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Is physical training a good synchronizer of the performance?

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Whether changes in the training schedule are capable of modifying the daily pattern of performance has been studies. Twelve swimmers were selected to determine their performance in 25 meter crawl races. Their body temperature was also measured. This group was subsequently divided into 3 subgroups: Sub-group 1, made up of 2 subjects who acted as the control subgroup, trained only in the afternoon; Subgroup 2, composed of 5 subjects, trained only in the morning; and Subgroup 3, also made up of 5 subjects, trained in the afternoon but with an additional session of 10 min of swimming in the morning. All subjects followed their corresponding training pattern for three weeks after which they were subjected to a second study or testing day. Thereafter, they all trained one more week according to the same habitual schedule in the evening; after that, they were tested again. A significant variance in the performance time was observed throughout the day (a maximum performance being observed at around 20:30 h), although the changes introduced in the training schedule did not modify the curve of performance.

Key words: Circadian rhythms, Swimming, Training schedule.

Circadian rhythms have been described with regard to physical performance (11, 16), different times of day being more suitable for optimal or best performance depending upon the given variable (7, 10). Optimal performance appears to occur most frequently in the evening (6, 8, 16); as it was found in swimmers (2, 14). Only one study seemed to evaluate the training schedule as a change inducing synchronizer in the rhythmicity of the aforesaid performance (4). It indicated that the changes may have a small synchronization power

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capable of modifying only the ventilatory threshold, this being more elevated in the morning in the group that trained in the morning and more elevated in the evening in the group that trained in the evening.

Nevertheless, the introduction of changes in the training schedule often occurs in several sports to improve performance in competition (9). The usual procedure is to modify the morning schedule if the competition is to take place in the morning and the sportman was usually training in the evening and viceversa.

The purpose of the present study was to determine if the modifications in the training schedule have any repercussion on the peaks of performance and to evaluate whether such maneuvers are of any practical value; at the same time, we wanted to assess if physical performance at the training time is susceptible of improvement.

Materials and Methods

Twelve healthy volunteers (youthful) national-class swimmers, 14.8 ± 0.4 years old, 170.4 ± 5.0 cm high, weighing 66.4 ± 8.4 kg, with a background in sports competition of 3 ± 0.7 years, and with 12 h of training per week. The study was carried out at the "Institut Nacional d'Educació Física de Barcelona" where the swimmers were lodged until all the pertinent data had been collected. The facilities and premises of the Institute were made available for the sole purpose of the study in order to prevent any possible interference from external factors. The control subjects (swimmers) were informed of the details of the procedure by the researchers themselves (authors). The variables controlled were: body temperature and timings in 25 m free-style swimming races. The temperature was measured at the axilla using a clinical thermometer (H. Ico, Spain), keeping the device in the axillary cavity for 5 minutes. The body temperature measurements started few minutes after rising and were continued every two hours, thereafter, until night bed rest. Temperature measurements were made during each of the study or testing days as well as during the two preceding days. The 25 m free-style races were performed in an indoor swimming pool adjacent to the Center where the observations were being made. A standard diet was served, strictly followed by the swimmers, during each of the testing days, both with respect to the quantity of food and their nutrient composition. There were no significant differences in the amount of calories consumed at each of the 4 meals ingested throughout the day. The participants in the study rose at 7:30 A.M. with the first trial taking place at 8:30 and every 2 h thereafter until 22:30 h. Breakfast was served at 9:00 h, lunch at 13:30 h, a mid-afternoon snack at 17:00 h, and dinner at 21:00 h. This program was followed during the 3 days of testing.

The previously described protocol was followed by all participants on the 1st day of the study. On the 2nd testing day, the same basic protocol was followed, the sample being divided into 3 different subgroups: a) Subgroup M (n = 5), which changed their usual training schedule from 19 to 20:45 h to a new one from 7 to 8:45 h A.M., which was maintained during a 3 week period, after which the individuals were subjected to a second control or "testing day".

b) Subgroup AM (n = 5), continued training at the usual time in the afternoon during 3 weeks since the 1st testing day, a short warm-up session, of ten minute duration, at 8:15 A.M being added as a light exercise. This group was considered to be the one that exercises in the morning and in the afternoon. After these 3 weeks of training the individuals were subjected to a second testing day.

c) Subgroup C (n = 2), maintained their usual training schedule in the afternoon throughout the study and was used as a "reference group".

A third evaluation was performed a week after the second testing day with the same protocol used during the first and second testing days. All participants in the study trained, from 19 to 20:45 h, their habitual time throughout this week during the same number of hours, the volume and load of training being the same for all.

Statistics.– All measurements were analyzed by means of multivariate analysis of variance (ANOVA), the following independent parameters being considered: day, time of day, and subject in each of the groups. The performance achieved at different times on different days was compared using the Student's *t* test for paired observations.

The COSINOR method was used for the analysis of data on temperature recordings with the purpose of defining possible circadian rhythms.

Results

First evaluation day.– A statistically significant difference in the performance (evaluated by the MANOVA method) along the different trials was observed on the first day of the study (1st testing day) in all twelve swimmers (F = 3.19, p = 0.005). The best performance time was achieved at 20:30 h (15.1 ± 0.2 s), and the worst at 14:30 h (15.5 ± 0.2 s, mean ± SE). The body temperature recorded on the first day of the study (first testing day) showed statistically significant variations along the day, according to the ANOVA method (F = 20.32, p < 0.001). The highest values were observed between 16:30 h and 18:30 h (fig. 1).

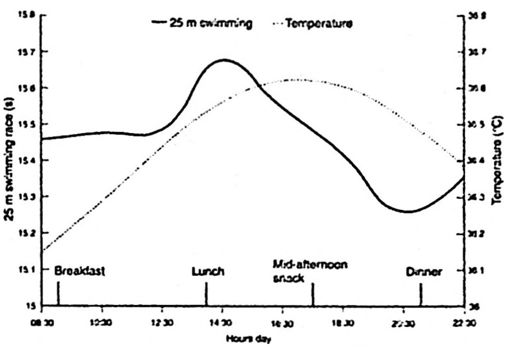

Fig. 1. *Comparison of 25 m free-style swimming race and temperature in the first day.*
The 25 m performance curve is the mean (mean ± SD) of the group and the temperature curve is obtained from the Cosinor method.

Comparison of the 25 m free-style race performed during the three study days.– Control Subgroup (C). When the timing-scores obtained by the control group in the 25 m races were compared by the ANOVA method, no significant differences were found between the times achieved during the different trials performed at the same time during the three study days (F = 1.41, p > 0.05) (fig. 2).

Subgroup Training in the afternoon and the morning (MA).– When the scores obtained in the successive 25 m races by the group training in the morning and in the afternoon significant differences were observed between the times achieved during the different days of the study (p = 0.01), with a significant fall in the performance on the 2nd day of the study when compared to the 1st. When the scores obtained at the different time controls on each of the 3 days were compared to each other, no statistically significant differences in the morphology of the oscillation curve was observed (p > 0.05), suggesting that the variation in performance was not different on any of the 3 days of the study in this group.

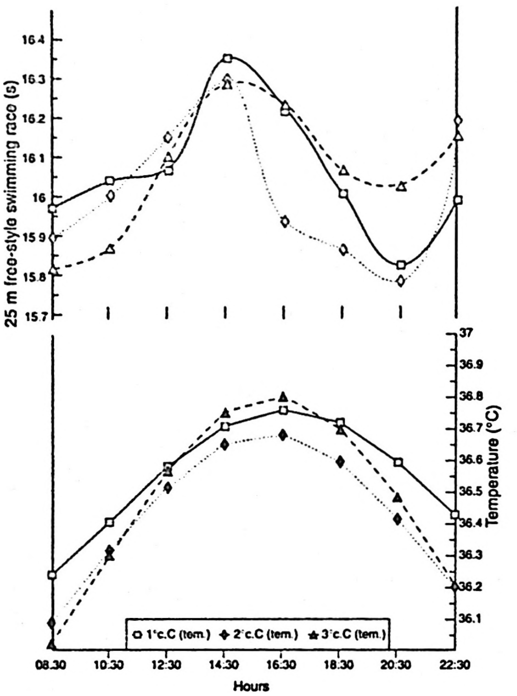

Fig. 2. *Comparison of performance in 25 m free-style swimming race and of the temperature curve, obtained by means of the Cosinor method, in the group C in the 3 days of study.*

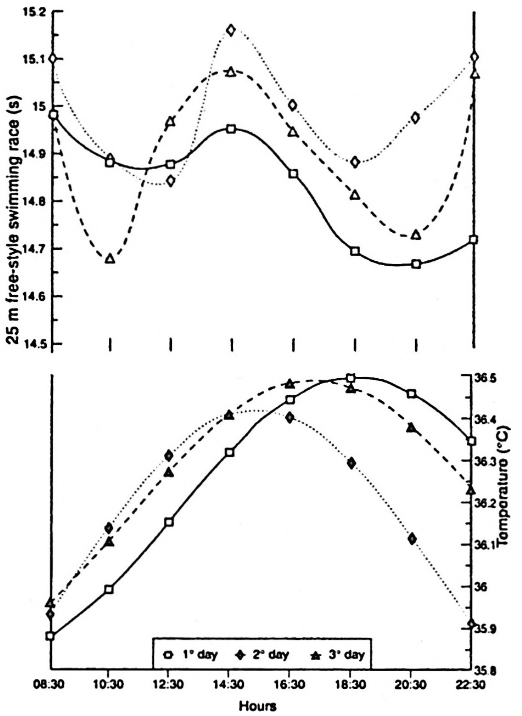

Fig. 3. *Comparison of performance in 25 m swimming race and of the temperature curve, obtained by means of the Cosinor method, in the group MA in the 3 days of study.*
Values are the mean ± SD

An analysis of the differences between the different days at all the control times was done utilizing the Student's *t* test which showed a significant difference between the 1st and 2nd day of the study at 20:30 h ($t = -3.26$, $p < 0.05$), the 1st day being the best; and a further difference between the 2nd and 3rd day at 10:30 h ($t = 8.57$, $p = 0.001$), the 3rd day being the best (fig. 3).

Subgroup training only in the morning (M).– When the scores corresponding to each of the 25 m races performed by the group training in the morning were compared, no significant differences were observed between any of the three study days ($p > 0.05$). An analysis of the differences between the different days at the different time controls was done utilizing the Student's t test which showed a significant difference between the 2nd and 3rd day at 22:30 ($t = -3.14$, $p < 0.05$), the score obtained on the 2nd day being the best (fig. 4).

Temperature oscillations.– The statistical analysis of the data recorded in all groups and days was carried out by means of the COSINOR method; it showed the existence of a circadian rhythm (table I) in all of them.

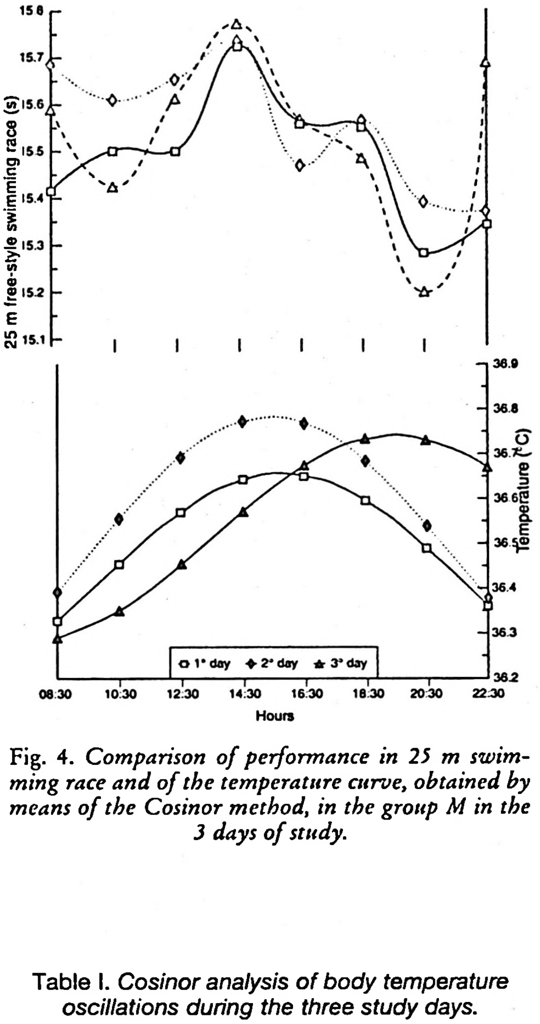

Fig. 4. *Comparison of performance in 25 m swimming race and of the temperature curve, obtained by means of the Cosinor method, in the group M in the 3 days of study.*

Table I. *Cosinor analysis of body temperature oscillations during the three study days.*

Sub-group	Day study	Mesor °C	Amplitude °C	Acrophase h
C	1	36.4	0.3	16.69[a]
	2	36.3	0.4	16.32[a]
	3	36.3	0.5	16.19[b]
AM	1	36.2	0.3	18.69[c]
	2	36.0	0.4	15.39[c]
	3	36.2	0.3	17.26[a]
M	1	36.5	0.2	15.77[d]
	2	36.5	0.3	15.41[a]
	3	36.5	0.2	19.47[a]

C = Control; AM = Afternoon and morning and M = morming. Significance of the COSINOR method (p): [a]0.001, [b]<0.001, [c]0.01, [d]<0.05.

Discussion

A diurnal variation in performance in competitive swimmers being significantly better in the evening than in the morning has been observed. The best time has been achieved consistently at 20:30 h in the control on evaluation day. On the other hand, the worst performance has been achieved during the period following lunch (14:30 h) a fact unnoticed by other studies (5, 13) probably due to their having taken only one measurement per day preceded by a few hours of fasting. The performance impairment observed here might pass unnoticed in other swimming studies as they had only one control in the morning and another one in the evening. Furthermore, since most of these studies were carried out with nonspecific tests for swimmers (as the Wingate's test), the whole procedure might be thought to be endowed with a low degree of sensitivity, thus precluding the detection of the changes observed by us (3, 15).

A circadian rhythm in body temperature with an acrophase at around 17:30 h has been noticed. A certain parallelism has been described between physical performance and body temperature, this relationship not being constant (2), and suggesting that although there may be optimal temperatures for each physical performance (1), it could be influenced by several factors. This would suggest that physical performance and body temperature are not related to the same oscillator. Nevertheless, REILLY and MARSHALL have observed a fairly good interrelationship between these 2 factors (12).

In the control subgroup (C) no noticeable modifications were observed during the three evaluation days, the swimming performance times as well as the body temperature values showing the same rhythmic oscillations. In group (MA), a general impairment is observed on the 2nd day of the study with regard to the 1st, which could be attributed to the modifications provoked by the change in the training schedule routine. These changes may have affected the average level of performance for that day. This adverse effect was counteracted when the extra 10 min morning session was suppressed, the training being only in the evening, as before. This may be the case, as this decrease in performance disappeared on the 3rd control day, maintaining, however, a significant improvement in the morning (10:30 h) when compared to the performance on the 2nd day. Contrariwise, body temperature oscillations were not affected by these modifications. This maneuvering would seem to induce greater alterations in the morphology of the circadian oscillations of the performance rather than on body temperature.

In group (M) no significant differences were observed in the average performance times during all the 3 testing days, but there were differences in the temperature curve, which showed an important delay of the acrophase on the 3rd day of the study. In this case, the sudden or harsh change in the training routine would seem not to have such great influence on the oscillation of the performance but it would definitely have an impact on the course of temperature variations.

Training, in general, would seem to have a very weak synchronizing effect and although capable of provoking small changes in the morphology of the curves, they are not statistically significant and, therefore, not capable of altering the peaks of performance. These results are similar to those reported by HILL *et al.* in as much as the only modification depending on the training schedule (4) was in the ventilatory threshold, this being greater in the morning for morning trainees and greater in the evening for evening trainees. No statistically significant differences were found among the different maximal variables in both groups of that study. It is also worth pointing out that those subjects were training in the evening or in the morning for the first time and had not, therefore, been exposed to the distortion of the training schedule that our swimmers experienced when the routines were changed.

With regard to the swimming performance, there appears to be better performance time towards the end of the evening, which in our group corresponded to 20:30 h. A decrease in the performance at lunch time was also noticed, as well as a lack of correlation between the curves of performance in swimming and the curves of body temperature. The performance does not seem to be necessarily better at the time of the actual training, at least in a training session of the studied characteristics. It is not, therefore, beneficial to introduce important changes in the training schedule three weeks in advance with the only aim of achieving a better performance in a competition that takes place outside the regular training time. Furthermore, these changes leave sequelae in the daily circadian rhythmicity and affect also negatively the performance for at least one week after the competition for which we wished to synchronize.

In conclusion, the time of the training, "training schedule", would not be a good synchronizer of the rhythmicity oscillation of physical performance in swimming, being this small ability to synchronize relatively independent of the intensity and volume of the training. This is illustrated by group (MA), that had only 10 minutes of additional training in the morning to their usual time in the evening, showing distortions in the rhythms. Because of this, important changes in the training schedule would not be sufficient to generate an improvement in the short run (in a short period) and would, on the other hand, induce alterations in some circadian rhythms, a fact which may have negative effects on performance.

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C. JAVIERRE, J. LL. VENTURA, R. SEGURA, M. CALVO y E. GARRIDO. *¿Es el entrenamiento un buen sincronizador del rendimiento?* J. Physiol. Biochem. (Rev. esp. Fisiol.), 53, 239-246, 1997.

El objetivo del estudio es observar si cambios en el horario de entrenamiento pueden provocar modificaciones en la evolución diaria del rendimiento. El rendimiento de 12 nadadores se estudia en carreras máximas de 25 metros estilo libre, cada dos horas a lo largo de un día. También se controla su temperatura corporal. Tras el primer control de rendimiento, cuando todos entrenan por la tarde, el grupo se divide en 3 subgrupos: 1) compuesto por dos sujetos es el subgrupo control (C), entrenando sólo por la tarde; 2) compuesto por 5 sujetos, que entrenaban sólo por la mañana(M); y 3) compuesto por 5 sujetos, que entrena por la tarde, con una sesión adicional de 10 min de natación por la mañana (AM). Todos los deportistas siguen este horario de entrenamiento durante tres semanas, tras la cual se estudian por segunda vez, volviendo a entrenar durante otra semana, al mismo horario habitual en la tarde, realizando después un tercer día de estudio. Se encuentran diferencias en el rendimiento a lo largo del día (con un pico máximo alrededor de las 20:30 h), sin producirse cambios en la curva de rendimiento a pesar de las modificaciones en el horario de entrenamiento introducidas, por lo que cabe concluir que el entrenamiento no es un buen sincronizador del rendimiento.

Palabras clave: Ritmos circadianos, Natación, Entrenamiento.

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