. 405 s. ISBN 0880118512

Bompa, O. T., & Haff, G. G. (2009). Periodization: Theory and methodology of training (5th ed.). *Champaign, IL: Human Kinetics.*

Bonifazi, M., Sardella, F., & Lupo, C. (2000). Preparatory versus main competitions: differences in performances, lactate responses and pre-competition plasma cortisol concentrations in elite male swimmers. *European Journal of Applied Physiology,* 82(5–6), 368–373. https://doi.org/10.1007/s004210000230

Breiman, L., Friedman, J. H., Olshen, R. A., & Stone, C.J. (1984). Classification and Regression trees. *Wadsworth, Belmont CA*; 1984

Camp, N. J., & Slattery, M.L. (2002). Classification tree analysis: a statistical tool to investigate risk factor interactions with an example for colon cancer (United States). *Cancer Causes Control* 13, 813–823. https://doi.org/10.1023/A:1020611416907

Cohen, J. (1988). Statistical power analysis for the behavioral sciences. 2nd ed. New York: *Lawrence Erlbaum Associates*. ISBN 0-8058-0283-5

Finney, J. (2003). How they train: Four days of workouts with Grant Hackett and Michael Phelps. *Swim news,* 276, 38 - 39. ISSN 1209 – 5966

González-Ravé, J. M., Pyne, D. B., Del Castillo, J. A., González-Mohíno, F., & Stone, M. E. (2021). Training periodization for a world-class 400 meters individual medley swimmer. *Biology of Sport*, *39*(4), 883–888. https://doi.org/10.5114/biolsport.2022.109954

Gussakov, I., Olzhas, A., Nurmukhanbetova, D., Yermakhanova, A., Bakytbek, K., & Kefer, N. (2023). Original Article Optimization of the speed-strength training technique for highly qualified swimmers. *Journal of Physical Education and Sport*, *23*(4), 950–956. https://doi.org/10.7752/jpes.2023.04119

Hellard, P., Avalos-Fernandes, M., Lefort, G., Pla, R., Mujika, I., Toussaint, J., & Pyne, D. B. (2019). Elite swimmers' training patterns in the 25 weeks prior to their season's best performances: Insights into Periodization from a 20-Years cohort. *Frontiers in Physiology*, *10*. https://doi.org/10.3389/fphys.2019.00363

Hermosilla, F., González-Ravé, J. M., Del Castillo, J. A., & Pyne, D. B. (2021). Periodization and Programming for Individual 400 m Medley Swimmers. *International Journal of Environmental Research and Public Health*, *18*(12), 6474. https://doi.org/10.3390/ijerph18126474

Chatard, C. J., & Stewart, M. A. (2011). Training load and performance in swimming. *World Book of Swimming: From Science to Performance*. ISBN: 978-1-61668-202-6

Kachaunov, M., & Petrov, L. (2020). Upper body anaerobic power and freestyle swimming performance. *Journal of Physical Education and Sport,* 20(04). https://doi.org/10.7752/jpes.2020.04265

Krčková, R. (2013). Training and performance of swimmers of international level in the category of juniors, seniors and masters. *Dspace.cuni.cz*. from https://dspace.cuni.cz/handle/20.500.11956/55611

Lehmann, E.L. (1975). Nonparametrics: Statistical Methods Based on Ranks. *Holden-Day,* San Francisco; 1975

Makar, P., Skalski, D,. Pęczak-graczyk, A., Kowalski, D., & Grygus, I. (2023). Correlations between chosen physiological parameters and swimming velocity on 200 meters freestyle distance before and after 5 months of training. *Journal of Physical Education and Sport*, *23*(7). https://doi.org/10.7752/jpes.2023.07214

Meeusen, R., Duclos, M., Foster, C., Fry, A. C., Gleeson, M., Nieman, D. C., Raglin, J. S., Rietjens, G., Steinacker, J. M., & Urhausen, A. (2013). Prevention, diagnosis, and treatment of the overtraining syndrome. *Medicine and Science in Sports and Exercise*, *45*(1), 186–205. https://doi.org/10.1249/mss.0b013e318279a10a

Mujika, I., Padilla, S., & Pyne, D. B. (2002). Swimming performance changes during the final 3 weeks of training leading to the Sydney 2000 Olympic Games. *International Journal of Sports Medicine*, *23*(8), 582–587. https://doi.org/10.1055/s-2002-35526

Pla, R., Meur, Y. L., Aubry, A., Toussaint, J., & Hellard, P. (2019). Effects of a 6-Week period of polarized or threshold training on performance and fatigue in elite swimmers. *International Journal of Sports Physiology and Performance*, *14*(2), 183–189. https://doi.org/10.1123/ijspp.2018-0179

Platonov V. (2019). Theory of periodization of elite athlete preparation during a year: prerequisites, formation, criticism. *Science in Olympic Sport*. 118-137.

Pollock, S., Gaoua, N., Johnston, M. J., Cooke, K., Girard, O., & Mileva, K. N. (2019). Training Regimes and Recovery Monitoring Practices of Elite British Swimmers. *Journal of sports science & medicine*, *18*(3), 577–585.

Pretorius, S. (2020). The effect swimming training intensity has on sleep,mood and recovery in elite swimmers. *Faculty of Health Sciences; University of the Witwatersrand, Johannesburg,* from https://wiredspace.wits.ac.za/server/api/core/bitstreams/9f5a4ce7-b2b1-45ad-88f5 fccfcc48f77a/content

Ravé, J. M. G., González-Mohíno, F., Rodrigo-Carranza, V., & Pyne, D. B. (2022). Reverse Periodization for Improving Sports Performance: A Systematic review. *Sports Medicine - Open*, *8*(1). https://doi.org/10.1186/s40798-022-00445-8

Rădulescu, A., Marinescu, G., & Ticală, L. (2017). Theoretical aspects of training periodization in swimming. *Physical Education, Sport and Kinetotherapy Journal,* 4(50), 59-62. ISSN 2286 – 3702

Rushall B. S. (2018) Step-By-Step USRPT Planning and Decision-Making Processes and Examples of USRPT Training Sessions, Microcycles, Macrocycles, and Technique Instruction. *Swimming Science Bulletin, San Diego State University*

Solonenco, G., Stepanova, N., Onoi, M., & Viorel, D. (2021). Analysis of training programs of the performance swimmers within the basic macrocycle of the annual training cycle. *Ştiinţa Culturii Fizice*, *35/1*. https://doi.org/10.52449/1857-4114.2020.35-1.09

Sylta, Ø., Tønnessen, E., Hammarström, D., Danielsen, J., Skovereng, K., Ravn, T., Rønnestad, B. R., Sandbakk, Ø., & Seiler, S. (2016). The effect of different High-Intensity Periodization Models on Endurance adaptations. *Medicine and Science in Sports and Exercise*, *48*(11), 2165–2174. https://doi.org/10.1249/mss.0000000000001007

Vaňková, K. (2010). Analysis of the training diary of an elite swimmer. Palacký University in Olomouc, *Faculty of Physical Culture*, from https://theses.cz/id/lx0koq/128406-233451294.pdf

Yakovlev, B. P., Babushkin, G. D., Rybin, R. E., Babushkin, E. G., & Tarasenko I. B. (2018). Elite swimmers, precompetitive meso-cycle, competitive performance. *Theory and practice of physical culture,* ISSN: 2409-4234