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Is the post-lunch dip in sprinting performance associated with the timing of food ingestion?

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To detect whether the drop in performance around lunch has any direct association with the time of food ingestion, a group of 8 sprinters were studied for 5 consecutive Saturdays. On each testing day, the times achieved during 80 meter sprints performed at eight different times of the day separated by 2 hour intervals were recorded. The 1st and 4th testing days, had identical sleep and mealtime schedules, and were therefore considered "control days", while on the 2nd and 3rd testing days the schedule was brought forward ("advanced") or backward ("delayed") by 2 hours respectively. On the 5th testing day the sleep-wake cycle was brought forward 2 hours without changing the mealtime schedule. A post-lunch dip (PLD) was detected on all testing days although at different times. No significant differences in performance were observed between days 1 and 4 while there were differences in performance during the other testing days. It is worth pointing out that PLD occurred at about 15:00 h on the control days, with significant differences between the 2nd ($p < 0.05$) and 3rd days ($p < 0.05$), and with the deterioration in performance starting at 15:00 h on the 3rd day despite the fact that lunch had been served at 16:00 h. In conclusion, PLD does not appear to be directly linked to the time of lunch, although lunch itself could potentiate its effects. It is also worth mentioning the fact that this deteriorating effect does not occur after any other meals of the day.

Key words: Chronobiology, Circadian rhythm, Post-lunch dip, Performance.

Among the different variables that show circadian rhythms in the human being there are some that are closely associated with physical exercise, such as VO_2 max, heart rate, muscle strength, etc. (5, 7, 8, 13, 14), whose oscillations may affect athletic performance, depending on the time of day (3, 4, 6, 9, 10).

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A significant reduction in physical performance around lunch time (between 12:00 and 14:00 hours) has been observed (11), although this does not appear to be a constant fact, for other studies have failed to detect it (3, 9). On the other hand, this reduction in performance does not seem to occur after meal ingestion at other times of the day. Thus, the relationship between post-lunch dip (PLD) and the changes induced by meal ingestion is not clear. Is this phenomenon induced by external factors or is it basically due to the existence of an internal rhythm?. To what extent can it be influenced by other factors affecting physical performance such as fatigue, changes in sleep pattern, etc? Due to the implications of post-lunch dip on physical performance, we carried out a study aimed at determining whether this phenomenon is also present in sprinters and whether it is linked basically to the time of food ingestion.

Materials and Methods

Eight national-class competition male sprinters, with a mean age of 21 (SE 2) years, volunteered to take part in the study. The mean height of the group was 181 (SE 2) cm and the mean weight 70 (SE 1) kg. All the components of the group had been athletes for an average period of 6 (SE 0.4) years with approximately 12 hours of training per week.

The participants were studied on five consecutive Saturdays during the months of September and October. All the tests were conducted at the "Instituto Nacional de Educación Física" (Barcelona), whose facilities were made available for the sole purpose of this study, with the object of preventing any possible interferences by external factors.

The participants reported to the laboratory early in the morning one hour before the beginning of the first trial. After that they had a standard breakfast, with an energy content of 2.85 MJ (680 kcal). Then they continued performing the different trials separated by two-hour intervals, until completing the eight trials scheduled for each testing day. At lunch, mid-afternoon and dinner time (which varied according to the different testing days) they had standardized meals with an energy content of 2.8 MJ (670 Kcal), 2.85 MJ (680 Kcal) and 2.8 MJ (670 Kcal), respectively. The participants strictly adhered to the stipulated diet, both as to the total amount of food ingested as well as to the different constituents of the meals. They only drank mineral water, and were not allowed other drinks such as coffee, tea, wine, etc.

The eight sprinters raced a distance of 80 m at their maximun possible speed, during each of the eight different trials, on a synthetic outdoor track adjacent to the laboratory, encircled by high walls to preclude wind interference The weather on all the days was mild -as usual during this season in our city- and without rain. Each participant performed the corresponding trials separately. On every testing day, the times achieved by each athlete during the 80 m sprint trials, on eight different occasions or times throughout the day, were recorded by an experienced timekeeper who was unaware of the differences in the times achieved on different days and for different trials.

On days 1 and 4 (considered to be the "control" days) the sprinters were tested, in relation to their race performance, at 9:00, 11:00, 13:00, 15:00, 17:00, 19:00, 21:00 and 23:00 hours. On day 2, their trials started two hours earlier and on day 3 two hours later than in the control days and, at the same time, their meal times were also advanced or delayed by two hours with respect to meal times on the control days. On day 5 the sleep-wake cycle was advanced two hours in relation to the control days but meal times followed the same schedule as the control days. In order to facilitate the change-over to the new performance times on testing days 2, 3, and 5, the previous day the corresponding schedule of activities was advanced or, correspondingly, delayed by one hour.

Table I shows an outline of the time schedules for the different testing days. Beforehand, the subjects were advised as to which time-tables they were to follow and one of the authors ensured that they would be observed. No one had problems following the sleep schedule.

Statistical analysis.– In order to evaluate the effects of the day and time of day variables (independent variables) on performance (dependent variable), all data was analyzed by means of two way analysis of variance (ANOVA).

Results

A statistical analysis of the data gathered at the controls corresponding to 11:00, 13:00, 15:00 and 17:00 h on all 5 days was done using the ANOVA method. This analysis showed a statistically significant difference between the times recorded on the different days of the study ($F=4.8$, $p = 0.001$). A difference in the recorded times in the 80 m sprint was

Table I. *Schedules of testing day.*

Time day (hours)	Testing day				
	1	2	3	4	5
06:00		wake up			wake up
07:00		race			race
08:00	wake up	meal		wake up	
09:00	race	race		race	race
10:00	meal		wake up	meal	meal
11:00	race	race	race	race	race
12:00		meal	meal		
13:00	race	race	race	race	race
14:00	meal			meal	meal
15:00	race	race	race	race	race
15:30		meal			
16:00			meal		
17:00	race	race	race	race	race
17:30	meal			meal	meal
18:00		meal			
19:00	race	race	race	race	race
19:30			meal		
20:00	meal			meal	meal
21:00	race	race	race	race	race
22:00			meal		
23:00	race	race	race	race	race

also observed when compared to the different controls (F=2.8, p = 0.04), (fig. 1).

During day 2 of the study, when both sleep and mealtimes were advanced by two hours in relation to the control days, a reduction in performance was observed at 13:00 h, corresponding to the post-lunch trial, with a mean performance time of 10.0±0.1 (mean±SE). When we compared the times achieved on the control day, the interaction between the two independent variables (study day and hour of the race) was statistically significant (F=3.2, p = 0.03).

On day 3 of the study, when sleep and mealtimes were delayed by two hours, the

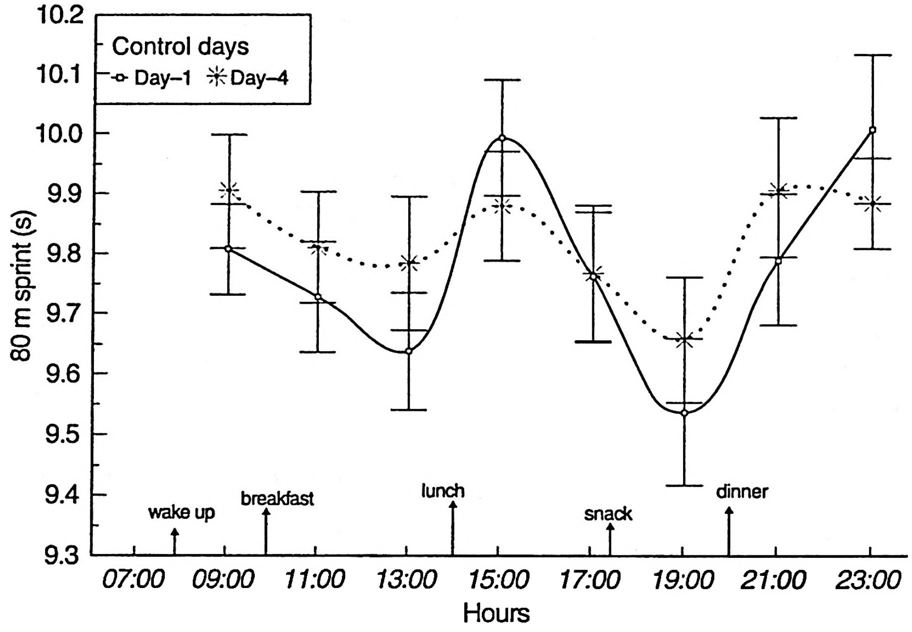

Fig. 1. *Performance evolution comparison in the two control days.*
Values are mean ± SE (n = 8).

Table II. *Performance evolution in the days of study.*
Values are mean ± SE.

Days	Hours			
	11:00	13:00	15:00	17:00
Day 1	9.73 (0.09)	9.64 (0.09)	9.99 (0.10)	9.76 (0.10)
Day 2	9.74 (0.16)	9.99 (0.12)	9.82 (0.12)	9.43 (0.13)
Day 3	10.01 (0.08)	9.99 (0.11)	10.10 (0.10)	10.08 (0.10)
Day 4	9.81 (0.09)	9.78 (0.11)	9.88 (0.09)	9.77 (0.11)
Day 5	9.87 (0.13)	9.94 (0.14)	10.13 (0.11)	9.83 (0.13)

worst performance times were recorded at the trial at 15 h, performed before lunch. A significant impairment on performance with regard to the control day was observed ($F=14.2$, $p < 0.001$).

On day 4 of the study, when sleep and mealtimes were identical to those of the first day (control day), no statistically significant differences, with respect to the times achieved during the first day, were observed.

During day 5 of the study (when only the sleep cycle, but not the mealtimes, were advanced) the poorest performances were observed during the trials at 15:00 h (mean±SE) (10.1±0.1 s) immediately after lunch, as observed on the control days. No significant differences were observed in recorded times with respect to those achieved on control days.

Discussion

Physical performance seems to improve as the day progresses, reaching a maximum in the evening (3, 4, 9), although a reduction or dip in performance around lunch time has been reported by some authors (8, 14). In the present study this tendency was also found, when the best performance was observed in the evening (at 19:00 h) while immediately before or after lunchtime (at 15:00, 13.00 or 17:00 hours depending on the sleep and meal time schedule), a significant reduction in physical performance was detected. This last observation would lead to the hypothesis that the changes induced by the ingestion of food would be responsible for the poor performance recorded at this time, although other factors must be taken into account.

In our study, the participants ingested 4 meals a day, all of them of similar characteristics in as far as total amount of calories ingested and nutritional make up. Despite that, the reduction in performance occurred only after or around lunchtime, while the best times were achieved during the trials that followed the ingestion of the mid-afternoon meal (at 17:30 h, 15:30 h and 19:30 h on control days, day 2 and day 3, respectively).

On day 2 of the study, when sleep and meal times were advanced two hours in relation to the control days, the poorest performance was also observed to occur during the trials performed after the meal (on this occasion at 13:00 h), a fact which would suggest that the ingestion of food has something to do with poor performance. However, during day 3 of the study, when sleep and meal times were delayed by two hours in relation to the control days, the performance time at the trial performed after the meal (on this day at 16:00 h) was also very poor, although the trial before the meal (at 15:00 h) showed an even poorer performance, a fact that would suggest that this impairment in performance is independent of previous meal ingestion. However, the maintenance of such low performance during the trial that followed the meal as well indicates that food can be, to some extent, a contributing factor in the reduction of performance. A similar situation was repeated on the 5th day (when only the sleep cycle was advanced). In the first part of the day, it would seem that evolution is contingent upon the sleep pattern up until that time. However, the synchronizing marker introduced by the meal may break that tendency, moving forward by 2 hours and changing over to the natural rhythm of the control day.

Despite the fact that PLD is a phenomena previously described in Chronobiology (14), there is no complete agreement among different authors (3, 9) on several aspects of this phenomenon. However, we must point out that some of these studies show certain pecularities which could explain why PLD was not detected:

A) The type of exercise performed during the trials was not specific for the habitual athletic activity of the subjects, with no clear indication whether the different muscle groups were involved to the same degree and with metabolic characteristics similar to those of the exercise performed habitually by the participants. Thus, although the athletes tested were not cyclists, the different trials were performed on a cycloergometer. In contrast, the participants in our study were runners specialized in high speed races, and all the tests were performed through trials designed to test the speed power of the subjects. Taking these aspects into consideration would have conferred a higher degree of sensitivity and reliability to the trials, as has been indicated by several authors (1, 12).

B) The tests covering the whole daily spectrum were not carried out all on the same day, but subdivided in different days, a fact that would introduce a certain degree of variability on the performance time (above 2 % for this kind of exercise trial) which could have masked the post-lunch dip (2). In our work, all tests, corresponding to different times of the day, were performed on the same day, for each protocol. This was possible due to the high training level of these sprinters, who did not show any kind of fatigue, with the best performance time being detected in the afternoon. Besides, for trained athletes, it would be better that the tests of the different hours be performed on the same day, in order not to interfere with their habitual training schedule. Such an interference, in a study of several weeks' duration, would affect their training level.

C) The tests performed on the subjects studied in other works (3, 4) were done three hours after meals, a fact that may modify the "natural" circadian rhythm, because meals act as a syncronizer (14).

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C. JAVIERRE, J. LL. VENTURA, R. SEGURA, M. CALVO y E. GARRIDO. *¿Está el bache postprandial en el rendimiento en velocidad asociado con el momento de la ingestión de la comida?* J. Physiol. Biochem. (Rev. esp. Fisiol.), 52 (4), 247-254, 1996.

Se estudian 8 velocistas durante 5 sábados consecutivos con objeto de detectar la disminución en el rendimiento que se produce alrededor de la comida del mediodía y su posible asociación con el momento concreto en que es ingerida. En cada uno de los días de estudio, se registran los tiempos obtenidos durante una carrera de 80 m a velocidad máxima, repetida en ocho ocasiones distintas a lo largo del día, separadas por intervalos de dos horas entre ellas. El horario de sueño y comidas fue idéntico para el primer y cuarto día del estudio, siendo considerados ambos como días "control". En los días segundo y tercero, el horario se adelanta ("día de adelanto") o retrasa ("día de retraso"), respectivamente, en 2 horas. En el quinto día el horario de sueño se adelanta en dos horas, aunque se mantiene el horario de comidas. Se detecta una disminución en el rendimiento tras la comida del mediodía ("post-lunch dip", PLD) ($p<0,001$) en los días 1 y 4 del estudio, sin existir diferencias estadísticamente significativas entre ellos; en dichos días el momento de deterioro más importante en el rendimiento se observa en el control de las 15:00 h, con diferencias significativas en relación con lo obtenido en las pruebas del segundo ($p<0,05$) y tercer día de estudio ($p<0,05$). En el tercer día, el bache se produce en el control de las 15:00 h, aunque la comida se realiza a las 16:00 h. Se concluye que el bache postprandial en el rendimiento no parece estar directamente relacionado con el momento en el

que se realiza la ingesta, aunque ésta podría potenciar sus efectos. Este deterioro no se produce tras la ingesta de otras comidas.

Palabras clave: Cronobiología, Ritmos circadianos, Bache postprandial (PLD), Rendimiento.

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