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Sleep restriction and degraded reaction-time performance in Figaro solo sailing races

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Abstract

In solo offshore sailing races like those of the Solitaire du Figaro, sleep must be obtained in multiple short bouts to maintain competitive performance and safety. Little is known about the amount of sleep restriction experienced at sea and the effects that fatigue from sleep loss have on sailors' performance. Therefore, we assessed sleep in sailors of yachts in the Figaro 2 Beneteau class during races and compared response times on a serial simple reaction-time test before and after races. Twelve men (professional sailors) recorded their sleep and measured their response times during one of the three single-handed races of 150, 300 and 350 nautical miles (nominally 24–50 h in duration). Total estimated sleep duration at sea indicated considerable sleep insufficiency. Response times were slower after races than before. The results suggest that professional sailors incur severe sleep loss and demonstrate marked performance impairment when competing in one- to two-day solo sailing races. Competitive performance could be improved by actively managing sleep during solo offshore sailing races.

Keywords: *sleep restriction, reaction-time performance, solo sailing*

Introduction

Solo offshore sailing races require sustained cognitive involvement for boat handling, navigation and tactical skills. To meet this requirement, sailors use polyphasic sleep patterns with multiple naps of durations in the order of minutes, which only partially make up for loss of sleep at sea (Stampi, 1989a; Theunynck, Hurdiel, Pezé, Estruch, & Bui-Xuân, 2010; Weston, Thelwell, Bond, & Hutchings, 2009). Sleep loss has adverse effects on alertness, attention, memory, mood, decision-making and executive functioning (Jackson & Van Dongen, 2011; Lim & Dinges, 2010). Solo sailors are not immune to these effects and have substantial functional impairments in offshore races, such as increased technical errors, mood changes, feelings of fatigue and even hallucinations (Hurdiel et al., 2012; Portier et al., 2008). Nonetheless, there is little information in sailing on amounts of sleep restriction and resulting effects on performance at sea. Therefore, the purpose of this study was to assess sleep during solo offshore sailing races and compare response times on a serial simple reaction-time test before and after these races.

Methods

With approval from the research ethics committee of Lille Nord-Ouest IV (Lille, France), 12 men, professional competitive sailors (age: 30 ± 6 years, stature: 177 ± 7 cm, body mass: 78 ± 10 kg, body fat: 20 ± 6%), were recruited at the French federal training centre, Pôle France Finistère Course au Large in Port La Forêt, France. All completed the study. The sailors had competed in solo races for more than 2 years. They were free of sleep disorders, as assessed with home polysomnographic screening.

Recordings were made during the three races of a French offshore sailing championship off the Atlantic coast. These races were similar to stages of the Solitaire du Figaro in terms of distance, difficulty of route and number of participating yachts. Standardised yachts of the Figaro class, the 10-m Figaro 2 Beneteau, were used by all the competitors. Participants were studied during one of the three single-handed races of 150, 300 and 350 nautical miles. Six participants competed in a race of 150 nautical miles, which started at 10:08 and lasted for about 24 h, i.e. these participants finished

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between 10:30 and 10:48 the next day. Three other participants competed in a race of 300 nautical miles, which started at 15:10 and lasted for about 36 h; these participants finished between 3:24 and 4:07 two days later. An additional three participants competed in a race of 350 nautical miles, which started at 12:08 and lasted for about 50 h; these participants finished between 13:32 and 14:45 two days later.

Recordings began the day before each race and ended a few hours after the finish. Participants slept at their own discretion during this period. Each sailor's rest/activity pattern was recorded by means of two tri-axial actigraphs (GT3X, TheActigraph, Pensacola, FL, USA). Using procedures specifically developed for sailing (Stampi, 1989b), one actigraph was placed on the participant's non-dominant wrist and was worn throughout the study periods, while another was fixed at the bottom of the mast as a reference for yacht motion while at sea. The actigraphs sampled movements at 30 Hz, and activity counts were recorded in 60-s epochs. The activity magnitude of each actigraph (the square root of the sum of the squares over the three axes) was determined for each minute of recording. The activity magnitude record for the yacht was subtracted from that of the participant, and negative values were considered to be indicative of sleep. Self-reported sleep times, collected using an electronic on-board sleep diary designed for use in offshore sailing (Scextan, Université du Littoral Côte d'Opale, France), were used to control for periods when a participant removed his actigraph and otherwise confirm the actigraphy-based results.

Performance was assessed on board the day before races between 9:44 and 21:31 when the sailors' preparation activities allowed for using a 5-min serial simple reaction-time test (Wilkinson & Houghton, 1982). The test required participants to respond as quickly as possible to a visual stimulus presented at random intervals between 2 and 12 s. The test was repeated on board between 44 and 113 min after the finish of the 150 nautical miles race; between 80 and 267 min after the finish of the 300 nautical miles race and between 46 and 164 min after the finish of the 350 nautical miles race. The number of lapses (errors of omission, defined as response time > 500 m · s) was used as the primary outcome measure; the number of false starts (errors of commission) was used as a secondary outcome measure.

Outcome measures were analysed using mixed-effects analysis of covariance (ANCOVA) with a fixed effect for measurement point to compare performance before and after race, a random effect over participants to account for systematic individual differences in overall performance and a categorical covariate for race (150, 300 or 350 nautical miles) to account for the systematic differences between races. The analysis was repeated with each of the following variables as a second covariate: time of day of performance testing before/after the race (linearised through sine/cosine transform), time of day of finishing the race, time between finishing and post-race testing and sleep duration during the night before the race. The type 1 error threshold was set to 0.05. Analyses were performed using Proc Mixed in SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

Results

From actigraphy, participants slept 8 h 32 min ± 39 min (mean ± standard deviation) the night before races. Similarly, actigraphy-estimated sleep during the 150-nautical-mile race was 22 ± 30 min (2 ± 1 naps; two sailors did not sleep at all). During the 300-nautical-mile race, it was 92 ± 34 min (6 ± 3 naps) and during the 350-nautical-mile race, it was 172 ± 122 min (8 ± 2 naps) (see Figure 1).

From the 5-min serial simple reaction-time test, there were more lapses after races than before (1.3 [95% confidence interval: 0.0–3.9] to 5.0 [95% confidence interval: 2.4–7.6]). The effect size of this difference was large ($F[1,11] = 12.1$, $P = 0.005$, $f^2 = 0.92$) (see Figure 2).

Race was not influential as a covariate ($F[2,11] = 0.7$, $P = 0.50$). The time of day of finishing the race, the time between finishing and testing after the race and the sleep duration during the night before the race were not influential as second covariates. However, the time of day of performance testing before/after the race was influential as second covariate ($F[1,9] = 6.52$, $P = 0.031$). With this covariate in the model in addition to race, the increase in lapses after the race continued to exhibit a large effect size ($F[1,9] = 10.8$, $P = 0.009$, $f^2 = 0.93$).

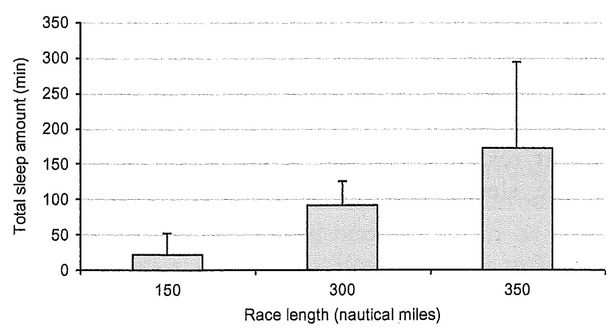

Figure 1. Actigraphically recorded sleep amounts by race length. Six sailors competed in the race of 150 nautical miles (about 24 h), 3 sailors competed in the race of 300 nautical miles (about 36 h) and 3 sailors competed in the race of 350 nautical miles (about 50 h). Bars indicate means; whiskers indicate standard deviations.

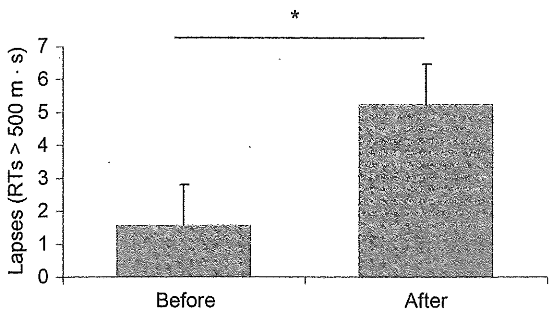

Figure 2. Performance on a 5-min serial reaction-time test before the race versus after the race in 12 sailors. *$P > 0.05$. RTs, reaction times.

The number of false starts on the 5-min serial simple reaction-time test did not demonstrate a difference between testing before and after the race ($F[1,11] = 2.8$, $P = 0.12$, $f^2 = 0.15$). The grand mean of false starts was 0.8 (95% confidence interval: 0.2–1.4).

Discussion

This study assessed sleep and response times in difficult and short offshore sailing stages of the challenging race "Solitaire du Figaro". Objective assessment of sleep and performance in sailing races is technically and logistically challenging, and our sample size was small. Even so, we showed race-induced impairment of response times. Our results support reports of performance deficits in skippers who competed in solo trans-Atlantic and round-the-world races (Hurdiel et al., 2012; Theunynck et al., 2010) as well as crewed sailing races (Leger et al., 2008; Portier et al., 2008).

While the high demands of the races could have contributed to the increase in lapses on the 5-min serial simple reaction-time test, sleep loss was probably the greatest influence. Our actigraphic assessments of sleep indicated that the sailors experienced considerable sleep insufficiency during the race. Although the reliability of actigraphic assessments of sleep while at sea is not as high as at home or in laboratory-based studies (Stampi, 1989b), these data are in agreement with those from other sailing races (Tiberge, 1992).

Our results show that professional sailors incur severe sleep loss and face marked performance impairment during one- to two-day solo offshore sailing races. This suggests that longer, more frequent or planned periods of actively managed sleep during solo sailing races would improve race performance. Further research is needed to identify an optimal balance between near-continuous wakefulness to handle the yacht and planned sleeping (power napping) to maximise the performance.

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