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ASSESSING THE ADAPTABILITY TO IRREGULAR REST-WORK RHYTHMS IN MILITARY PERSONNEL

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Operational decreases in performance resulting from sleep deprivation or irregular sleep-wake patterns are well known and are becoming increasingly important in today's industrialized society. Excessive sleepiness at unusual hours is estimated to affect approximately 5% of the general population and is associated with increased morbidity, loss of work hours, reduced productivity, increased work errors and impaired social and family relationship. In addition, there is an increased mortality risk when sleepiness affects motor vehicle and train drivers, aircraft pilots, nuclear power workers, and, generally, people involved in crucial occupations (e.g. Mittler, Carskadon, Czeisler, Dement, Dinges, Curtis, Graeber, 1988).

Military operations are often characterized by prolonged periods of wakefulness; irregular rest-activity patterns; long haul flights. These situations are unnatural. Severe sleep debt can accumulate, leading to dangerous levels of sleepiness and decreases of performance, which become evident after 24 hrs of sleep deprivation.

In addition, personnel involved in sustained/irregular operations are often unable to recognize and counteract fatigue and decreased performance. This condition can be due to: a) a discrepancy between subjective and objective decrease of vigilance; b) a tendency to underestimate fatigue; c) inadequate shift schedules; d) scarce attention to selecting people able to sustain prolonged wakefulness and/or unusual sleep-wake rhythms.

To maintain high levels of performance during sustained operation and/or irregular

work hours, it is possible to adopt several non-pharmacological alertness management strategies aimed to:

- a) optimize activity-rest schedules;
- b) maintain adequate levels of vigilance and performance;
- c) select people with the most useful psychological, psychophysiological, and chronobiological characteristics to adapt to work at unusual hours.

Optimize activity-rest schedules and maintain adequate levels of vigilance and performance.

Schedules implying night shifts and/or fragmentation of duty periods throughout the 24-hr day require meeting sleep need at different moments of the 24-hr continuum, until uninterrupted 8-hr sleep is possible. In such conditions, polyphasic sleep-wake strategies have potential practical applications. Sleep behaviour is considered polyphasic if less than 50% of total sleep time is obtained in one continuous episode. In such a situation, multiple naps and periods of wakefulness alternate throughout a 24-hr period (Stampi, 1992a). A large number of laboratory and field studies suggest that humans engaged in different types of polyphasic schedules can easily adapt to multiple napping regimens. It has been reported that some subjects can be able to reduce sleep to an average of less than 3 hours per day, up to 2 months. These were divided into 6 naps of 30 minutes each, one every 4 hours. Contrary to the usual findings of sleep deprivation experiments, in which only part of REM and stage 2 sleep,

but not SWS amount are penalized, all sleep stages were proportionately reduced. This was probably due to the very long duration of the study (Stampi, 1992b).

With regard to performance, preliminary data seem to show that individuals under polyphasic and ultrashort sleep schedules can function at levels equal to, or higher than, when they were under a comparable amount of monophasic sleep (Stampi, 1992c). It appears that polyphasic sleep-wake schedules are a viable solution in order to maintain high levels of efficiency during continuous work situations.

For the armed defence service on air bases, the Italian Air Force adopts, an unusual work schedule, characterized by 24-hrs on duty followed by a day off duty. The day on duty is characterized by 4 rest-activity cycles repeated throughout the day. Each cycle is of 2-hrs of activity and 4-hrs of rest (sleep allowed).

In a previous study (Porcù, Casagrande, Ferrara, Bellatreccia, 1998) Italian armed defence personnel were monitored by means of ambulatory polysomnography while attending their 24-hr rest-activity schedule. Sleep periods were visually scored according to standard criteria. Wake periods were visually scored using both 30 sec and 5 sec epochs in order to reveal episodes of drowsiness and/or microsleep. Results showed that total sleep time was substantially reduced as compared to the usual 7-8 hour monophasic nocturnal sleep. Subjects did not sleep during the first rest period (11.00-15.00). Time in sleep linearly increased in the course of the 3 remaining rest periods. Normal sleep structure was anyway substantially maintained. SWS and REM sleep were mostly expressed, respectively, in the first (3rd rest cycle: 9.00 p.m. - 1.00 a.m.) and in the last (4th rest cycle: 3.00-7.00 a.m.) third of the night, maintaining their own natural circadian rhythm.

In addition, our results indicate that this rest-activity schedule, despite the considerable sleep reduction, allowed maintaining good levels of vigilance as shown by the virtual absence of EEG microsleeps.

Thus, results of this study confirm that it is easy to break the usual monophasic sleep efficiency and to adapt to a complicated regimen, alternating 24 hrs of an usual rest-activity cycle with a nocturnal monophasic sleep and 24 hrs of a polyphasic pattern. However, these data do not allow to draw any conclusion about performance, since it was not evaluated in the present study. The great reduction of sleep duration did not cause any evident decrease of vigilance, as defined by the occurrence of microsleeps, but we cannot exclude that the very great sleep loss also did not cause detrimental effects on performance. Whether future research will prove that adult humans can adapt to this schedule with no significant decrease of performance, this alternating monophasic-polyphasic regimen should be a suitable strategy for the management of continuous operations.

Select people with the most useful psychological, psychophysiological, and chronobiological characteristics to adapt to work at unusual hours.

Although sleep deprivation, time of day and time on task are considered among the most important causal factors of daytime sleepiness (e.g. Åkerstedt and Kecklund, 1994), the levels of vigilance may still significantly vary according to individual differences. Some individual characteristics contribute, in fact, in modulating general levels and time of day effects of vigilance, sleepiness and performance and modulate even the intensity with which the various deactivating factors individually act (e.g. Åkerstedt and Torsvall, 1981; Hama, 1993).

Verifying whether and to what extent some stable individual differences are associated to specific variations of vigilance and performance may be important in orienting the best criteria for the selection of personnel involved in particular types of professions requiring shift work, prolonged activity for many hours or unusual hours, and/or monotonous activity.

Poor attention has been paid to such important factors as the individual ones. In

fact, there is a surprising lack of studies on individual differences in the adaptability to irregular sleep-wake rhythms.

Many factors have contributed to this condition. Studies on individual differences are necessarily long, time consuming and require a large sample size.

To find out which individual characteristics can guarantee the best adaptability to sustained operations and to irregular or unusual rest-activity schedules, it is essential to define:

- a) Which physiological, behavioral and/or psychological parameters are useful to define the "adaptability dimension".
- b) Which individual traits can allow us to predict adequate adaptability.

To evaluate both the "adaptability construct" and the "individual traits", it is necessary to take into account a very large number of variables: psychological, subjective, behavioral, physiological/biological, psychophysiological, chronobiological.

It is also necessary to use a multivariate statistical approach:

- a) Factor Analysis, Discriminant Analysis, and/or Cluster Analysis to single out the parameters (and their weight) that contribute to define the "adaptability construct";
- b) Multiple Regression Analysis to evaluate the predictors of adaptability;

- c) Multivariate Regression Analysis for evaluating the specific contribution of several "predictors" (independent variables) on several "criteria" (dependent variables).

To carry out such statistical analysis it is necessary to have a huge subject sample. It is estimated that about 12 observations are needed for each considered variable.

Studies of this size can hardly be carried out by a single laboratory. A multicentric approach is necessary:

- a) several laboratories (nations) should participate to a common "core project";
- b) the same experimental design should be followed in each laboratory;
- c) the subject sample size should be shared by the participants;

- d) each country might add original contributions to the project, integrating the "core project"

Here follows a summary of a research project, which we propose to carry out on personnel working on polyphasic-rest activity schedules, in order to address the above issues.

Research project.

Subject inclusion criteria

- Healthy males
- Age: 18-40 years old
- No sleep disorders in the anamnesis
- No previous significant shift-work/irregular sleep-wake experience
- No drugs/alcohol
- Normal lifestyle

Experimental design

The project is divided into 4 phases:

- Phase one, immediately before the beginning of the polyphasic activity, to be carried out in the lab;
- Phase two and three, during the polyphasic activity, to be carried out "in the field";
- Phase four, during the polyphasic activity, to be carried out in the lab on subjects with extreme individual characteristics, selected on the basis of the results of the three previous phases.

PHASE 1 (Before the polyphasic activity)

a) Questionnaires will be used to evaluate of the following individual traits:

- Sleepiness: Epworth Sleepiness Scale (ESS, Johns, 1991);
- Circadian Typology: Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976);
- Extroversion, Neuroticism, Psychoticism: Eysenck Personality Inventory (EPI, Eysenck, 1967);
- Coping Strategies: Coping Inventory for Stressful Situations (CISS, Endler e Parker, 1990);

- Sleep, Vigilance and Sleep-Wake Cycle Characteristics (Questionnaire by the Italian Air Force).

b) Laboratory evaluation of:

- Standard polygraphic recordings of sleep for two nights;
- Diurnal and nocturnal administrations of MSLT and MWT;
- Diurnal and nocturnal repeated assessments of vigilance, performance and mood (mainly by means of EEG measures, "pencil-and-paper" and/or computerized task;

c) Biological parameter assessment:

- Multiple salivary samples to evaluate melatonin and cortisol rhythms;
- Continuous recording of body temperature;
- Multiple blood samples to evaluate parasympathetic and orthosympathetic hormones, as well as lymphocyte benzodiazepine receptors;
- EKG recording and heart rate spectral analysis;

PHASE 2 (After 1 month of polyphasic activity)

"In the field" recordings, 4 consecutive days (2 days on duty, 2 days off duty):

- Ambulatory polysomnography (96 hrs);
- Reaction Time Task to weak vibratory stimuli (96 hrs);
- Letter Cancellation Tasks (Casagrande, Violani, Curcio, Bertini, 1997) and subjective evaluations of mood and alertness as follows:
- DAY ON DUTY: before and after each rest period;
- DAY OFF DUTY: upon morning awakening, at the same time of the day on duty, immediately before "lights off";
- Sleep logs as follows:
- DAY ON DUTY: a brief questionnaire on the sleep-wake cycle and vigilance filled in after each of the 4 rest periods;
- DAY OFF DUTY: a brief questionnaire on the sleep-wake cycle and vigilance filled in upon morning awakening.

- Photostimulation: blind counterbalanced administration of bright and dim light as follows:

- 10 min stimulation after each of the 4 rest periods (immediately before working);
- 30 min stimulation at the end of the working day (i.e. in the morning of the day off duty).

PHASE 3 (After 6 months of polyphasic activity)

The same experimental design as in PHASE 2 will be followed, in order to assess possible changes in the considered variables due to an improved adaptation to the irregular rest-work schedule

PHASE 4 (After 8 months of polyphasic activity)

The same experimental design as in PHASE 1 will be followed, on groups of subjects selected for their "extreme" characteristics of adaptability to the irregular rest-work schedule (i.e. the best and worst adapted subjects).

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