

677A

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<b>Publisher:</b>		<b>Publication:</b> VTI MEDDELANDE 677A	
 <b>Swedish Road and Traffic Research Institute</b> Swedish Road and Traffic Research Institute • S-581 01 Linköping Sweden		<b>Published:</b> 1992	<b>Project code:</b> 58319-5
		<b>Project:</b> Sleep deprivation and heavy workload: Effects on performance	
<b>Author:</b>		<b>Sponsor:</b>	
Jan Törnros and Hans Laurell		Swedish Road Safety Office	
<b>Title:</b>			
Effects from participating in the long-distance bicycle race "Vätternrundan" on reaction time performance			
<b>Abstract (background, aims, methods, results) max 200 words:</b>			
<p>The aim was to study effects on simple reaction time performance from participating in "Vätternrundan", a Swedish non-competitive bicycle race (300 km distance), which for most cyclist requires 12-20 hours of cycling. The participants in the study were also subjected to sleep deprivation. Their performance was tested on three occasions, 15 min. after the race, 3 hours after, and, finally, 6 hours after completion. The subjects acted as their own controls, with rotated order between conditions. Performance was impaired after the race. No recovery was noted at the later test sessions.</p>			
<b>Keywords:</b>			
<b>ISSN:</b>	0347-6049	<b>Language:</b>	English
		<b>No. of pages:</b>	7

## **PREFACE**

H Laurell was head of the study. Both authors planned the study and collected the data. J Törnros analyzed the data and wrote this report.

The study was sponsored by the Swedish Road Safety Office.

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## **EFFECTS FROM PARTICIPATING IN THE LONG-DISTANCE BICYCLE RACE "VÄTTERNRUNDAN" ON REACTION TIME PERFORMANCE**

by Jan Törnros and Hans Laurell

### **SUMMARY**

The aim was to study effects on reaction time performance from participating in "Vätternrundan", a Swedish non-competitive bicycle race (300 km distance), which for most cyclist takes between 12 and 20 hours. The participants in the study were five women and five men, all reasonably well prepared for the race. Since they all started the race in the evening, they were also subjected to the effects of sleep deprivation. After having completed the race, their performance was tested on a visual simple reaction time task of ten minutes' duration. They were tested on three occasions, 15 minutes after the race, 3 hours after, and finally, 6 hours after completion. The subjects acted as their own controls, with rotated order between the experimental and control conditions. Complete performance data was obtained for seven of the subjects (one of them did not complete the race, another never participated in the race, and the third one did not appear for the control session). It was found that their average performance was impaired after the race. No recovery was noted at the later test sessions.

## 1 INTRODUCTION

"Vätternrundan" is a Swedish non-competitive bicycle race of super marathon type - the task is to get around lake "Vättern" (a distance of 300 km) by bicycle - which for most participants takes between 12 and 20 hours. The race takes place in the early summer, and attracts more than 15,000 participants from many countries each year, which makes it the biggest bicycle race in the world. The cyclists start the race at different times, beginning in the early evening and continue through the whole night. Most participants therefore get no sleep during that night. They are thus subjected to the effects from a combination of extended heavy physical exercise and sleep deprivation.

The aim was to study after-effects on simple reaction time performance from this heavy task. Measurements were to be carried out directly after completion and later, in order to study possible recovery.

Mental performance has been found to be impaired after one or more nights without sleep (reviews by Kjellberg [1] and Naitoh [2]). When studied in combination with physical exercise, the experimental evidence differs regarding the modifying influence of the latter. Positive effects from exercise have thus been reported [3], however only when performance has been measured during or immediately after the exercise, presumably due to a temporary reduction in drowsiness. When measured some time after the exercise, two studies report the sleep loss effect not to be markedly influenced by the former, either from moderate amounts of exercise; riding a bicycle ergometer for a total of 2 hours during a sleep loss period of 48 hours [4], or from larger amounts; treadmill walking for a total of 20 hours during a 60 hour vigil [5]. Detrimental effects of exercise have also been reported [6], from riding a bicycle ergometer for a total of 10 hours during a sleep deprivation period of 40 hours.

It may be assumed that the physical exercise in the present study was considerably more exhaustive than in the other studies, since it was not spaced but more or less continuous for many hours. Considering the demonstrated effects from sleep loss and the possible accentuation by the physical exercise involved, a substantial performance impairment was expected as a result from participating in the "Vätternrundan".

## 2 METHOD

Ten healthy volunteers (five women, five men; aged 22-51 years) were enrolled for the study, all of whom were reasonably well prepared for the race (700 miles or more of cycling since last winter). Seven of them had completed the race before.

Lisper & Kjellberg [7] found a simple reaction time (SRT) task of 10 min. duration to be sensitive to the effects from one night of sleep deprivation. The performance task of the present study was a computerized version of this test, transformed from the auditory to the visual mode, developed by the Swedish National Board of Occupational Safety and Health [8]. The equipment included a microcomputer (ABC 806, Luxor AB, Motala, Sweden) with a dual disc drive, a printer, a reaction time panel (with a response button and a diode for stimulus presentation), and an external millisecond clock. The task was to press the response button as fast as possible each time the diode was lit. Mean inter-stimulus-interval (ISI) was 3.5 sec. with a variation of  $\pm 1.25$  sec. A mean SRT value was calculated for every min. of the 11 min. test, with the exception for the first min., which was a warm-up period.

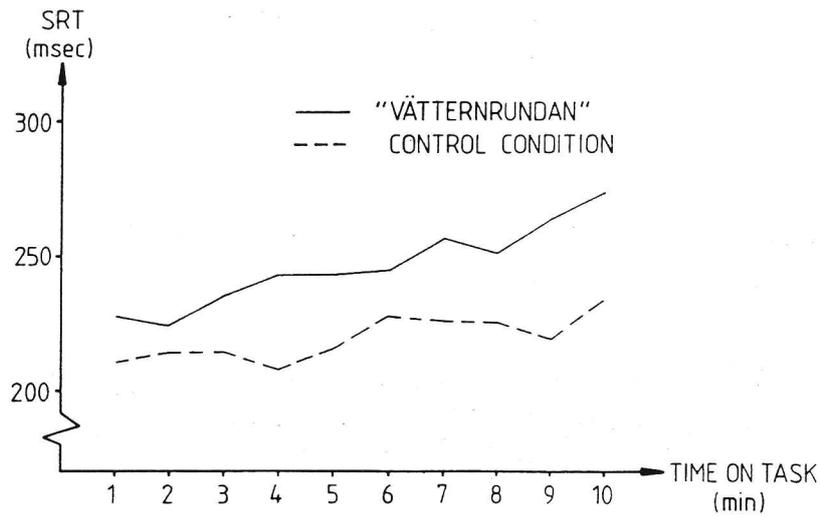
The participants of the study started the race between 8pm and 11pm, and completed the race in 11 to 18 hours. The time of completion varied from 8am until 3pm. After the race, the subjects were given refreshments, after which they were tested on the SRT task, which was initiated approximately 15 min. after completion. They were later tested on two more occasions; 3 hours, and 6 hours after completion. For the 6 hour period following the race, the cyclists had no special instructions but to rest, except to reappear at specified times for testing.

Five days before the race the participants practised the SRT task for a few min. Later that day, five subjects were tested in the control condition at times which were estimated to be approximately the same as in the experimental condition. The remaining subjects made their control measurements 5 days after the race, at times very similar to when they were tested after having finished the race.

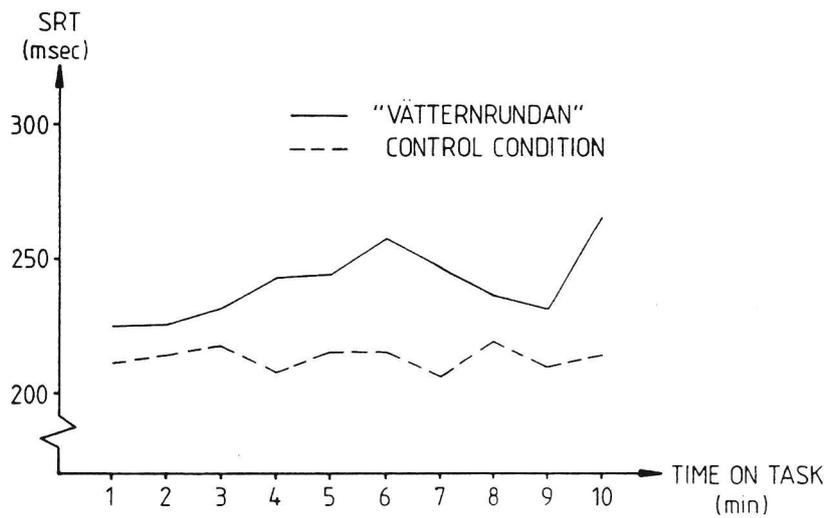
One of the subjects, for whom this was her first attempt to complete the race, did not manage to cycle all the 300 km of the race. Another of them never participated in the race. A third person did not reappear for the control measurement. Complete performance data was thus obtained for seven subjects, four of whom were tested in the control condition as their first condition.

Figures 1-3 show the results on the three test occasions in the two conditions. The result appears very similar in all three cases. When tested with an analysis of variance [9], no interaction with test occasion is significant (test occasion x participation:  $F[2,12] < 1$ ;  $p > .20$ , test occasion x participation x time on task:  $F[18,108] = 1.24$ ;  $p > .20$ ). The level of performance is seen to be impaired after having completed the race irrespective of test occasion; the difference between the two conditions is, however, not significant ( $F[1,6] = 4.24$ ;  $p < .10$ ). When including the time on task factor, on the other hand, a significant interaction with participation appears ( $F[9,54] = 3.89$ ;  $p < .01$ ).

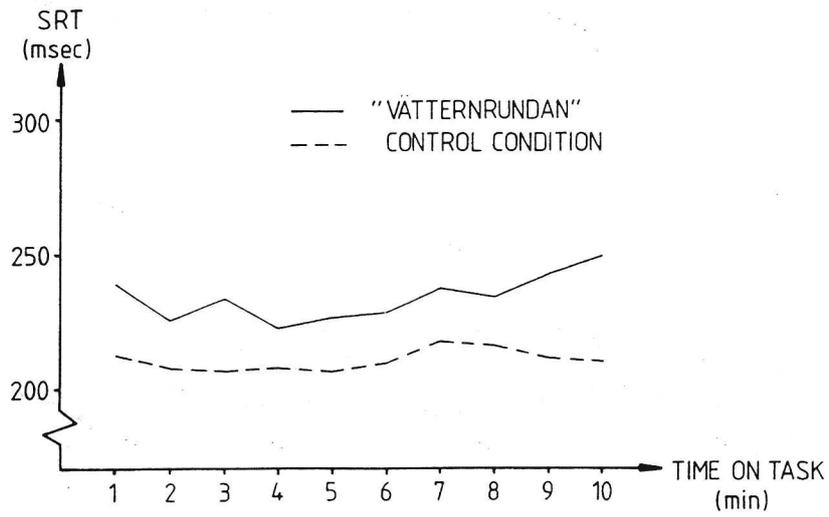
The time on task x participation interaction was examined further with respect to simple main effects; the effect from participation was studied at different levels for the time on task factor. A significant difference was obtained at four levels; after 5 min. ( $F[1,60] = 4.47$ ;  $p < .05$ ), after 7 min. ( $F[1,60] = 5.27$ ;  $p < .05$ ), after 9 min. ( $F[1,60] = 5.94$ ;  $p < .05$ , and after 10 min. of the test ( $F[1,60] = 10.75$ ;  $p < .01$ ). The present authors, however, are inclined to follow Kirk's [9] recommendation to "assign the same per family error rate to the simple main-effects tests as that allotted to the over-all F ratio". According to that principle, the only significant difference between conditions appears for the last min. of the test ( $F[1,60] = 10.75$ ;  $p < .005$ ).



**Figure 1** SRT performance 15 min after completion of the race, compared to performance in the control condition



**Figure 2** SRT performance 3 hours after the race, compared to performance in the control condition



**Figure 3** SRT performance 6 hours after the race, compared to performance in the control condition

**DISCUSSION**

The expected result appeared, with impaired simple reaction time (SRT) performance after having completed the "Vätternrundan". Regarding the issue of possible recovery during the 6 hour period following the race, all of the participants reported that they had rested; four of them had slept between one and two hours, two had not slept but had been dosing (also for one to two hours), only one of them had not slept nor dosed (did not experience a great need for it, and wanted to stay awake until the SRT testing was over). The impairment was, nevertheless, just as marked 3 or 6 hours after the race as directly after completion. It can thus be concluded that simply resting for the specified time interval, including taking naps, was not sufficient for the cyclists to regain their normal level of psychomotor functioning. Had they had the opportunity for undisturbed sleep for a few hours, the outcome might have been different.

The issue to what extent the impairment was due to sleep loss or to extended heavy exercise cannot be resolved, since there is no way to separate the two in the present study. Sleep deprivation itself most probably had an effect [7]. Regarding effects from moderate amounts of physical exercise, when studied in combination with sleep loss, Lubin et Al [6], reported detrimental effects of the former on subsequent mental performance. When extending the sleep deprivation period and increasing the amount of exercise, Angus et Al [5], however, with one exception, did not find any effects of physical exercise. They concluded that their results did not "support the common-sense view that prolonged moderate exercise increases the deterioration in mood and performance that accompanies sleep loss". Since the exercise in the present study was probably more exhaustive than in the earlier studies, it is nevertheless quite possible that this factor, as well, contributed in a significant way to the impairment found in the present study.

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