

Memorandum

To: Board of Directors
Council Officers

From: Rachelle A. Greenman, MD, FACEP
Chair, Well-being Committee

Jay Kaplan, MD, FACEP
Board Liaison

Date: September 9, 2010

Subj: Circadian Rhythms and Shift Work

The Well-being Committee (WBC) was assigned an objective in accordance with the sunset policy review process to revise the policy resource and education paper (PREP), “Circadian Rhythms and Shift Work.”

The revised policy statement, “Emergency Physician Shift Work,” was approved at the June 2010 Board meeting. The PREP, “Circadian Rhythms and Shift Work,” was updated and revised based on current literature and offers more information on the topic of shift work than can be included in a policy statement.

Attachment A is the revised PREP.

Please review this document and submit your comments to Marilyn Bromley, RN (mbromley@acep.org) by October 25, 2010.

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Circadian Rhythms and Shift Work
Policy Resource and Education Paper (PREP)
Draft June 2010

This policy resource and education paper (PREP) was developed as an explanation of the ACEP policy statement, "Emergency Physician Shift Work."

Introduction

1 Emergency medicine is known as a high stress specialty. The adverse effect of constantly rotating shifts is
2 the single most important reason given for premature attrition from the field. The problems of rotating
3 shifts stem mainly from working in opposition to the body's normal circadian rhythms. The major
4 circadian rhythm involved is the sleep/wake cycle. Social isolation of those who must work while others
5 sleep is also a major problem.

6 There are many biological and social problems associated with rotating shifts. Physical problems include
7 an incidence of peptic ulcer disease eight times that of the normal population. Cardiovascular mortality
8 has also been noted to be increased among shift workers.¹ Other physical problems include chronic
9 fatigue, excessive sleepiness, and difficulty sleeping. Part of the social toll on those who must work
10 rotating shifts is reflected in an increased divorce rate. Shift workers are also known to have higher rates
11 of substance abuse and depression. Shift workers are much more likely to view their jobs as extremely
12 stressful. Accidents are increased as a result of working night shifts. Many of the recent major disasters
13 attributed to human error (Exxon Valdez oil spill, Three Mile Island, Bophal chemical plant explosion,
14 Chernobyl), occurred on the night shift, when alertness is at its lowest point.

15 **Circadian Rhythms**

16 Circadian comes from two Latin words *circa*: about and *dia*: day. It refers to the bodily rhythms that vary
17 throughout the day in a periodic fashion. These rhythms have been recognized since the times of Aristotle
18 and Hippocrates. Many bodily functions exhibit circadian rhythms, from the best known sleep/wake cycle
19 to all of the vital signs. As we become capable of more precise measurements, more and more circadian
20 cycles are being recognized. Even bone length has been found to exhibit a circadian periodicity.

21 Most circadian rhythms have both an endogenous component (regulated by an internal clock located in
22 the supra-chiasmatic nucleus of the hypothalamus) and an exogenous component.² The exogenous
23 component is composed of various time clues called *zeitgebers*. One of the most powerful *zeitgebers* is
24 the light/dark cycle.

25 Temperature is one of the best studied of the circadian rhythms and exemplifies the effect of both
26 endogenous and exogenous factors. People with a diurnal (work during day, sleep at night) orientation
27 have a peak temperature about 4 pm and a trough about 4 am. During the day people are up using
28 muscles, generating heat, and eating which produces heat as food is metabolized. During the night not
29 only is muscle use decreased, but one doesn't eat. Subjects kept in a so called steady state, forced to
30 remain in bed but awake and fed the same amount of calories each hour still exhibit the same temperature
31 curve, but not with as much periodicity (peaks and troughs do not differ by as much). In normal
32 individuals, the endogenous and exogenous components of the circadian rhythms tend to complement
33 each other and work in harmony. Those who must work at night and sleep during the day pit the
34 endogenous and exogenous components against each other, and suffer the consequences. One important
35 finding about the internal "clock" is that it runs on a 25-hour day, not the expected 24-hour day. Subjects
36 who are isolated and removed from all *zeitgebers* will predictably go to bed an hour later each "day" and
37 sleep an hour longer into the next day. Why this is so is unknown. It is postulated that this allows the

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38 body to adjust depending on the season and other external considerations. This 25 hour day explains why
39 it is so easy to stay up later during holidays but so hard to get back on a work schedule rising earlier. It is
40 also why traveling from east to west is much easier (where one adapts by staying up later and sleeping in)
41 than vice versa. This is the basis for recommending a clockwise shift rotation that takes advantage of this
42 natural tendency to stay up later and later.

43 Different circadian rhythms change at different rates and with greater difficulty. This accounts for the out
44 of sorts, jet-lagged feeling as one attempts to change to a nocturnal schedule and vice versa. This jet-
45 lagged feeling while different circadian rhythms adjust at differing rates is the inevitable result of
46 attempting to reset ones bodily clock to a nocturnal schedule. It is referred to as circadian disharmony.

47 **Sleep**

48 In order to understand the effects of shift work and how to best schedule any 24-hour operation, some
49 understanding of sleep is necessary. Little enough is known about normal sleep taken at night, but even
50 less is known about the sleep of those who must attempt to sleep during the day and work during the
51 night. It is not clear how much sleep is actually necessary for optimal health. There is evidence that very
52 long natural sleepers and very short sleepers have increased mortality.³

53 Sleep is divided into several stages based on electroencephalogram (EEG) criteria. Stage I is the initial
54 part of any sleep episode lasting 10 to 15 minutes. Most subjects when awakened from stage I will deny
55 being asleep at all. Stage II accounts for the largest percent of sleep (50%), yet it is the least understood of
56 all sleep stages, because it is the matrix from which all the other stages proceed. Sleep stages are typically
57 studied by selectively depriving a subject of that particular stage and observing the results. Attempts to
58 selectively deprive a subject of stage II sleep results in total sleep loss because it is impossible to enter
59 other stages without going through stage II. Stage II is the stage least likely to be made up after a period
60 of sleep deprivation, and the most likely to be increased with the use of sedative hypnotics. Stage III and
61 IV are now collectively termed slow wave sleep or (SWS) (the only difference between the two is the
62 absolute number of delta waves recorded on the EEG). In contrast to stage II, this stage is most constant
63 from individual to individual and most consistently made up after a period of sleep deprivation. SWS is
64 felt to be important for bodily repair. It is the stage during which growth hormone is secreted during
65 normal sleep. The single most important determinant of SWS is the length of time since the last sleep
66 episode, and as such it is not as subject to circadian factors. Rapid eye movement (REM) sleep is the most
67 well known sleep stage. During this time the body is completely paralyzed, and in fact loses its
68 thermoregulatory properties. This is the main time when dreaming occurs, which is thought to be
69 important for psychological adjustment and development. Unlike SWS, REM is highly influenced by
70 circadian periodicity.

71 Normally these stages cycle throughout the night in periods of about twenty minutes with relatively more
72 SWS alternating with stage II in the earlier part of the night while REM sleep dominates during the latter
73 part of a sleep episode. Many things can alter this sleep architecture. Drugs are an important cause of
74 altered sleep patterns; caffeine causes a more rapid than normal cycling between stages, while alcohol
75 suppresses REM sleep. Sedative hypnotics (with the possible exception of zolpidem) will result in greater
76 total sleep time but almost exclusively increase stage II sleep (which may not be particularly restorative).
77 Noise, even if it doesn't awaken one, will alter sleep cycles. Circadian placement of sleep is also very
78 important.

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79 Daytime sleep is typically one and one-half to two hours shorter than a nocturnal sleep period. REM and
80 to a lesser extent stage II are the most shortened. This compounds the problems of alertness on the night
81 shift. The night worker must contend not only with the expected circadian trough of energy and alertness,
82 but also with sleep deprivation from the poor quality of daytime sleep. Many shift workers develop a near
83 obsession with sleep.

84 **Social/Domestic Factors**

85 The social effects of rotating shifts on the worker and his family are also important. Society seems to
86 actively subvert the shift worker. Neighbors insist on mowing their lawns while a night worker is
87 sleeping. People who would never telephone at 2 am routinely do so at 2 pm when the night worker is
88 attempting to sleep. Education of the worker and his family is one of the most important strategies for
89 coping with shift work. Everyone in the family must understand that shift work is a lifestyle. Most of
90 society realizes that sometimes one must work during important social functions but they are not so
91 forgiving if one is “only sleeping.” One of the most important things any shift worker can do is to
92 acknowledge the negative impact of shift work, and attribute more importance to circadian principles.
93 Other industries have demonstrated greater productivity and increased job satisfaction by applying
94 circadian principles to scheduling.⁴

95 **Commuting**

96 The risk of “drowsy driving” is increasingly recognized. Sleep deprivation has been equated to driving
97 while intoxicated and over 1000 fatal motor vehicle crashes yearly are attributable to falling asleep behind
98 the wheel.⁵ Commuting home after a night shift is recognized as being a major risk factor for motor
99 vehicle crashes. Providing a place for a post shift nap before driving home is recommended.

100 **Scheduling Strategies**

101 How best to schedule a department is one of the most important issues for adaptation to shift work.
102 Unfortunately there is no one best schedule. Many factors must be considered including the census and
103 acuity of the department, individual group member’s preferences, group size, part time help, etc. Two of
104 the biggest issues are number of night shifts in a row and shift length.

105 **Night Shift Scheduling**

106 There are two diametrically opposite approaches to scheduling night shifts. From a circadian perspective,
107 the gold standard is never to rotate shifts. A group lucky enough to find someone who will work
108 permanent nights should work hard to retain him or her and make sure they are appropriately
109 compensated. Without a permanent night worker the best shift rotation, from a circadian perspective, is to
110 have group members work a long string of nights, 4 to 6 weeks. The idea is that each person can group
111 their nights for the year together and only need to shift their circadian rhythms twice, once onto nights
112 and once back again. Everyone in the group will work exclusively nights for that one period, but have 10
113 to 11 months of the year when they will only work an occasional night, on the night person's shift off. It is
114 important for the night person to stay up even on their nights off so as not to lose their hard won night
115 orientation.

116 The other strategy is to work as few a number of nights in a row as possible, ideally one. The idea is to
117 never reset your circadian rhythms but to maintain a constant diurnal orientation. Which strategy a group

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118 uses depends on whether one finds circadian disharmony, that jet lagged feeling as one adjusts to a stretch
119 of nights and then back again to days, or inappropriate phasing, being awake and alert at night when one
120 is used to being asleep, to be most distasteful. Working 4 to 7 night shifts in a row is universally
121 condemned. One suffers from inappropriate phasing during each night shift and then just when the body
122 starts to adapt to nights, switches back again, experiencing the worst of both systems.

123 The major benefit of working many night shifts in a row is that once adjusted to nights one will be alert,
124 well rested, and provide optimal patient care, rather than struggling to stay awake for every single night
125 shift. With the use of bright lights and possibly melatonin, rapidly adjusting circadian rhythms has
126 become possible. Many individuals oppose this strategy for social reasons. They fear never seeing their
127 families during night shifts. This is a key place where education and recognition of the tolls of traditional
128 shift work can come into play. This strategy is based on the assumption that one will work a certain
129 number of nights each year. While one may not see as much of their family during their time on nights
130 they can spend proportionately more time during the remaining 10 to 11 months and be well rested and
131 fun to be around.

132 **Shift Length**

133 Another major decision for any group is how many hours in a row to work.⁶ Traditionally most groups
134 have worked two primary shifts of 12 hours each, with additional double coverage shifts of varying
135 lengths as needed. There is a trend to shortening the primary shift. Patient care is thought to be improved
136 with a better rested, more alert physician. There is also the ability to enjoy recreational pursuits even on
137 workdays with shorter shifts. Circadian principles are much more easily applied with eight-hour shifts. If
138 a group adopts a system of many nights in a row, shorter shifts are an advantage.

139 The major advantage to 12-hour shifts, is having one-third more days off completely free of hospital
140 responsibilities. Those with a long commute are likely to favor longer shifts as well as those lucky enough
141 to reliably get 2 to 3 hours sleep on each night shift. As physicians age or as patient census and acuity
142 increase, most find shorter shifts more appealing. Patient care is probably improved with shorter shifts.

143 Other scheduling strategies for groups to consider are to change shifts at different times. Some groups
144 work from 2 am to 10 am, 10 am to 6 pm, and 6 pm to 2 am. With this system each person gets some
145 sleep during the normal sleep time. Many groups also vary shift length, typically making the night shift
146 shorter, ie, 10-hour day shifts, 8-hour evening shifts, and 6-hour night shifts. It is also possible to shorten
147 the night shift by overlapping shifts, ie, 7 am to 3 pm, 3 pm to 12 pm, 1 am to 7 am with an overlap shift
148 from 6 pm to 2 am. The department will have single coverage for one hour from 12 pm to 1 am but when
149 the night person arrives there will be double-coverage again until the bulk of patients have been seen.

150 **Shift Differentials**

151 Most other industries pay a differential for night work. Groups of all sizes are beginning to reward night
152 shifts in different ways, particularly monetarily. It is well established that working night shifts becomes
153 more difficult as one ages and increases the potential for errors. Older members who don't tolerate nights
154 well often gladly "pay" extra to those younger members who are more tolerant of nights and less secure
155 financially. It is relatively easy to devise a reimbursement system whereby the night shift pays relatively
156 more and other shifts proportionately less. In other industries this helps retain valuable workers who
157 would otherwise prematurely retire as night shifts become increasingly burdensome. Some groups reward

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158 night shifts in other ways such as fewer total shifts and/or fewer weekend and holiday shifts. Non-
159 monetary incentives for working nights should also be considered such as decreased administrative duties.

160 **Individual Strategies**

161 There are also many individual strategies to help adapt to shift work. One of the most important is
162 education of family and friends. Many studies have shown that those who are most successful at shift
163 work don't try to live in two different worlds. Friends and family should be educated about the importance
164 of uninterrupted daytime sleep. An answering machine is a must for all shift workers. A dark, cool, quiet
165 sleeping place increases both total sleep time and sleep quality. Black out curtains are a worthwhile
166 investment for all who must sleep during the day.

167 There are also individual sleeping strategies that can be used. A split sleep period is a technique where
168 one sleeps for 3 to 4 hours immediately before and 3 to 4 hours immediately after a night shift. The
169 rationale is that at least part of each sleep episode is during the circadian period when sleep is expected.
170 Anchor sleep is a technique used following one's shift during a series of nights. It is basically a
171 compromise to switching to a diurnal orientation. One would stay up until 3 am or 4 am and then sleep
172 until 10 am or 11 am. That way one gets some time to socialize but doesn't completely lose a nocturnal
173 orientation. Naps are problematic.⁷ Regularly scheduled naps can be effective and some industries with
174 multiple workers on night shifts include them in their shift design. In general, however, random
175 unscheduled naps serve to hinder adaptation (making it harder to get proper sleep during the planned
176 sleep period) and do not increase alertness or improve mood.

177 Pharmacology must also be considered. Sedative hypnotics should not be routinely used by night
178 workers. They are very addictive and, while they do increase total sleep time during the day, they do not
179 hasten resetting of rhythms to night shifts or improve alertness during the night.⁸ Shift workers nearly
180 universally use caffeine. It can increase alertness but can alter sleep architecture when used within 4 hours
181 of a planned sleep period. Another alerting agent of proven benefit is modafinil, and more recently its
182 isomer armodafinil.⁹ They are in the broad family of amphetamines but are felt to have very low abuse
183 potential. They are not proven to be significantly more alerting than higher doses of caffeine (500-600
184 mg) but may have fewer side effects. Alcohol induces sleep, but the sleep is markedly distorted with
185 decreased REM sleep, which is already diminished during daytime sleep periods. Another
186 pharmacological agent which holds promise is melatonin. It is a hormone secreted nightly by the pineal
187 gland in response to darkness. Melatonin is a sedative but more importantly has been shown to hasten
188 resetting of circadian rhythms. Ramelatonin, a selective melatonin receptor agonist, has proven to be a
189 useful long term hypnotic agent, although its use for daytime sleep is untested.¹⁰ Several studies of jet lag
190 have shown significant improvement with melatonin. Careful timing of melatonin has also been shown to
191 be helpful for shift workers. Bright light of greater than 3,000 lux can also hasten resetting of circadian
192 rhythms.¹¹ Bright lights during the nights will increase alertness on the night shift and rapidly convert
193 circadian rhythms. Bright light in the early morning (5 am to 7 am) can hasten adaptation back to days by
194 phase advancing one's rhythms and allowing earlier night sleep. Exercise is a useful strategy to adapt to
195 shift work. Not only does it improve general mood but also promotes alertness on night shifts (if not too
196 strenuous). It has been shown to increase circadian adaptation also. Aerobic exercise immediately after
197 awakening, no matter which shift one is working, is most effective.

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199 **Conclusions**

200 Shift work is a necessary fact of life for emergency physicians. Emergency physicians must attribute more
201 importance to well being and acknowledge adverse effects of shift work. This includes making rational
202 schedules from a circadian perspective. Individual strategies should also be employed, particularly good
203 sleep hygiene and decreasing potential interruptions.

Revised by the Wellness Section under the direction of
Harold A. Thomas, Jr, MD, FACEP
June 2010

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205 **References**

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