Adaptation of sport training plans by swarm intelligence

Iztok Fister Jr.[1], Andres Iglesias[3], Eneko Osaba[2], Uroš Mlakar[1], Janez Brest[1], and Iztok Fister[1]

[1] University of Maribor, Faculty of electrical engineering and computer science
Smetanova 17, 2000 Maribor, Slovenia
Email: iztok.fister1@um.si,
[2] University of Deusto, Av. Universidades 24, Bilbao 48007, Spain
[3] University of Cantabria, E.T.S.I. Caminos, Canales y Puertos, Avda. de los Castros, s/n, E-39005, Santander, Spain

Abstract. Automatic planning of sport training sessions with Swarm Intelligence algorithms has been proposed recently in the scientific literature that influences the sports training process in practice dramatically. These algorithms are capable of generating sophisticated training plans based on an archive of the existing sports training sessions. In recent years, training plans have been generated for various sport disciplines, like road cycling, mountain biking, running. These plans have also been verified by professional sport trainers confirming that the proposed training plans correspond with the theory of sports training. Unfortunately, not enough devotion has been given to adapting the generated sports training plans due to the changing conditions that may occur frequently during their realization and causes a break in continuity of the sports training process. For instance, athletes involved in the training process can become ill or injured. These facts imply disruption of the systematic increase of the athlete's capacity. In this paper, therefore, we propose a novel solution that is capable of adapting training plans due to the absence of an athlete from the training process.

Keywords: artificial sport trainer, multisport, sport training, swarm intelligence, running

1 Introduction

During the process of sports training, an athlete's body adapts to loading that causes the raising of the athlete's capacity due to external loading or adjustment to specific environmental conditions [2]. Indeed, external loading is determined by sports trainers prescribing their trainees the corresponding sports training plans. The sports training plans include a sequence of sports training sessions for a specific period of sports training (also a cycle). Thus, each sports training session is determined by exercise type, duration, intensity and frequency.

Actually, the athlete's body undergoes three kinds of adaptation during the sports training process, i.e., physical, intellectual and emotional adaptation. However, all three kinds refer to a psycho-physiological adaptation of the athlete in the sports training process. This process has been led by the sports trainers until now, who affect the normal realization of the sports training plan with adapting the sports training plans according to the current athlete's performance.

Usually, the normal realization of the sports training plan can be disturbed due to an athlete's injury, illness, travel during the competition season, or even some other psychological problems. The mentioned factors imply disruption of the systematic increase of loading by an athlete in sports training. Consequently, this means a break in continuity of the physiological adaptation process, where the effects of loading are lost, especially when the intervals between training exercises are too long.

In more detail, injuries are one of the more complex disturbing factors that may disable the athletes from the normal training process for a longer time. When injuries have been acquired by athletes, they usually have to seek medical advice. However, sports trainers are also involved in the recovery process. Actually, sports trainers, along with medical experts, decide how to continue with the sports training process, i.e., what is the best way to continue treatment and what will be the starting steps for recovery. The major sports injuries are as follows: Various bone fractures, head injuries [7], strains, etc. On the other hand, there are also some minor sports injuries that affect the athlete's sports training for some days only. In this group, we count different abrasions, burns, blisters and so on. Not only injuries, but also illness, is very unpredictable disturbing factor that depends not only on sports involvement, but also on the other areas of a human's life. For example, in the winter season there is a lot of flu that may infect the athletes as well. This infection can prevent them from the sports training process from one day to several weeks. Automatic planning of the sport training sessions has been become a very popular research topic. In recent years, the concept of an Artificial Sport Trainer (AST) has been proposed by Fister et al. in [4]. The aim of the AST is to automate tasks of the real Sport Trainer, especially in those phases of the sports training where a lot of data are generated by using the wearable mobile devices and the data analysis cannot be performed without the help of digital computers. In a nutshell, an AST is able to plan sport training sessions for short, as well as long, periods of sports training.

Adaptation of sports training plans using an AST has not been studied deeply, until recently. In this paper, we present the problem of adapting the training plans. The Particle Swarm Optimization (PSO) algorithm [6] is one of the first members of Swarm-Intelligence (SI) based algorithms that was proposed back in 1997. The remainder of the paper is organized as follows. Firstly, we expose a problem theoretically, while secondly we present a solution and results.

2 A problem description

In the case of an athlete's deviance from the planned sport training sessions, an athlete has basically the following scenarios with which to catch up missed sports training sessions:

- Increase the intensity of the next training session that is planned in the schedule: In this case, the intensity of the training sessions that are still waiting in the schedule are enhanced. Usually, we cannot enhance them too much, because athletes can be injured again. On the other hand, they can easily become over-trained.
- Prolonged schedule: In this case, we increase the number of days in the schedule.
- Generate a totally new training plan: In this case, we generate a new training plan for the remaining cycle.
- Perform more training sessions in one day: This is a very uncommon situation because, performing more sports training sessions in one day, demands from the recovered unfit athlete too much effort. Although performing more training sessions in one day is normally for professional or some other semi-professional athletes, this is untypical for the amateur athletes, who go to work each day.
- Nothing with missed training: The athlete just continues with the proposed training plan as if nothing has happened. However, this is good solution only for athletes without any competition goals.

However, there is no universal recipe for which of the mentioned scenarios is the more appropriate for adapting their sports plans in the case of the sports training session loss. Indeed, all athletes are unique and possess their own characteristics. Therefore, the adaptation of sports training plans demands a perfect knowledge about the psycho-physical characteristics of the athlete in training. In line with this, this adaptation seems to be a much harder problem than generating a training plan from scratch. In the remainder of the paper, we present a mathematical description of a problem along with one case study. In our case, we proceed from the first scenario, where increasing the intensity of the future training sessions is taken into account.

3 Materials and methods

This section acquaints readers with the background information needed for understanding the subject in the continuation of the paper. In line with this, the sports training plan generated by the AST is discussed, that serves as a benchmark for testing the proposed algorithm for adapting the sports training plan. Additionally, the basics are described of the Particle Swarm Optimization (PSO) algorithm underlying the proposed algorithm. Finally, the proposed PSO for adapting the sports training plans is illustrated.

3.1 Test sports training plan

A sports training plan generated by an AST [4] serves as a test instance for adaptation. Although this supports various nature-inspired algorithms, this instance was generated with the PSO algorithm. Let us notice that this training plan is intended for a semi-professional runner, who prepares himself for 10 km long-distance runs and half-marathons (21.1 km). The test sports training plan was generated for a cycle of 50 days, while the total training load indicator of this sports training plan amounts to TRIMP = 386484.0. The training load indicator TRIMP is simply the product of TRIMP $= TD \cdot HR$, where the HR denotes the intensity and the TD the duration of the sports training session [1]. This measure is devoted for measuring the internal loading, where the effective values of the intensity and duration are measured using wearable mobile devices.

Table 1. Proposed training plan for semi-professional runner generated by the AST.

Training sessions	HR	TD	TRIMP	Training sessions	HR	TD	TRIMP
1	142	65	9230	26	105	29	3045
2	156	64	9984	27	142	65	9230
3	141	91	12831	28	141	55	7755
4	125	38	4750	29	125	45	5625
5	141	74	10434	30	162	51	8262
6	158	47	7426	31	136	31	4216
7	128	36	4608	32	126	38	4788
8	128	26	3328	33	169	65	10985
9	142	65	9230	34	128	75	9600
10	141	55	7755	35	158	45	7110
11	141	91	12831	36	121	41	4961
12	115	28	3220	37	141	52	7332
13	142	65	9230	38	133	71	9443
14	158	51	8058	39	142	65	9230
15	129	45	5805	40	115	28	3220
16	125	45	5625	41	125	38	4750
17	128	75	9600	42	138	87	12006
18	142	65	9230	43	169	65	10985
19	132	29	3828	44	141	71	10011
20	115	28	3220	45	138	87	12006
21	125	29	3625	46	162	41	6642
22	141	87	12267	47	121	26	3146
23	141	55	7755	48	129	84	10836
24	128	75	9600	49	141	54	7614
25	157	65	10205	50	141	71	10011
Total	136.84	55.76	193675	Total	137.96	55.2	192809

Let us imagine that the athlete who is training according to the schedule presented in Table 1 becomes injured and absent from training after conducting 50 % of the total schedule (training sessions 1-25 in Table 1). Then, the injury causes an absence of 10 days (20 % of the schedule), which means that 30 % of the whole schedule remains yet unfinished. The border between both schedules is denoted with two double line between 35 and 36 training days in Table 1. In the sense of the training load indicator TRIMP, the exposed facts can be expressed as follows (Fig. 1):

- 50 % of completed sports training sessions in the schedule is 25 days (Total TRIMP: 193675.0),
- 20 % of failed sports training sessions in the schedule is 10 days (Total TRIMP: 70616.0), and
- 30 % of unfinished sports training sessions in the schedule is 15 days (Total TRIMP: 122193.0).

It means that the athlete has realized the first 25 days of the prescribed sports training plan successfully, while he was disturbed for the next 10 days. In summary, 15 days of training remain for him to realize, where he must catch up the training sessions in the 10 days that were not performed due to his illness. Catching up the whole TRIMP for these 10 days is impossible, because of exhaustion, over-training or any injuries. However, an athlete can conduct training sessions that are in the schedule, while the intensity of these training sessions can be enhanced.

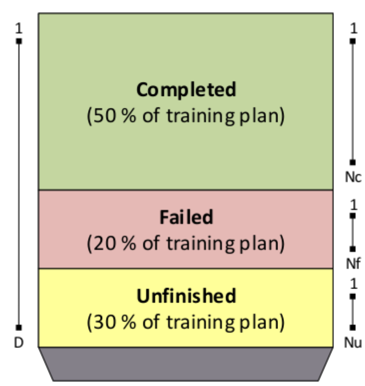

Fig. 1. Dividing the sports training plan into various types of sports sessions by adaptation, where the unfinished training sessions must be adapted with regard to the failed ones.

The sports training cycle of length D in Fig. 1 is divided into: The completed sports training sessions of dimension Nc, the failed sports training sessions of dimension Nf, and the unfinished sports training sessions of dimension Nu.

3.2 Particle Swarm Optimization

The PSO algorithm maintains a population of solutions, where each solution is represented as a real-valued vector $\mathbf{x} = (x_{i,1}, \ldots, q_{i,D})^T$ for $i = 1, \ldots, Np$ and $j = 1, \ldots, D$, and the parameter Np denotes the population size and the parameter D the problem dimension. This algorithm explores the new solutions by moving the particles throughout the search space in the direction of the current best solution. In addition to the current population $\mathbf{x}_i^{(t)}$ for $i = 1, \ldots, Np$, also the local best solutions $\mathbf{p}_i^{(t)}$ for $i = 1, \ldots, Np$ are maintained denoting the best i-th solution found. Finally, the best solution in the population $\mathbf{g}^{(t)}$ is determined in each generation. The new particle position is generated according to Eq. (1):

$$\begin{aligned} \mathbf{v}_i^{(t+1)} &= \mathbf{v}_i^{(t)} + C_1 U(0,1)(\mathbf{p}_i^{(t)} - \mathbf{x}_i^{(t)}) + C_2 U(0,1)(\mathbf{g}^{(t)} - \mathbf{x}_i^{(t)}), \\ \mathbf{x}_i^{(t+1)} &= \mathbf{x}_i^{(t)} + \mathbf{v}_i^{(t+1)}, \end{aligned} \tag{1}$$

where $U(0,1)$ denotes a random value drawn from the uniform distribution in interval $[0,1]$, and C_1 and C_2 are learning factors. The pseudo-code of the original PSO algorithm is illustrated in Algorithm 1.

Algorithm 1 Pseudocode of the basic Particle Swarm Optimization algorithm

Input: PSO population of particles $\mathbf{x_i} = (x_{i1}, \ldots, x_{iD})^T$ for $i = 1 \ldots Np$, MAX_FE.
Output: The best solution $\mathbf{x}_{best}$ and its corresponding value $f_{min} = \min(f(\mathbf{x}))$.

init_particles;
$eval = 0$;
while termination_condition_not_meet **do**
    for $i = 1$ to Np **do**
        f_i = evaluate_the_new_solution($\mathbf{x}_i$);
        $eval = eval + 1$;
        if $f_i \leq pBest_i$ **then**
            $\mathbf{p}_i = \mathbf{x}_i$; $pBest_i = f_i$; // save the local best solution
        end if
        if $f_i \leq f_{min}$ **then**
            $\mathbf{x}_{best} = \mathbf{x}_i$; $f_{min} = f_i$; // save the global best solution
        end if
        $\mathbf{x}_i$ = generate_new_solution($\mathbf{x}_i$);
    end for
end while

In the next subsection, the proposed PSO algorithm is presented for adaptation of training plans.

The PSO for adaptation of training plans The algorithm for adapting sports training sessions relates to the results of the algorithm for planning sports training sessions based on existing sports activities proposed by Fister et al. in [3]. Actually, the solution in this algorithm is presented as a real-valued vector:

$$\mathbf{x}_i^{(t)} = (x_{i,1}^{(t)}, \ldots, x_{i,D}^{(t)})^T, \quad \text{for } i = 1, \ldots, Np. \tag{2}$$

Additionally, a permutation of clusters $\mathbf{\Pi}_i^{(t)}$ is assigned to each solution $\mathbf{x}_i^{(t)}$, as follows:

$$\mathbf{\Pi}_i^{(t)} = (C_{\pi_{i,1}}^{(t)}, \ldots, C_{\pi_{i,D}}^{(t)})^T, \quad \text{for } i = 1, \ldots, Np, \tag{3}$$

where $\pi_{i,j}$ for $j = 1, \ldots, D$ denotes a permutation of a cluster set $C = \{C_1, \ldots, C_m\}$, where m is the number of clusters. Thus, each cluster $C_{\pi_{i,j}}^{(t)} = \{s_{\pi_{i,j},1}^{(t)}, \ldots, s_{\pi_{i,j},n_{\pi_{i,j}}}^{(t)}\}$, where $n_{\pi_{i,j}}$ is the cluster size, combines sports training sessions $s_{\pi_{i,j},k}^{(t)}$ of the similar internal loading measured by the training load indicator TRIMP. The specific sports training session $s_{\pi_{i,j},k}^{(t)}$ is selected from the cluster $C_{\pi_{i,j}}^{(t)}$ by calculating the index k according to the following equation:

$$k_j = \left\lceil x_{i,j}^{(t)} \cdot n_{\pi_{i,j}} \right\rceil. \tag{4}$$

Each sports training activity specified in the cluster $C_{\pi_{i,j}}^{(t)}$ is a couple $s_{\pi_{i,j},k_j}^{(t)} = \langle TD_{\pi_{i,j},k_j}^{(t)}, HR_{\pi_{i,j},k_j}^{(t)} \rangle$, where $TD_{\pi_{i,j},k_j}^{(t)}$ denotes the duration and $HR_{\pi_{i,j},k_j}^{(t)}$ the average heart rate of the $x_{i,j}^{(t)}$-th element of the corresponding solution. The fitness function of the algorithm for planning sports training sessions based on existing sports activities is expressed as follows:

$$f^*(\mathbf{x}_i) = \max \sum_{j=1}^{D} TD_{\pi_{i,j},k_j}^{(t)} \cdot HR_{\pi_{i,j},k_j}^{(t)}, \tag{5}$$

subject to

$$\begin{aligned} &TD_{\pi_{i,j},k_j}^{(\min)} \leq TD_{\pi_{i,j},k_j}^{(t)} \leq TD_{\pi_{i,j},k_j}^{(\max)}, \text{ and} \\ &HR_{\pi_{i,j},k_j}^{(\min)} \leq HR_{\pi_{i,j},k_j}^{(t)} \leq HR_{\pi_{i,j},k_j}^{(\max)}, \end{aligned} \tag{6}$$

where $TD_{\pi_{i,j},k_j}^{(\min)}$ and $HR_{\pi_{i,j},k_j}^{(\min)}$, and $TD_{\pi_{i,j},k_j}^{(\max)}$ and $HR_{\pi_{i,j},k_j}^{(\max)}$ denote the minimum and maximum values of variables $TD_{\pi_{i,j},k_j}^{(t)}$ and $HR_{\pi_{i,j},k_j}^{(t)}$, respectively. The main modifications of the original PSO algorithm for adapting the sports training plans encompass the following components:

- Representation of individuals,
- Initialization of solutions (function 'init_particles' in Algorithm 1),
- Fitness function evaluation (function 'evaluate_the_new_solution' in Algorithm 1).

Individual in the PSO algorithm for adapting the training plans is represented as a real-valued vector $\mathbf{y}_i^{(t)}$ for $i = 1, \ldots, Np$ and $j = 1, \ldots, 2 \cdot Nu + 1$, where the parameter Nu denotes the number of days that need to be adapted. In fact, two elements of the solution vector $y_{i,2*j}^{(t)}$ and $y_{i,2*j+1}^{(t)}$ are reserved for each day denoting the adapted duration $TD_{i,j}^{(t)}$ and average heart rate $HR_{i,j}^{(t)}$ for the corresponding sports training session $\langle TD_{i,j}^{(t)}, HR_{i,j}^{(t)}\rangle$, respectively.

Fitness function maximizes the training load indicator TRIMP, as follows:

$$f^*(\mathbf{y}_i^{(t)}) = \min \left| \sum_{j=1}^{Nc} TD_{\pi_{i,j},k_j}^{(t)} \cdot HR_{\pi_{i,j},k_j}^{(t)} + \sum_{j=1}^{Nu} y_{i,j*2}^{(t)} \cdot y_{i,j*2+1}^{(t)} - f^*(\mathbf{x}_i^{(t)}) \right|, \quad (7)$$

subject to

$$\begin{aligned} \widetilde{TD}_{i,j}^{(\min)} \leq y_{i,2\cdot j}^{(t)} \leq \widetilde{TD}_{i,j}^{(\max)}, \\ \widetilde{HR}_{i,j}^{(\min)} \leq y_{i,2\cdot j+1}^{(t)} \leq \widetilde{HR}_{i,j}^{(\max)}, \end{aligned} \quad (8)$$

where $\widetilde{TD}_{i,j}^{(\min)}$ and $\widetilde{TD}_{i,j}^{(\max)}$ are by 60 %, enhanced values of $TD_{i,j}^{(\min)}$ and $TD_{i,j}^{(\max)}$, and $\widetilde{HR}_{i,j}^{(\min)}$ and $\widetilde{HR}_{i,j}^{(\max)}$ are by 15 %, enhanced values of $HR_{i,j}^{(\min)}$ and $HR_{i,j}^{(\max)}$, respectively.

In Eq. (7), the first term denotes the training load of complete training sessions according to Eq. (5), the second term the training load of the adapted training load, while the $f^*(\mathbf{x}_i^{(t)})$ is the training load of the proposed sports training plan. The purpose of the fitness function $f^*(\mathbf{y}_i^{(t)})$ is to adapt the remaining training sessions so that the difference between the proposed and real sports training plan is as small as possible.

4 Experiments and results

The goal of the experimental work was to show that the proposed PSO algorithm is appropriate for adapting the sports training plans, when the normal realization of the sports training plans is disturbed due to an athlete's illness. In our case, the illness prevented the athlete from training for ten days. From the sports trainer standpoint, this means that the realization of the sports training plans was deteriorated by 20 %. The PSO algorithm for adapting the sports training plans was implemented in Python programming language using no special external libraries. The task of the algorithm was to adapt the training plan of duration 15 days for the semi-professional runner that missed 10 sports training sessions due to illness. The parameter settings of the PSO as presented in Table 2 were used during the experimental work. Three different runs of the proposed PSO algorithm were analyzed in detail.

Test problems as illustrated in Section 3.1 were used in our experimental work. The results were measured according the minimum value of the difference between the training load indicator TRIMP of the proposed and adapted sports training plans. The results of the optimization obtained by the PSO algorithm for adaptation of sports training plans are presented in Tables 3 and 4. Actually, Table 3 depicts the reference training as proposed by the algorithm for generating

Table 2. Parameter setting for the PSO algorithm

Parameter	Variable	Value
Population size	NP	100
Maximal number of fitness function evaluations	MAX_FE	50000
Dimension of the problem	D	30
Velocity coefficients	C_1, C_2	2.0

the training plans based on the existing sports activities, and the results of the adapting the sports training sessions in the first run. Moreover, Table 4 depicts the results of adapting as proposed in runs two and three.

Table 3. Results of the reference training and the run 1.

Reference training	HR	TD	TRIMP	Adapted training 1	HR	TD	TRIMP
1	121.00	41.00	4961.00	1	105.00	29.45	3092.04
2	141.00	52.00	7332.00	2	154.30	103.64	15991.99
3	133.00	71.00	9443.00	3	130.66	75.01	9800.94
4	142.00	65.00	9230.00	4	136.04	32.01	4354.44
5	115.00	28.00	3220.00	5	154.75	80.85	12512.51
6	125.00	38.00	4750.00	6	111.74	27.59	3083.23
7	138.00	87.00	12006.00	7	124.41	45.02	5600.95
8	169.00	65.00	10985.00	8	183.54	101.23	18579.72
9	141.00	71.00	10011.00	9	142.41	101.37	14435.17
10	138.00	87.00	12006.00	10	127.19	61.31	7797.60
11	162.00	41.00	6642.00	11	114.67	59.32	6802.42
12	121.00	26.00	3146.00	12	158.10	49.13	7768.27
13	129.00	84.00	10836.00	13	135.22	112.37	15193.61
14	141.00	54.00	7614.00	14	161.53	73.36	11850.48
15	141.00	71.00	10011.00	15	125.46	28.39	3561.54
Summary	137.13	58.73	**122193.00**	Summary	137.67	65.34	**140424.91**

As can be seen from Tables 3-4, the internal training load of the adapted sports training plans 1 to 3 increases from 140424.91 to 148583.51. All adapted training plans increase the intensity of the adapted sports training plan significantly, although the days lost cannot be caught up. Actually, the realization of the sports training plan can be increased from 68.30 % (TRIMP=264291) by the reference sports training plan to 74.95 % (TRIMP=289681.55) in the case of the most intensively adapted sports training plan 3. The results according to adapted sports training sessions obtained in three different runs with regard to the proposed sports training plan are presented in Fig. 2, from which it can be seen that the adapted sports training plans obtained in runs 1-3 increase the intensity load indicator TRIMP significantly compared with the reference sports training plan.

Table 4. Results of the run 2 and run 3.

Adapted training 2	HR	TD	TRIMP	Adapted training 3	HR	TD	TRIMP
1	114.66	29.05	3331.37	1	104.99	29.28	3074.43
2	143.01	68.10	9738.62	2	146.26	103.47	15133.47
3	132.01	87.18	11508.11	3	138.70	67.38	9345.47
4	121.38	71.49	8676.65	4	139.59	56.20	7845.18
5	185.67	80.43	14932.78	5	153.08	80.03	12250.38
6	147.35	30.04	4426.45	6	123.09	31.50	3877.42
7	132.54	49.10	6507.57	7	135.56	22.68	3074.11
8	193.07	70.20	13553.10	8	183.07	103.57	18959.61
9	139.37	119.52	16656.97	9	145.80	98.21	14319.49
10	166.55	70.48	11739.26	10	139.28	62.54	8710.66
11	138.75	43.07	5975.89	11	128.89	61.09	7873.57
12	159.46	82.76	13197.50	12	160.68	82.53	13260.56
13	125.75	69.26	8708.94	13	138.88	74.00	10277.32
14	144.12	103.91	14975.78	14	155.43	103.47	16083.29
15	111.95	32.22	3607.20	15	115.05	39.10	4498.55
Summary	143.71	67.12	**147536.18**	Summary	140.56	67.67	**148583.51**

The summary results of the PSO algorithm for adapting the sports training plans are illustrated in Table 5, that compares the results of planning the reference sports training sessions with the results of adapting the sports training plans obtained in three different runs. This comparison is performed in the sense of calculating the difference between the adapted training load obtained in three independent runs and the training load obtained by the reference sports training plan.

Table 5. Summary results of the adapting the sports training plans.

Training	$\overline{\text{HR}}$	$\overline{\text{TD}}$	TRIMP	$\Delta\overline{\text{HR}}$	$\Delta\overline{\text{TD}}$	ΔTRIMP
Reference	137.13	58.73	122193.00	0.00(0.00 %)	0.00(0.00 %)	0.00(0.00 %)
Run 1	137.67	65.34	140424.91	0.53(0.39 %)	6.60(11.24 %)	18231.91(14.92 %)
Run 2	143.71	67.12	147536.18	6.57(4.79 %)	8.39(14.28 %)	25343.18(20.74 %)
Run 3	140.56	67.67	148583.51	3.42(2.50 %)	8.94(15.22 %)	26390.51(21.69 %)

Interestingly, the internal loading can be increased by raising either the intensity (HR) or duration (TD) of the corresponding sports training plan. In the first adapted training plan, the average heart rate is increased only by 0.39 %, while the duration even by 11.24 %. However, this is in accordance with the boundary constraints that enable increasing the intensity by, at most, 15 % and the duration by, at most, 60 %. The second run proposes raising the intensity by 4.79 % and duration by 14.28 %, while the third run, in contrast, raises the intensity only by 2.50 %, but the duration even by 15.22 % that, in summary,

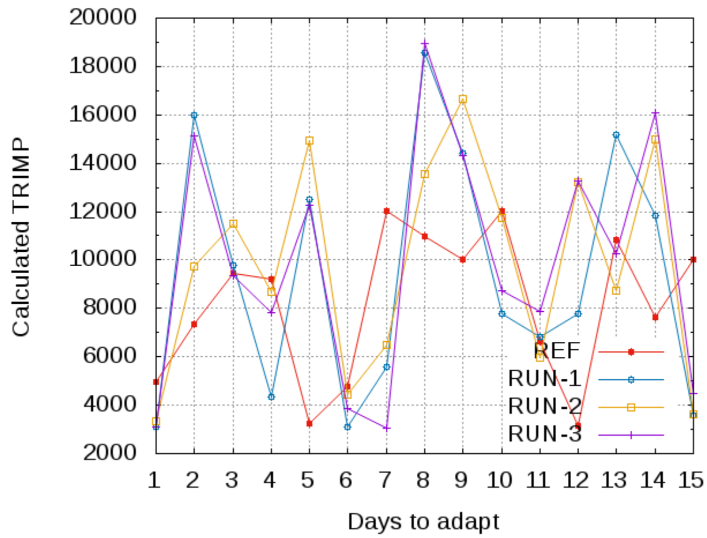

Fig. 2. Graphical presentation of the results obtained by adapting the sports training plans.

means increasing the sports training load by 21.69 %. This is a characteristic of the training load TRIMP, where the increasing of this coefficient can be performed either by increasing the average heart rate or the duration of the sports training session.

5 Conclusion

Adaptation of sport training plans is a very important task of real sport trainers, especially for those who are not very experienced [8]. Dealing with this is very hard, because adaptation takes place usually when athletes are injured or ill. Because of that, they are absent from sports training and, therefore, not able to perform sports training sessions according to the schedule. This paper proposed a simple yet effective solution for adaptation of sports training plans based on the Particle Swarm Optimization algorithm. The results presented in this paper confirmed that it is possible to adapt the sports training plans that were initially generated by an AST efficiently. In fact, there are still really big opportunities for improvement of this solution. Firstly, results should be more aligned to the pure theory of sport training while, secondly, other ways of adapting the sports training plans should be explored. Additionally, it would be interesting to see the performance of various population nature-inspired algorithms [5] in solving this problem.

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