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SWIMMING – THE STRUCTURE AND VOLUME OF TRAINING LOADS IN THE FOUR-YEAR TRAINING CYCLE OF AN ELITE OLYMPIC ATHLETE

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Abstract
Introduction. The improvement of outcomes in sport requires the creation of appropriate conditions for training and the search for more effective forms of its organisation and effective technology. Starting with this belief, the aim of the work is to identify the size and structure of the training loads and determine the effectiveness of the training process of an elite athlete in the Olympic macrocycle (2004-2008). ***Material and methods.*** We analysed loads in the four-year training cycle from 2004 to 2008. The parameters of the loads relating to the intensity (T_1-T_5) and type of training (general, special, and specific) were analysed. The present study also attempted to assess the impact of the work on the results obtained. Due to the nature of the competitive effort, we used the measurable parameter of distance (m, km) in the load analysis depending on the type and intensity of the physical effort. ***Results.*** This work reports on the implementation of a specially designed four-year training programme. The material gathered and the conclusions resulting from its analysis have made it possible to identify organisational and training solutions suitable for the athletic proficiency phase. The analysis of training loads indicated that in the training of a highly skilled swimmer, the general work is particularly important and that the largest volume was realised in the second intensity range (T_2). ***Conclusions.*** The positive training and competition outcomes were the result of a deliberate training process. The training proved to be effective, leading to an increase in the athlete's training status. This was achieved primarily owing to the training loads, which were accurately planned and implemented according to the special requirements of the race distance and the individual characteristics of the swimmer.

Key words: swimming training, training periodisation, volume of training loads, competition participation policy, training intensity, training specificity, monitoring and evaluation of training effectiveness, evaluation of parameters in swimming technique

Introduction

The overwhelming and unilateral work characteristic of swimming training is becoming less and less attractive for athletes, which has motivated trainers to perform in-depth analyses of training programmes. The results of specialist research are of vital importance in terms of their practical implications.

There is no doubt that only long-term observations and conclusions can be motors for progress. Coaches and athletes should be aware that only improving the quality of training can ensure a higher level of performance. This is mainly related to the size and type of training and competition loads, but it is also connected with improved planning and programming of training aimed to optimise the training process [1].

Training volumes currently used in swimming vary from 1,500 to 2,000 km in special training and may be up to 2,400-3,000 km in women and 2,400-3,000 km in men in specific training [2]. However, there is a definite tendency to reduce the volume of training in water and replace it with various forms of training on land [3].

The implementation of the training plan aimed at achieving the goals set assumes the application of specified, reasonably selected training loads [4]. Searching for an effective stimulus that would help the athlete reach the highest level of preparation for the competition in a relatively short time leads directly to the need to precisely determine the type, volume, and intensity of training. It is also important to work on the improvement of the technique and to choose the right competition participation policy to achieve the desired results [5].

On the scale of the whole process, by training loads we generally mean the type and amount of training stimulating athletic development, leading to changes in the athlete's training level and thus the level of their physical preparation for the competition, as well as the improvement of the results through an optimal synergy of workloads [4]. This is the result of a permanent training process. This process is complex and is affected by many factors [6]. Training load is the amount of work done in a particular exercise, unit of training, or cycle [7, 8, 9].

The volume of work is influenced by two components: the quantitative one, expressed in volume – which is the working time, distance, mass or number of repetitions – and the qualitative one, characterised by the intensity expressed by the ratio of the power developed to maximum power [1]. Hence, loads have been categorised as external and internal [8]. The former

category relates to quantitative and qualitative data, and the latter has to do with the energy cost and the sources from which energy was drawn to accomplish this task [6].

As far as the impact of the different types of exercise is concerned, the loads are categorised as general, special, and specific, in terms of their specificity, or what has also been called the information sphere [10]. When it comes to their energy cost, they are classified according to their intensity; in the current study, we have divided the exercises into 5 intensity ranges based on physiological determinants (heart rate, HR, and the biochemical parameter of the lactate concentration in the blood after the exercise, LA), taking into account the duration of the physical effort of a defined intensity and exercises increasing anabolic metabolism [8, 11, 12]. This criterion for the classification of physical exercise has also been called the energy sphere [13].

In swimming, the ongoing assessment of training and qualification of loads according to energy criteria requires a knowledge of the individual competencies of the athlete and the correctness of the classification of the workload to the appropriate zones based on the speed with which and the time within which the distances are covered, resting periods, and the frequency of movement [14]. This makes it possible to precisely plan the training according to the principles of the interdependence of motor characteristics and prevent them affecting each other in an adverse way [6].

The physiological principles of training should determine the maximum amount of training loads and their optimisation, so that the athlete can achieve a high level of morphological, functional, and motor qualities [8]. Therefore, when planning training loads, factors related to the several-year duration of the training process, the proportion of work types and their orientation, the dynamics and age of the athlete, their level of achievement, and many other conditions should be taken into consideration [6, 15, 16].

The search for optimal solutions for the selection and amount of the workloads have prompted us to analyse the preparation of an athlete at the highest level of training for the Olympic Games in Beijing (2008). The study was motivated by the need to obtain and collect objective information about the implementation of the training process, and in particular the volume and structure of the workloads. Parallel to its cognitive value, such data is of great practical importance.

This research work attempts to present the solutions used in the training of the most prominent swimmer in the history of Polish swimming athletes, a medallist of the Olympic Games and World and European Championships. The model of training loads planned and implemented in the four-year training cycle in 2004-2008 was considered. We analysed the parameters of the loads relating to energy sources during the training and competitions and the types of training, that is general, special, and specific training. The data presented are the result of the implementation of an original, specially designed four-year training programme.

It is very important to identify the intensity of the exercise during which the transition from aerobic (oxidative) to anaerobic performance is observed [17].

Material and methods

The study included data documenting the 4-year training process of the Olympic champion O.J. The swimmer participated in four Olympic Games, where she won 1 gold medal and 2 silver medals (Athens 2004), as well as taking 4th place (Beijing 2008). She won 14 medals during the World and European Championships. She was also a two-time world record holder. During the course of the training macrocycle, the athlete was 21-25 years old, and her training period was 14-18 years [18].

In the macrocycle analysed (2004-2008), the training process was monitored in detail. The study used a method of recording and analysing workloads developed at the Department of Sports Theory at the University of Physical Education in Warsaw [6], identifying the loads in terms of their type (general, special, and specific) and the intensity of the work (T_1-T_5) (Tab. 1). Due to the nature of the competitive effort, the measurable parameter of the distance covered (m, km) according to the type and intensity of exercise was used in the load analysis [8].

In preparation for the Olympic Games in Beijing, O.J. completed 12 training cycles, three in each annual macrocycle. A total of 206 microcycles and 1,647 training units were implemented in 2004-2008.

Table 1. Intensity ranges according to blood lactate level [mmol/l]

Intensity ranges				
T_1 (…-1mmol)	T_2 (1-3 mmol)	T_3 (3-5 mmol)	T_4 (5-…mmol)	T_5 (sprint)

Results

In the whole Olympic cycle, 84.8% of the plan was realised. The training was completed to the greatest extent in the third cycles (647, which is 97.0% of the plan) and to the smallest extent in the first cycles (373, which is 70.8% of the plan).

The total planned load was 10,277.0 km. The athlete actually swam 8,472.2 kilometres (which is 82.4% of the value assumed); she covered the greatest part of this distance in the last year of preparation (2,563.0 km) and the smallest one in the first year (1,697.9 km) (Tab. 2). The largest part of the training

Table 2. Size of training loads planned and executed in water in particular cycles of Olympic training [km]

Years	Cycle 1		Cycle 2		Cycle 3		Total	
	Plan	Execution	Plan	Execution	Plan	Execution	Plan	Execution
2004-2005	0.0	45.3	1394.4	1102.5	584.1	550.1	1978.5	1697.9
2005-2006	1031.7	320.8	1021.4	845.9	639.8	603.2	2692.9	1769.9
2006-2007	757.6	650.0	1082.5	897.6	986.2	893.8	2826.3	2441.4
2007-2008	854.9	755.3	768.8	548.9	1155.6	1258.8	2779.3	2563
2004-2008	2644.2	1771.4	4267.1	3394.9	3365.7	3305.9	10277	8472.2

Table 3. Comparison of types and sizes of loads in cycles 1, 2, and 3 of the 2004-2008 macrocycle [km]

Years	General	Special						Specific	
	Swimming in full coordination	Arm-only swimming	Leg-only swimming	Breath-hold swimming	Swimming with paddles	Swimming with fins	Swimming with drag belt	Swimming in main style	Improving the technique
Cycle 1									
2004-2005	24.7	9.8	10.8	0.7	4.6	4.5	1.2	3.3	2.4
2005-2006	192.3	66.8	61.7	17.8	91.5	31.3	5.7	5.5	7.3
2006-2007	392.7	137.1	120.2	45.9	184.2	88.2	34.3	55.3	27.9
2007-2008	471.0	132.7	151.6	42.9	205.6	107.5	39.7	43.7	43.7
Cycle 2									
2004-2005	662.8	233.9	205.8	67.1	393.4	181.4	81.6	73.9	38.1
2005-2006	499.9	189.3	156.7	34.3	324.1	149.2	37.8	84.7	45.0
2006-2007	578.2	164.1	155.3	45.6	255.6	118.8	69.9	78.9	34.9
2007-2008	337.8	110.3	100.8	57.1	135.2	96.6	30.8	33.4	38.2
Cycle 3									
2004-2005	321.4	126.8	101.9	24.8	169.0	61.0	32.2	59.9	20.1
2005-2006	386.9	114.6	101.7	22.7	209.3	80.8	22.5	74.7	35.6
2006-2007	552.7	165.1	176.0	80.8	232.9	133.0	41.4	64.2	44.6
2007-2008	718.3	263.2	277.3	98.5	352.8	262.4	57.8	53.5	63.0
Total									
2004-2008	5138.7	1713.7	1619.8	538.2	2558.2	1314.7	454.9	631	400.8

Table 4. Distribution of training loads in the 2004-2008 macrocycle [km, %]

Total load = 8472.2 km								
Unit of measurement	General	Special	Specific	T_1	T_2	T_3	T_4	T_5
km	5138.7	2301.7	1031.8	1308.9	4975.3	1799.6	232.6	155.8
% of total load	60.6	27.2	12.2	15.4	58.8	21.3	2.7	1.8
	Training specificity			Training intensity				

in water was completed in the third cycle in 2007-2008, and the smallest one was completed in the first cycle in 2004-2005 (Tab. 2).

A detailed analysis of the training in the water divided into annual macrocycles was made. In terms of the specificity of the training, the swimmer performed the greatest work using a load of a general character. O.J. covered 5,138.7 kilometres within 4 years swimming using all styles in full coordination. The type of loads that had the smallest share were specific loads; the athlete swam 400.8 km perfecting the basic style (butterfly) technique (Tab. 3).

In subsequent years, we can see that as far as the general training load is concerned, the largest part of the training took place in the cycle from 2007 to 2008 (1,527.1 km) (Tab. 3). Within the special load, the largest volume was completed swimming in swim paddles. In the year 2007-2008, O.J. covered 693.6 kilometres in this manner. The smallest volume was reported in 2005-2006, when she swam 66.0 km with a drag belt (Tab. 3). As for specific training, O.J. completed the largest load in the 2006-2007 macrocycle, swimming 198.4 km in her primary competition style (butterfly style). The exercises perfecting the technique of the butterfly style were of the smallest volume in this group in the 2004-2005 cycle (60.6 km) (Tab. 3).

Considering the classification according to intensity range, the highest load in the water was scheduled in aerobic (oxidative) performance (T_2) in the 1 to 3 mmol/l range (5,999.7 km). The lowest load (206.2 km) was planned in alactic anaerobic performance (T_5), characteristic for sprint training. Throughout the whole four-year cycle, the exercises within the aerobic (oxidative) zone dominated (T_2), making a total of 4,975.3 km. Training in the T_5 (alactic anaerobic) zone had the smallest volume, which was 155.8 km (Tab. 4).

We analysed the size of the loads with respect to training specificity and intensity for each of the training cycles. Due to the design of the training programme and the specific nature of each cycle, we compared all the three cycles in each macrocycle to each other. With reference to training specificity, it was determined that in all of the first cycles of the years under investigation, the largest volume of work was performed as part of general training. The maximum was reached in 2007-2008 (swimming in full coordination: 471.0 kilometres), and the minimum was achieved in 2004-2005 (breath-hold swimming: 0.7 km) (Tab. 3).

Regarding the classification of the loads according to intensity, in the first cycles, the swimmer performed the largest work in the T_2 range (aerobic/oxidative exercise) in the 2006-

2007 macrocycle, covering 398.9 kilometres. The smallest load was noted in the 2004-2005 macrocycle in the T_5 range (alactic anaerobic exercise), that is 0.1 km (Fig. 1).

In the second cycles in the years 2004-2008, the majority of the loads were general loads. In the 2004-2005 season, O.J. covered 662.8 km swimming in all the techniques in full coordination. On the other hand, the smallest amount of work was noted in the group of special loads. Here, in the years 2007-2008, the swimmer covered 30.8 km using a drag belt (Tab. 3).

As for the intensity of the training, the greatest volume of the work was performed in the 2004-2005 macrocycle (642.8 km in the T_2 intensity range), and the smallest one was completed in the 2005-2006 macrocycle, in the T_5 range (lactic anaerobic performance, 7.6 km) (Fig. 2).

In the third cycles, general loads consistently dominated. The athlete swam 718.3 kilometres in all the techniques in the 2007-2008 macrocycle. The smallest volume was dedicated to perfecting the butterfly style in the 2004-2005 season (specific

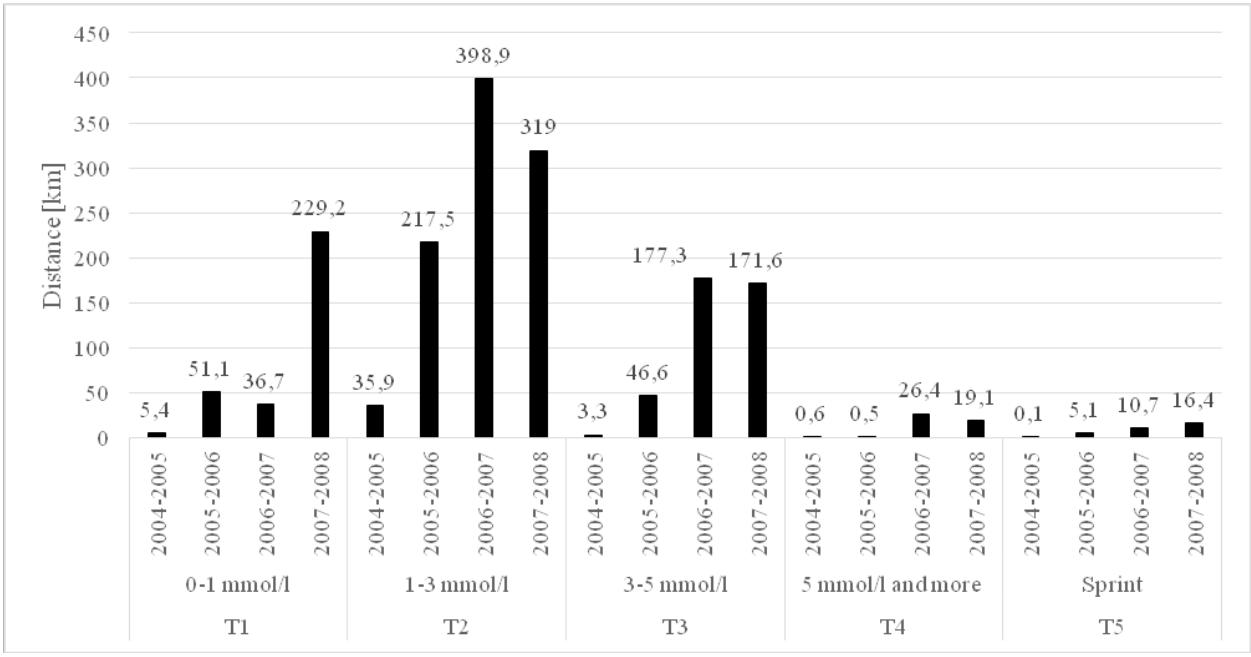

Figure 1. Comparison of intensity ranges and sizes of loads in the first cycles of the 2004-2008 macrocycle [km]

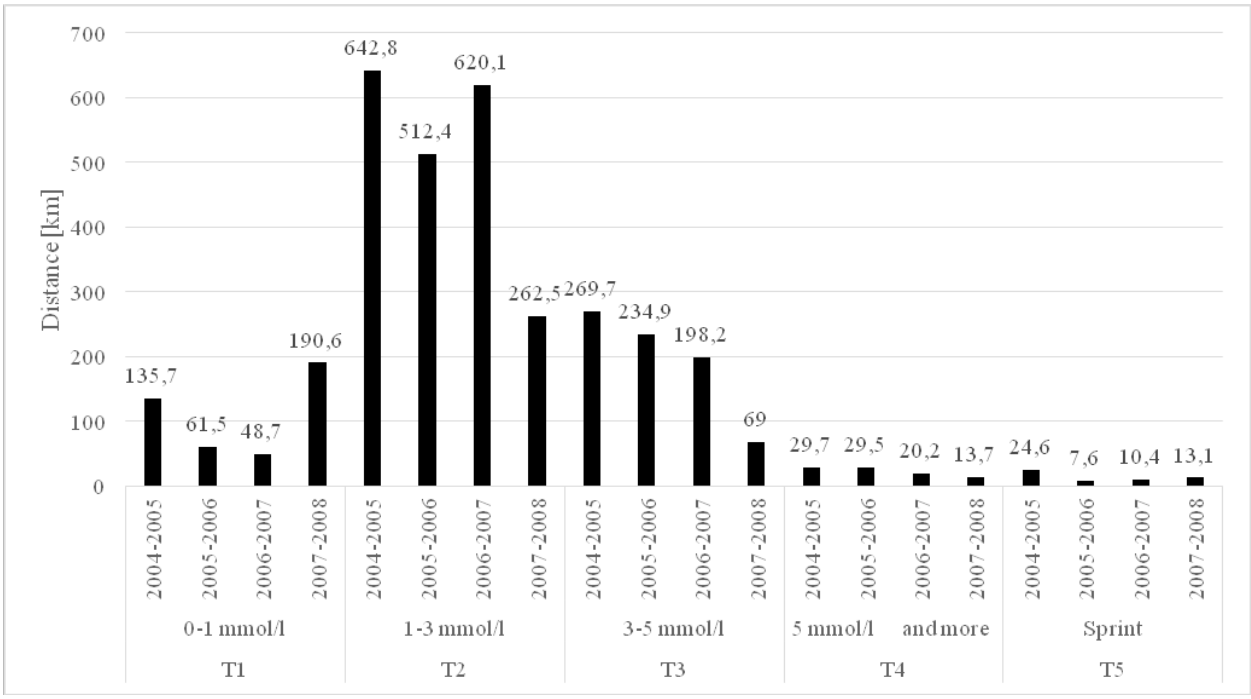

Figure 2. Comparison of intensity ranges and sizes of loads in the second cycles of the 2004-2008 macrocycle [km]

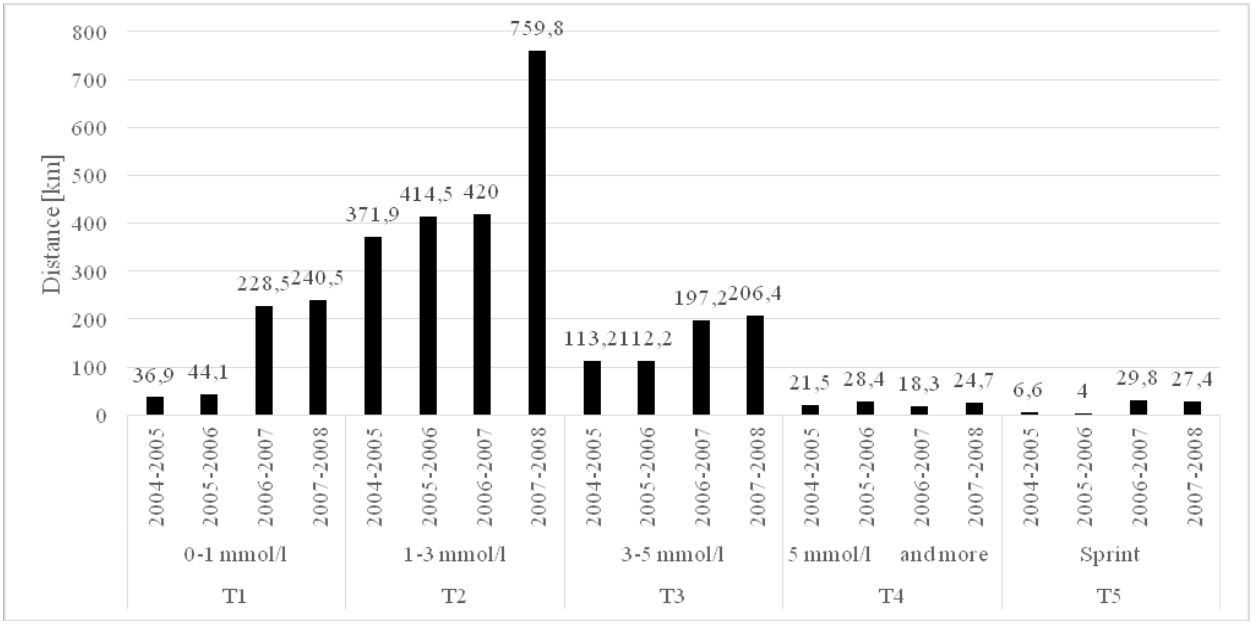

Figure 3. Comparison of intensity ranges and sizes of loads in the third cycles of the 2004-2008 macrocycle [km]

exercise – 20.1 km) (Tab. 3). In terms of intensity, in the third cycles, the largest amount of work was completed in the T_2 range in the 2007-2008 macrocycle (759.8 km), and the smallest one was performed in the T_5 range in the 2005-2006 macrocycle (4.0 km) (Fig. 3).

The size of all training loads implemented in the years 2004-2008 amounted to 8,472.2 km. As far as training specificity is concerned, O.J. swam 5,138.7 km (60.6%) as part of general training, an average of 3.12 km/unit. The special training was carried out as follows: arm-only swimming – 1,713.7 km (1.04 km/unit), leg-only swimming – 1,619.8 km (0.98 km/unit), breath-hold swimming – 538.2 km (0.33 km/unit), swimming with swim paddles – 2,558.2 km (1.55 km/unit), swimming with fins – 1,314.7 km (0.80 km/unit), and swimming with a drag belt – 454.9 km (0.28 km/unit). The total distance covered as part of special training was 2,301.7 km, which is 27.2% of the total planned load. As far as specific training is concerned, the swimmer covered 631 km (7.5%, 0.38 km/unit) in butterfly style and 400.8 kilometres (4.7%, 0.24 km/unit) performing technical exercises related to this style. This gives a total of 1,031.8 km (12.2% of the total training load) (Tab. 3 and 4).

As for the intensity of the training, the following values of loads were found in various ranges of intensity: T_1 – 1,308.9 km (15.4%, 0.79 km/unit), T_2 – 4,975.3 km (58.7%, 3.02 km/unit), T_3 – 1,799.6 km (21.2%, 1.09 km/unit), T_4 – 232.6 km (2.7%, 0.14 km/unit), and T_5 – 155.8 km (1.8%, 0.09 km/unit) (Tab. 5).

An important element of the athlete's training is their participation in competitions. In addition to providing information related to the technique of covering the distance (including stroke rate, stroke length, and stroke index) as well as the distribution of the pace in each section of the race, they are an excellent form of mental preparation. If properly scheduled, they make it possible for the athlete to learn targeted behaviours that help fight stress and for the coaches to improve their practices related to programming racing activity [19]. During the 141 days of the competitions, in 2004-2008 macrocycle, O.J. competed 321 times, most often in the years 2006-2007 and 2007-2008. In both seasons, she competed 109 times a year. She competed the least often (39 times) in 2005-2006 (Tab. 6).

The swimmer raced the least frequently in the first cycles (88 times). This is related to the low volume of training loads after transitional periods. Most races were noted in the third cycles, as they usually preceded the most important races each year. Moreover, 76% of competitions took place at 50-m swimming pools (244) and only 24% at non-Olympic swimming pools which were 25 metres long (77) (Tab. 6).

At the level of world competitions, proper planning plays a significant role in preparing for the most important races. It

Table 5. Size of training loads in the 2004-2008 macrocycle in particular intensity ranges

	T_1	T_2	T_3	T_4	T_5
km	1308.9	4975.3	1799.6	232.6	155.8
% realisation	15.4	58.8	21.3	2.7	1.8
km/training	0.79	3.02	1.09	0.14	0.09

should take into account the distances as well as the style. In a well-structured program, the swimming styles or the ability to recover after exercise can be adjusted. Based on the plan adopted for the current swimmer, in the years 2004-2008, she competed in 12 individual events and three relay races (Fig. 4).

She competed most often in her strongest style (200-m butterfly style). In 2004-2008, she competed in it a total of 81 times. However, in the entire four-year period, she did not participate in any events in the classic style (Fig. 4).

The four-year macrocycle preparation for the Olympic Games in Beijing was a project planned specifically considering the multiplicity of the needs and requirements related to the preparation for the competition for the Olympic medal. The size, type, and structure of the loads were chosen in such a way that in the first phase (macrocycles 2004-2005 and 2005-2006), the programme was aimed at increasing aerobic capacity. Mainly general training loads were used. Later (macrocycles 2006-2007 and 2007-2008), a simultaneous reduction of the training volume and increase in special and specific loads were planned.

Discussion

The preparations for the Olympic Games are an imminent phase of long-term sports training. This is a complex process involving multiple factors. Its effect does not depend directly on the perfection of individual elements; its prospective success is largely determined by the perfection of the whole action. All the elements included in the system are closely linked, and a central place is taken by three subsystems: training, competitions, and recovery [20]. Participating in competitions is also one of the ways of training the athlete, and in every race, the individual biological capacity of the body should be taken into consideration. The appropriate organisation of the processes of physical and mental recovery, which integrate work and leisure, is being increasingly appreciated [21, 22, 23, 24].

Table 6. Races at 25-m and 50-m swimming pools in the 2004-2008 macrocycle [%]

Years	25-m swimming pool		50-m swimming pool		Total	
	Number	%	Number	%	Number	%
2004-2005	5	1.6	59	18.4	64	19.9
2005-2006	0	0.0	39	12.1	39	12.1
2006-2007	29	9.0	80	24.9	109	34.0
2007-2008	43	13.4	66	20.6	109	34.0
Total	77	24.0	244	76.0	321	100.0

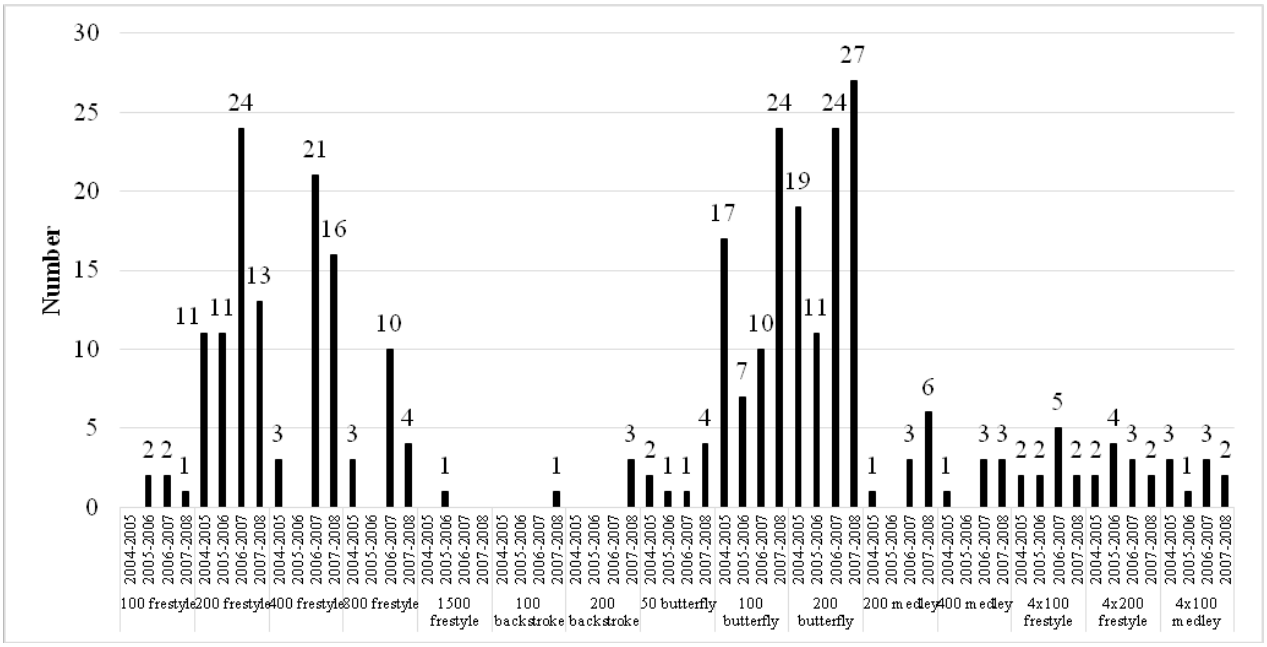

Figure 4. Races from 2004 to 2008 divided according to the style of the competition [number according to years]

Competition at the highest level and the level of performance athletes reach today make the training process more complex. As a result of the evolution of the latter, not only the training but also the entire training process has undergone changes [1]. The most objective information about the process is the data on the training loads, which are a fundamental source of information about training nowadays [1].

Theoreticians and practitioners hold different opinions on the recommended loads. On the one hand, it is said that swimmers must cover at least 10 km per day; on the other hand, it is considered that it is possible to increase the capabilities of swimmers by training a volume of 4-6 km per day [25]. Effective training management is possible through the precise design of tasks of an appropriate volume and intensity [15]. In the differentiation of loads, it is very important to take into account individual intensity ranges (T_1-T_5 in this study). Particular attention should be paid to the boundary between aerobic and anaerobic zone [6, 26].

The size of post-training effects and the pace at which they are achieved are largely determined by the nature and size of the loads and the activity of the organs and functional mechanisms [27]. The energetic metabolism of exercise that is varied (in terms of intensity and volume) must first be known in order to prepare a proper plan and choose the loads [28]. There is thus a need for programmed control of training status, as it is a key tool for effective management and programming of the training process [29]. For effective selection of exercise and precise determination of the actual intensity of the loads, it is necessary to conduct a systematic study in this field.

The competition method is used for a broadly defined intensification of training [14, 30]. It assumes that participation in competitions is an integral component of training. In the preparation period, swimmers compete repeatedly, and the intensity of their competitive activity decreases with the approaching main race. The results achieved in several of these competitions are in fact primarily used to gain information about the athletes' current state of preparation and also the dynamics and direction of the changes taking place under the influence of training [3, 31].

Establishing the optimal number of races is a condition for the proper implementation of the training process. The competitions determine the training goals, and the entire training programme is tailored to the competition schedule [29, 32, 33].

The basis of all discussions and inquiries regarding the effectiveness of the training is analysing the quantitative data characterising the process in a formalised way [6]. In the current paper, the identified training load values are presented in terms of the training cycles and features of the training, specifying also the competitive participation workloads. We have presented the individual characteristics of O.J.'s loads in subsequent years of training and the whole 2004-2008 Olympic training cycle. Detailed reference has also been made to data concerning her competition activity. The entire description and analysis of the data have an individual character, and they refer to an elite swimmer.

Repeated participation and improved results during the four-year period of time had an effect in the form of O.J.'s achievement during the Olympics in 2008 in Beijing, where she took 4th place. Of course, many factors could have had an impact on this achievement, not only those concerning the structure and size of the workloads. Taking into consideration that throughout the four-year period analysed, O.J. was one of the best swimmers in the world, the training solutions applied can be regarded as efficient and as meeting the criteria for training elite swimmers.

The collected material, its analysis, and resulting conclusions have helped identify organisational and training solutions. Reporting on specific cognitive values, it also proposes original practical applications, which can guide coaches who train elite swimmers. They can also be of use to theoreticians and practitioners and are a contribution to the body of knowledge of the theory and technology of training.

Conclusions

1. The structure and programme of the four-year training cycle were consistent with the principles and requirements formulated in training theory.
2. The size, type, and distribution of the loads and the qualification of the training were mainly focused on the development of endurance, with a gradual shift to speed capacity.
3. The intensity ranges T_1 to T_5 were used depending on the specificity of the training. In all the cycles, there was a majority of loads of an aerobic character (T_2), with a much lower share of aerobic-anaerobic loads (T_3), and the lowest share of the most intense, anaerobic loads characteristic of specific exercise (T_4, T_5).
4. The entire four-year cycle consisted of compatibly designed annual macrocycles, each divided into three cycles of training. Their length resulted from the competition schedule; however, the internal structure (mesocycles, microcycles, and training units) was individually differentiated during the implementation of the training (and also due to chance events and training courses).
5. Participating in competitions was an important component of the comprehensive training programme in the four-year cycle, in the annual macrocycles, and in their structural components.
6. The positive training and competition outcomes were most likely the result of the deliberate training process. The accurately planned and implemented training loads, which were based on the special requirements of the racing distance and the individual characteristics of the athlete, were causative agents.

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