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# Sleep management and the performance of eight sailors in the Tour de France à la voile yacht race

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**Abstract**

We observed how sailors manage their sleep and alertness before and during competition in a long-haul yacht race. Global performance of the teams was also recorded. We assessed eight sailors aged 21 – 30 years, split into four teams, who competed in the Tour de France à la Voile 2002 yacht race. Two phases of the race were examined: two legs in both the Atlantic Ocean and Mediterranean Sea. Sleep length, sleep debt, and sleepiness before competition and on board during the race were assessed using ambulatory polysomnography. Intermediate and final rankings were considered as a reflection of performance. A significant correlation was observed between the sleep debt before competition and the total sleep time on board during the Atlantic legs. The greater the sleep debt, the more sleepy the participants were. During the Mediterranean legs, almost all the sailors were deprived of sleep and slept during the daytime competitions. We observed that the final ranking in the race related to the sleep management strategy of the participants. In extreme competitive conditions, the effect of a good night's sleep before competition on performance is important. The strategy of the winners was to get sufficient sleep before each leg so as to be the most alert and efficient during the race.

**Keywords:** *Sleep, alertness, sailing, performance, sleep debt*

## Introduction

Daytime alertness depends on the interaction of two primary endogenous systems, the circadian pacemaker and the homeostatic drive for sleep. The circadian pacemaker, located in the suprachiasmatic nucleus of the hypothalamus, generates rhythms in physiology and behaviour, while the homeostatic drive for sleep reflects the increasing need for sleep after a period of awakening. (Van Dongen & Dinges, 2005). These two systems can be disturbed when individuals have irregular sleep/wake patterns. Interferences such as shift work, night work or jet-lag may lead to chronic sleepiness and unintentional episodes of falling asleep (Akerstedt *et al.*, 2002).

It has been shown that sleep deprivation induces sleepiness and reduces daytime alertness and performance (Belenky *et al.*, 2003; Broughton, 1991; Herscovitch & Broughton, 1981; Van Dongen, Maislin, Mullington, & Dinges, 2003). Van Dongen and colleagues (2003) have recently shown a dose – response effect of chronic sleep debt on alertness and performance in healthy adults. Belenky *et al.* (2003) found that impaired performance as a result of chronic sleep restriction can be restored by a long night of sleep, or partially restored by shorter periods of sleep. The relationship between reduced performance and sleep restriction has also been documented outside laboratory conditions in real-life contexts involving shift workers, students, medical residents (Howard, Gaba, Rosekind, & Zarcone, 2002; Rollinson *et al.*, 2003; Veasey, Rosen, Barzansky, Rosen, & Owens, 2002), and athletes (Callard, Gauthier, Maffiuletti, Davenne, & Van Hoecke, 2000; Mougin *et al.*, 1989, 2001). Considering that young adults suffer from severe sleep deprivation in industrialized countries (Wolfson & Carskadon, 1998), and that this sub-population of young adults typically has a high percentage of car accidents and school failures (Marcotte *et al.*, 1998), better management of their daily sleep and the avoidance of sleep debt may lead to better results in academic studies and accident prevention. However, the effect of sleep on performance has not yet been examined in athletes, such as sailors, who require long-term, sustained performance.

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Dinges and Kribbs (1991) have noted that laboratory-based performance assessments are frequently considered "less valid a measure of sleepiness than physiological parameters" and that "they are often regarded as being too artificial and not reflective of operational performance demands made in real-life work scenarios". However, real-life settings such as sporting contests are subject to various environmental factors that could influence the validity of the results obtained. For this reason, it is difficult to perform validated studies on sleep management and performance in such a sport-related environment.

Yacht racing was chosen as the context in which to evaluate the role of sleep management during competition because it is one of the few competitive sports that requires constant vigilance and performance for long periods; races can continue throughout the night and so put the athletes on non-standard sleeping rhythms. In contrast to long-haul races without stopovers, one race – the Tour de France à la voile– has stopovers that allow regular and frequent assessment during competition. Therefore, the 2002 Tour de France à la voile was selected as an appropriate event to examine the sleep of several teams of sailors during the race.

The main aim of the study was to observe how athletes manage their sleep and alertness before and during competition in a long-haul race. A secondary aim was to obtain information about the global performance of the teams.

## Methods

### *Participants*

The 2002 Tour de France à la voile organizing committee recruited eight healthy young sailors to participate in the study. Sailors included in the study did not show evidence of any sleep disorder, as assessed by an interview with a sleep specialist. Sailors with non-stable diseases or who were on medications that could affect sleep and alertness were excluded. In exchange for their voluntary participation, the sailors received a sponsorship of approximately 5000 euros. All eight sailors were fully informed of the procedures of the study and signed an informed consent form before participating. Ethical approval for the investigation was obtained from the ethics committee of the Hotel Dieu, Université Paris 6.

The eight participants had over three years of competitive sailing experience. While each boat included six to eight sailors, the two sailors from each boat who had the greatest impact on the race strategy, the strategist and helmsman (skipper and the cox), were assessed.

### *Baseline observations*

The participants underwent a baseline sleep assessment in the sleep laboratory one month before the race to establish baseline values for the study. This assessment involved polysomnography, a 3-week sleep log, and an actigraphy (wrist-worn activity monitor; Actiwatch, Cambridge Technology, Inc.) recording. Sleep scoring was performed and analysed (Deltamed software system) according to the Rechtschaffen and Kales sleep scoring criteria (Rechtschaffen & Kales, 1968). Several questionnaires were also completed, including the Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), the Horne and Otsberg (H&O) questionnaire (Horne & Ostberg, 1976), a sleep disorders questionnaire (Léger, Guilleminault, Dreyfus, Delahaye, & Paillard, 2000), the Spiegel Sleep Index (Spiegel, 1981), and the Epworth Sleepiness Scale (ESS) (Johns, 1991).

### *Sleep recording tools during the race*

Sleep and alertness were surveyed from 24 h before each leg to the end of the leg. Sailors were asked to fill in a sleep log for both periods.

Sleep before competition was mainly recorded with a "night cap". The night cap (REMview, Respironics, Inc.) is a device with a head actigraph and an electro-oculograph, which is used to assess sleep duration and sleep latency, and can also provide information on rapid eye movement (REM) periods and REM latency but not on slow-wave sleep (Cantero, Atienza, Stickgold, & Hobson, 2002). The night cap was used to assess total sleep time before each leg of competition.

However, when the scheduled departure of the race was early in the morning (i.e. before 05.00 h), a complete ambulatory polysomnography (Brainwalker, Medatec software) was preferred (with the recording of EEG, EOG, and EMG) from the evening before to the end of the race, with sleep before competition being assessed by ambulatory polysomnography. Sleep scoring was performed according to the Rechtschaffen and Kales sleep scoring criteria (Rechtschaffen & Kales, 1968).

Sleep and sleepiness during competition were assessed by the same ambulatory polysomnography system (Brainwalker, Medatec software) continuously from the beginning to the end of each leg (Figure 1).

### *Description of the race and study schedule*

With the help of the race organizers we decided to focus on four representative legs, two on the Atlantic phase of the race and two on the Mediterranean

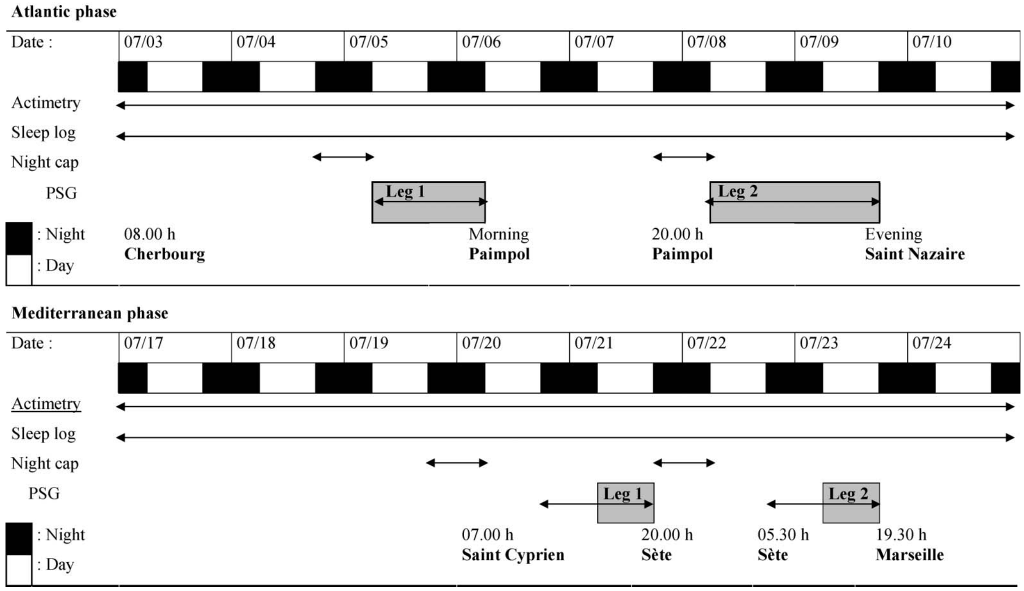


Figure 1. Sleep monitoring during the two phases: Atlantic and Mediterranean schedules. PSG = ambulatory polysomnography.



phase. These two sections were very different in terms of sailing and environmental conditions.

The Atlantic phase was at the beginning of the race and was the most intensive part. Legs lasted 36–48 h and included one or two nights. We observed the first leg from Cherbourg to Paimpol (from 20.30 h on 5 July through to the morning of 6 July; length: 90 nautical miles) and the second one from Paimpol to Saint-Nazaire (from 20.00 h on 8 July through to the evening of 9 July; length: 244 nautical miles).

The Mediterranean phase was less physically and mentally demanding and included only daytime legs. Temperatures were warmer and the goal for the teams was usually to maintain their position in the race. We observed the first leg from Saint Cyprien to Sète (from 07.00 to 20.00 h on 21 July; length: 56 nautical miles) and the second from Sète to Marseille (from 05.30 to 19.30 h on 23 July; length 75 nautical miles).

Between the Atlantic and Mediterranean phases, we maintained contact with the teams but did not interfere with their behaviour.

### *Global performance*

Official ranking was provided by the race organizing management team and both intermediate and final rankings were determined for each leg by the organizers. We decided to use only the final result, which was deemed to reflect most fairly the official performance of the teams. Due to the nature of the competition, sailors were considered both as individuals and as members of the same team in consideration of final ranks.

### *Data analysis*

Several indicators were used to compare the sailors during the race. The reference total sleep time (RTST) was based on the total sleep time (TST) assessed in our laboratory during the reference night. The sailors were allowed to sleep as usual. To validate these data, the RTST was then compared with the mean TST obtained with the 21-day baseline actigraphy. Statistical comparison of the two mean values did not reveal any significant difference ($P = 0.1721$). The RTST may thus be considered as the usual, non-competition TST. The TST 24 h before the leg (TST 24) was assessed by night cap or by ambulatory polysomnography. The night cap was used mainly but ambulatory polysomnography was preferred on nights with early awakening schedules (to avoid a much shorter sleep efficiency, the ratio of TST to nocturnal time in bed, and the percentages of slow wave sleep and REM sleep, were calculated for the reference night, as well for the 24 h before the leg). Total sleep time on board (TSTOB) was assessed by ambulatory polysomnography recording on board the yacht. It included TSTOB Night (Atlantic phase) + TSTOB Day (for Atlantic and Mediterranean phases). We also calculated sleep efficiency and the percentages of slow wave and REM sleep for TSTOB. Total sleep debt (TSD) was defined as the difference between RTST and sleep time the night before the leg (TST 24). It was calculated to gain a better understanding of the magnitude of the sailors' sleep debt 24 h before each leg.

The main aim of the study was to compare TSD and TSTOB. Values are reported as means and standard deviations ($s$). As a result of the small sample size, the Wilcoxon non-parametric two-tailed test was used to compare intra-individual differences. A $P$-value of less than 0.05 was considered to indicate statistical significance. Calculations were performed with SAS software.

## Results

### *Characteristics of the sailors*

Eight healthy young sailors [6 males, 2 females; mean age 24.6 years, $s = 3.0$ (range 21 – 30 years), height 1.73 m, $s = 0.06$ (1.63 – 1.79), body mass 62.6 kg, $s = 9.3$ (51 – 73.4), body mass index 20.75, $s = 2.25$ (18 – 23)] participated in the study.

Table I shows the baseline sleep characteristics of the eight sailors, with the details of the RTST and the scores from the questionnaires. The sailors slept a mean of 459.9 min ($s = 63.6$). Only two participants (sailors 5 and 6) slept less than 420 min. The participants were considered to have normal sleep latency except for sailor 3 who went to bed earlier than usual. Sleep efficiency was above 90% for all sailors and the mean percentage of slow wave sleep was 30.5% ($s = 8.3$). Only one individual (sailor 6) had a percentage of slow wave sleep below 25%. The mean PSQI score for the total group was 4.7 ($s = 2.9$), which reflects a good quality of sleep (Buysse *et al.*, 1989). The mean ESS score was 8.7 ($s = 4.02$). Two of the participants had an ESS score above 11 (sailor 5 = 12 and sailor 2 = 15) and were considered as sleepy.

### *Atlantic phase results*

*Total sleep debt.* Before the first leg, all sailors in teams 1 and 2 had a sleep credit; that is, in the 24 h before leg 1 they slept more than usual (Table II). Mean TSD for team 1 was +135.5 min and that for team 2 was +97.5 min. However, for the two other teams, sailors had a sleep debt before leg 1: mean TSD for team 3 was −161 min and that for team 4 was −133.5 min. Before leg 2, all sailors were in sleep debt, with a mean sleep debt ranging from −117.5 min (team 1) to −231 min (team 4). The duration of REM sleep for all eight sailors was 80.1 min ($s = 36.0$) for leg 1 and 62.8 min ($s = 35.0$) for leg 2.

*Total sleep time on board.* During leg 1, sailors slept mainly at night (TSTOB Night = 116.7 min, $s = 131.8$) and rarely during the day (TSTOB Day = 9.9 min, $s = 7.2$). However, the duration of daytime sleep varied from 2 min (sailor 8, team 1) to 20 min (sailor 4, team 4). The mean number of sleep episodes was 15.2 ($s = 6.8$). The percentage of slow wave sleep varied from 15.8% (sailor 6) to 44.9% (sailor 5), while the percentage of REM sleep varied from 3.4% (sailor 8) to 22% (sailor 1). During leg 2, the mean TSTOB was 74.8 min ($s = 49.1$) for TSTOB Day and 131.2 min ($s = 139.8$) for TSTOB Night. The mean number of sleep episodes was 16.6 ($s = 10.2$). There was a non-significant correlation between TSD and TSTOB for leg 1 ($P = 0.08$) but a significant correlation for leg 2 ($P = 0.03$). These results indicate that greater sleep debt is associated with longer periods of TSTOB.

*Global performance.* Performance was assessed by ranking each leg of the race and the race positions after legs 1 and 2 and the final rank are given in Table II. It was impossible to compare a quantitative value such as TSTOB and a qualitative ranking of the 40 teams that competed in the race. However, in the sample examined we did observe that the winners

Table I. Demographics and sleep characteristics of the sailors.

| | | | | (RTST) | | | | Questionnaires | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Team | Sex | Age | TST (min) | SE (%) | SL (min) | SWS (%) | ESS | Spiegel | H&O | PSQI |
| Sailor 7 | Team 1 | M | 26 | 418 | 93.3 | 26 | 25.9 | 10 | 23/19 | 50 | 5 |
| Sailor 8 | Team 1 | M | 27 | 448 | 96.9 | 16 | 32.2 | 8 | 23/23 | 61 | 1 |
| Sailor 5 | Team 2 | M | 25 | 413 | 93.9 | 10 | 44.9 | 12 | 20/20 | 53 | 9 |
| Sailor 6 | Team 2 | M | 30 | 362 | 94.1 | 13 | 15.8 | 4 | 18/20 | 59 | 5 |
| Sailor 1 | Team 3 | M | 22 | 494 | 95 | 6 | 29.1 | 4 | 19/14 | 38 | 2 |
| Sailor 2 | Team 3 | M | 23 | 468 | 95.1 | 5 | 32.5 | 15 | 25/28 | 56 | 6 |
| Sailor 3 | Team 4 | F | 21 | 513 | 90 | 73 | 28.2 | 4 | 26/26 | 59 | 8 |
| Sailor 4 | Team 4 | F | 23 | 563 | 93.1 | 7 | 35.3 | 9 | 17/17 | 62 | 2 |
| Mean | | | 24.6 | 459.9 | 93.4 | 19.5 | 30.5 | 8.7 | 21.4/20.9 | 54.75 | 4.7 |
| *s* | | | 2.9 | 63.6 | 1.9 | 22.7 | 8.3 | 4.10 | 3.3/4.6 | 7.88 | 2.9 |

*Note*: RTST = reference total sleep time = total sleep time (TST) assessed in our laboratory during the reference night. M = male, F = female. TST = total sleep time; SE = sleep efficiency; SL = sleep latency; SWS = slow wave sleep; ESS = Epworth Sleepiness Scale; Spiegel = Spiegel Sleep Index; PSQI = Pittsburgh Sleep Quality Index; H&O = Horne and Ostberg Scale.

were those who managed to achieve a lower TSD and therefore a lower TSTOB.

### *Mediterranean period results*

*Total sleep time 24 h before the leg.* The mean TST 24 was 381.7 min ($s = 24.3$) before leg 1 and 270.4 min ($s = 37.1$) before leg 2. Despite good environmental conditions in the Mediterranean area, seven sailors still had a sleep debt during leg 1 with a mean TSD of −78.1 min ($s = 73.0$) (Table III). Only one sailor (sailor 5, team 2) slept longer than usual during leg 1 and had a sleep credit of 15 min. During leg 2, all sailors were in sleep debt with a mean TSD of −189.5 min ($s = 91.2$). The mean duration of slow wave sleep was 15.5 min ($s = 8.8$) for leg 1 and 114.2 min ($s = 19.4$) for leg 2. The mean duration of REM sleep was 69.6 min ($s = 19.4$) and 28.7 min ($s = 18.1$) for leg 1 and 2, respectively.

*Total sleep time on board.* Total sleep time on board was quite high for most sailors, with a mean duration of 93.2 min ($s = 53.1$) during leg 1 and 155 min ($s = 97.4$) during leg 2 (Table III). Sailors usually slept for a period that was longer than their sleep debt. However, no significant correlation was observed between TSD and TSTOB for leg 1 ($P = 0.22$) or leg 2 ($P = 0.69$) of the Mediterranean phase.

*Global performance.* Performance was assessed via rankings for each leg of the race. Team 1 was twentieth in leg 1 and fifth in leg 2. Team 2 was seventh in leg 1 and twenty-first in leg 2. Team 3 was sixth in leg 1 and fourth in leg 2. Team 4 withdrew from leg 1 and was thirtieth in leg 2. Team 1, however, with a smaller TSD and a shorter TSTOB, maintained their position in the race while team 4 had a greater sleep debt, a longer TSTOB, and lower position.

Table II. Atlantic phase: Total sleep time on board (night and day), sleep debt, and ranking.

| | | Leg 1 | | | | | Leg 2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TSD (min) | TSTOB (min) | | | | TSD (min) | TSTOB (min) | | | | Final rank |
| | | | Total | Night | Day | Rank | | Total | Night | Day | Rank | |
| Team 1 | Sailor 7 | +197 | 8 | 0 | 8 | 3 | −97 | 24 | 13 | 11 | 7 | 1 |
| | Sailor 8 | +74 | 74 | 72 | 2 | | −138 | 68 | 64 | 4 | | |
| Team 2 | Sailor 5 | +127 | 200 | 190 | 10 | 18 | 0 | | Withdrew* | | Withdrew | 6 |
| | Sailor 6 | +68 | 138 | 133 | 5 | | −148 | | Withdew* | | | |
| Team 3 | Sailor 1 | −151 | 41 | 23 | 18 | 5 | −139 | 258 | 155 | 103 | 28 | 22 |
| | Sailor 2 | −171 | 48 | 36 | 12 | | −184 | 408 | 349 | 59 | | |
| Team 4 | Sailor 3 | −137 | 419 | 407 | 12 | 33 | −224 | | NA# | | 32 | 34 |
| | Sailor 4 | −130 | 85 | 65 | 20 | | −238 | 274 | 135 | 139 | | |
| Mean | | −15.4 | 126.6 | 116.7 | 9.9 | | −158.5 | 206.0 | 131.2 | 74.8 | | |
| *s* | | 72.5 | 102.5 | 131.8 | 7.2 | | 42.8 | 85.4 | 139.8 | 49.1 | | |

*Note*: TSD = total sleep debt = RTST (baseline polysomnography) − TST 24 (night cap recording). TSTOB = total sleep time on board.
*Team 2 withdrew from leg 2 of the race and did not complete sleep recording.
#No data were recorded on this leg due to recording equipment failure as a result of mobile telephone interference.

Table III. Mediterranean phase: Sleep debt, total sleep time on board, and ranking.

| | | Leg 1 | | | Leg 2 | | | Final rank |
|---|---|---|---|---|---|---|---|---|
| | | TSD (min) | TSTOB (min) | Rank | TSD (min) | TSTOB (min) | Rank | |
| Team 1 | Sailor 7 | −25 | 129 | 20 | −106 | 93 | 5 | 1 |
| | Sailor 8 | −24 | 20 | | −116 | 116 | | |
| Team 2 | Sailor 5 | +15 | 60 | 7 | −73 | 125 | 21 | 6 |
| | Sailor 6 | −17 | 95 | | −148 | 128 | | |
| Team 3 | Sailor 1 | −115 | 138 | 6 | −214 | 127 | 4 | 22 |
| | Sailor 2 | −129 | 129 | | −258 | 159 | | |
| Team 4 | Sailor 3 | −159 | 22 | 26 | −283 | 101 | 30 | 34 |
| | Sailor 4 | −171 | 153 | | −318 | 391 | | |
| Mean | | −78.1 | 93.2 | | −189.5 | 155.0 | | |
| *s* | | 73.0 | 53.1 | | 91.2 | 97.4 | | |

*Note*: TSD = total sleep debt = RTST (baseline polysomnography) − TST 24 (night cap recording). TSTOB = total sleep time on board.

## Discussion

Our results suggest that sleep management is difficult for young sailors during long-haul competitions. Sailors had to cope with disruptions to both the circadian (a non-24 h schedule of sleep) and the homeostatic (the amount of sleep debt) determinants of sleep during the Atlantic phase. This is why many of them undertook episodes of sleep in night legs. However, the sailors also slept, sometimes for considerable periods of time, during the daytime competition on the Mediterranean phase. Furthermore, we observed that most of the participants had a permanent sleep debt during the race. Sleep debt had an impact on TSTOB during the first phase of the study. We demonstrated that individuals with a larger sleep debt had more extensive sleep on board compared with individuals with a smaller sleep debt. The sleep deprivation model has been previously to demonstrate the impact of sleep loss on alertness and performance (Dinges & Kribbs, 1991; Hamilton, Wilkinson, & Edwards, 1972; Van Dongen *et al*., 2003). A "dose–response" effect between the magnitude of the sleep debt and the severity of sleepiness has also been shown (Carskadon & Dement, 1979; Van Dongen *et al*., 2003). However, Dement (2005) also observed a satiety of sleep in students with extended hours of sleep.

Sailing is a very demanding sport that requires good physical and mental acuity, and constant appreciation of the boat and external conditions. To the best of our knowledge, few studies have been conducted to assess the sleep patterns of sailors. Stampi (1989) used actimetry to help show that polyphasic sleep strategies improve sustained performance in sailors. In our study, we randomly selected teams that performed differently and achieved final rankings from first to thirty-fourth. We observed that the winners of the race had a better sleep strategy with a sufficient amount of sleep (especially on the Atlantic phase) to help avoid sleeping on board during the legs. The winners even had a sleep benefit (they slept more than usual) before the two legs and they maintained their position in the race. Conversely, the last team of our sample (team 4) accumulated a large sleep debt and was unable to achieve a good ranking during the race. Consequently, this led us to conclude that sleep management is an important factor in improving performance in competition. The rational conclusion is that in a competition that demands alertness, vigilance, and concentration, the chances of winning are greater for those who have a smaller sleep debt. During the second part of the race, sailors constantly faced sleep restriction. Legs of the race began early in the morning and almost all the sailors had chronic sleep debt.

Belenky *et al*. (2003) have shown that the brain adapts to chronic sleep restriction and that in mild to moderate sleep restriction this adaptation is sufficient to stabilize performance at a reduced level. This was illustrated by the fact that a number of the sailors in this study managed to finish their legs of the race while getting sleep on board. However, Wehr (1991) has shown that sleep loss may influence mood change, which may impact performance and cannot be restored in just one night (he showed that the required duration of sleep in humans, after several weeks of paying accumulated sleep debt, is slightly above 8 h).

An important consideration is how individuals sleep, or their biological clock characteristics, might influence their ability to become elite sailors. Elite sailors have to overcome chronic sleep debts during competition. They also have to rapidly become extremely alert during important or dangerous phases of races. They also have to have high physical muscular strength (especially in the upper part of the body) and a clear mind to adapt their strategy to rapid changes in race conditions (sea, wind, position of the other sailors). Van Dongen and Dinges (2005) have recently discussed the impact of sleep and the circadian clock on psychomotor vigilance and they have underlined how humans have been found to differ substantially in the degree of cognitive performance impairment they suffer from sleep loss, whether under conditions of acute or chronic sleep deprivation. One of these aspects underlined by Aeschbach *et al*. (2003) is to understand how short sleepers (under 6 h per night) are biologically different from long sleepers (above 9 h per night). In our study, we did not classify sailors as long or short sleepers as it is difficult to assess these individual characteristics during just one night of sleep. We also did not check the sailors' prize list previous to this race, which could have influenced the final rank of the teams studied. All these aspects of sleep, the biological clock, and performance in sport have been detailed an previously (Postolache, 2005).

Other factors associated with better sleep hygiene could also have had an impact on the performance of the sailors. Poorer sleep hygiene could reflect less global or technical organization, less input by sponsors when taking care of the sleep of their teams, and greater anxiety among the sailors. We assume that these sailors were comparable based on the fact that they were all students or young professionals. However, it is impossible to conclude that they were similar.

Another important aspect is the impact of the environment of sleep. We did not consider the influence of bright light on sleep and alertness in our study. The potential circadian and sleep disruptive effects of bright (blue) light as reflected on water have been discussed by Postolache and Oren (2005). The thermoregulatory implications on the sea are also of importance (especially hot temperature in the Mediteranean versus cold weather in the Atlantic). We also did not take into account the influence of nutrition on the sailors' performance. Future studies should address these aspects.

Another limitation of the current study was the small sample size. Examining a greater number of sailors, or all race entrants, would have yielded substantially more information but unfortunately the resources available did not allow for this. In future, similar studies in larger populations would help improve our understanding of how sleep behaviour affects performance in a competitive environment.

This study focused on young athletes who are either students or young professionals in their everyday lives and the results suggest that having a good night's sleep may affect alertness the following day and therefore performance. Sleep management is an important aspect in a competitive environment and sufficient sleep before competition improves alertness and efficiency. Future work should study longer periods of sailing with actigraphy and examine the neurocognitive processes implicated in sailing and their relation to sleep strategies (naps, sleep extension, exposure to light).

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