Chewing Can Relieve Sleepiness in a Night of Sleep Deprivation

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Night sleepiness in two groups of student volunteers who stayed awake for one night was assessed at standardized time (22:00, 01:00, 04:00, 07:00) by the Stanford Sleepiness Scale (SSS). One group (N=21) chewed the chewing gum from midnight until the end of the experiment in the morning, the other group (N=43) was not chewing at all. The results show that both groups at the initial assessment at 22:00 were not sleepy, with similar SSS scores. Sleepiness in both groups appeared after midnight, worsening towards the morning. The students who were chewing from midnight assessed their sleepiness as lower than the students who were not chewing, which was more marked at 01:00 and 04:00. In the group of medical professionals, nurses and technicians, sleepiness was assessed by SSS in a routine night shift when they, according to their own experience, had the most difficulty overcoming it. Immediately after the assessment they chewed the chewing gum (N=60) or stood/walked (N=27) for 15 minutes. At the end of the fifteenth minute, they assessed their sleepiness again. After 15 minutes of treatment, both groups of medical professionals assessed their sleepiness as relieved, with a lower SSS score, more markedly in the chewing group. The obtained results seem to indicate that chewing may alleviate sleepiness in professionals and nonprofessionals who stayed awake through the night.

CURRENT CLAIM: Chewing gum can relieve the feeling of sleepiness during night sleep deprivation and at least temporarily abolish its negative effects.

It is not possible to avoid events which force us to stay awake and active in spite of our need for sleep. With the exception of pathological states, the main reasons of inappropriate sleepiness are lack of coordination of biological clock, time of day variation in physiology and alertness (Mitler et al., 1988) and homeostatic regulation of sleep and wakefulness (Akerstedt, 1995a). According to Mitler et al. (1988), in 1986, the Association of Professional Sleep Societies’ Committee on Catastrophes, Sleep and Public Policy claimed that medical incidents and human errors in industrial and technical operations occurred most often at times of day coincident with the temporal patterns of brain processes associated with sleep. Following the consensus statement from the International Conference on Work Hours, Sleepiness and Accident, Stockholm, September 8-10, 1994, the collection of the related papers appeared in 1995 dealing with the problem and suggesting possible countermeasurements (Akerstedt, 1995a).

Summarizing scientific reports, Mitler et al. (1988) emphasize that the neuronal processes controlling alertness and sleep produce an increased sleep tendency and diminished capacity to function during certain early morning hours (circa 2-7 a.m.) and to a lesser degree, during a period in the midafternoon (circa 2-5 p.m.) whether or not we have slept.

Sleepiness as a drive towards sleep (Dement and Carskadon, 1982) rises late in the night and might be heaviest in the early morning hours (Richardson et al., 1982; Akerstedt, 1995b; Gillberg et al., 1996). Sleepiness is enhanced with a length of continuous sleep deprivation (Carskadon and Dement, 1982; Roehrs et al., 1983; Rosenthal et al., 1993), but might be underestimated in cumulative sleep deprivation with shortened sleep 2-3 hours daily (Dinges, 1995). So, as it was pointed out by Babkoff et al. (1991) and Gillberg et al. (1996), sleepiness is caused by accumulated sleep loss; and circadian and ultradian factors.

There are many reports that sleepiness caused by sleep loss impairs human performances. Results in metaanalysis data from 19 original research studies suggest that sleep deprivation strongly impairs human function, mood is more affected than either cognitive or motor performance, and partial sleep deprivation has a more profound effect on functioning than either long-term or short-term sleep deprivation (Pilcher and Huffcutt, 1996).

The role of sleepiness in work-related conditions is strongly supported by subjective reports, behavioral measurements and by EEG studies showing that truck drivers, train drivers, airline pilots, process operators, and other groups suffer from attacks of drowsiness/sleep while on duty (Akerstedt, 1995b; Gillberg et al., 1996).

If one cannot avoid the cause of sleepiness, then there is no efficient and safe way to overcome it. According to Akerstedt (1995a), countermeasurements which abolish negative aspects of sleepiness due to schedules involve sleep-wake strategies and as the first choice move the main sleep closer to the night shift. Also, a short nap may maintain alertness during a night shift (Rosenthal et al., 1991; Rosekind et al., 1995; Muzet et al., 1995; Sallinen et al., 1998). Caffeine counteracts sleepiness (Zwyghuizen-Doorenbos et al., 1990; Johnson et al., 1991) and
may have a similar effect as the nap (Walsh et al., 1995). Melatonin may counteract sleepiness, seeming to exert its effect mainly through shifting the circadian rhythm of the individual with potential use in circadian rhythm disorders such as a jet lag and shift work (Arendt et al., 1995). Bright light virtually eliminates circadian maladjustment in night workers (Czeisler and Dijk, 1995).

In this study the influence of chewing gum on relief of sleepiness in healthy volunteer subjects who stayed awake the whole night and in medical workers in the night shift was investigated.

METHODS

Subjects

Experiment I

Healthy volunteers, students of psychology at the University in Zagreb, of both sexes, with no sleep complaints (N=64, m=11, f=53, age 21-27, mean age 21.83, SD=1.83).

Experiment II

Healthy medical professionals-nurses and technicians-with various experiences in shift work, from three medical institutions in Zagreb (psychiatric hospital, thoracic surgery, general surgery), of both sexes, declaring no sleep-wake disturbances (N=87, m=19, f=68, age 19-50, mean age 31.21, SD=9.44).

Procedure

Experiment I

The subjects randomized in two groups, experimental (N=21, m=2, f=19, age 21-23, mean age 21.33, SD=0.58) and control (N=43, m=9, f=34, age 20-27, mean age 22.07, SD=2.18), were awake all night in groups of 6 to 12 persons, supervised by the assistant examiner (one member of every small group). The subjects slept as usual during the previous night, they avoided coffee and cola drinks from the middle of the day preceding the experiment, they also refrained from heavy physical activity after noon. The smokers were allowed to smoke. During the experiment the subjects were sitting and they could listen to music, talk, or read. The subjects were not permitted to watch TV. The experiment began in the evening at 20:00. They assessed their sleepiness by using the Stanford Sleepiness Scale (SSS) (Hoddes et al., 1973) at 22:00, 01:00, 04:00, and 07:00. The experimental group was given a standard chewing gum at midnight, an hour before the second assessment of sleepiness at 01:00 and they chewed until the end of the experiment. Every three hours the gum was replaced by a new one. The assistant examiner in each group of subjects was careful to have looked to it that the subjects were instructed not to drowse and not to try to reduce sleepiness by any physical activities or by leaving the experimental room more than necessary. In the experimental groups the assistant examiner encouraged the subjects to chew the chewing gum with equal intensity through the whole night. The experiment with the chewing group took place at the end of September. The experiment with the control group took place at the end of April/beginning of May.

Experiment II

There were two experimental groups. One group (N=60, m=14, f=46, age 19-49, mean age 31.32, SD=9.72) consisting of nurses and technicians in the night shift (21:00-07:00), was instructed to assess their sleepiness on SSS at the time when, according to their own experience, they had the most difficulties in overcoming sleepiness. Immediately after this assessment they were chewing the standard chewing gum for 15 minutes. At the end of the fifteenth minute they assessed their sleepiness again.

The nurses and technicians in the other group (N=27, m=5, f=22, age 20-50, mean age 30.96, SD=8.96) were instructed to

Figure 1. Night sleepiness in two groups of sleep deprived student volunteers while chewing (N=21) and while not chewing (control, N=43).
assess their sleepiness in the SSS at the moment of greatest effort
to master sleepiness in the experimental night. Immediately after,
they stood or walked for 15 minutes and at the end of the fifteenth
minute they assessed their sleepiness again.

The experiment with both groups was performed in late
Autumn, at the end of November/beginning of December.

RESULTS

Statistics

Distributions for all variables (SSS score for all
participants) were tested for normality within respective
groups by Smirnov-Kolmogorov test. Only a few passed
normality test, therefore nonparametric analytic procedures
(Mann-Whitney U-test, Wilcoxon-Matched Pairs-Test
Conover, 1971) were applied.

Experiment I

There were no statistically significant differences between
chewing and control groups of students who stayed awake
through the night in the initial assessment of sleepiness at
22:00 (chewing group: SSS median 2, range 1-4; control
group: SSS median 2, range 1-4; Mann-Whitney U=437.0,
Z=0.2305, p = 0.8177) and the final assessment of sleepiness at
07:00 (chewing group: SSS median 4, range 1-6; control
group: SSS median 4, range 2-7; Mann-Whitney U=397.0,
Z=0.8057, p=0.4204). Only at the initial assessment at 22:00
neither group was chewing. A significantly lower sleepiness
score was obtained in the experimental group of subjects who
chewed at 01:00 (chewing group: SSS median 2, range 1-3;
control group: SSS median 2, range 1-5; Mann-Whitney
U=282.0, Z=2.6278, p=0.0086) and at 04:00 (chewing group:
SSS median 3, range 1-5; control group: SSS median 3, range
2-7; Mann-Whitney U= 278.0, Z= 2.5863, p = 0.0097). As was
pointed out above, in the morning at 07:00, when sleepiness
was assessed as the greatest in both groups of subjects,
sleepiness in the chewing group was scored lower in the SSS
compared with the subjects in the control group who did not
chew, but it was not statistically significant (Figure 1).

Experiment II

Sleepiness (SSS) in the two groups of medical professionals
in the night shift was not significantly different in the initial
situation before the treatment (chewing group: SSS median 5,
range 3-7; standing/walking group: SSS median 5, range 3-7;
Mann-Whitney U=698.5, Z=1.0699, p=0.2846). Subjectively
most explicit sleepiness appeared in the period 02:00-05:00
(SSS score 6 or 7) in both groups. After a 15-minute treatment
the assessment of sleepiness was significantly lower in both
groups (chewing group: SSS median 3, range 1-7; Wilcoxon
Matched Pairs Test: Z=5.87, p=0.0000; standing/walking
group: SSS median 4, range 3-7; Wilcoxon Matched Pairs Test:
Z=2.37, p=0.0176). Relief of sleepiness in SSS was significantly
more marked after chewing than after
standing/walking (Mann-Whitney U=552.0, Z=2.41, 
p=0.0158) (Figure 2).

In both groups of medical professionals the heaviest
sleepiness occurred mostly between 02:00 and 05:00 (67% in
chewing group and 74% in standing/walking group). No
significant differences occurred between the two groups in
distribution of the declared heaviest sleepiness through the
night. No significant differences were found between the
groups in distribution through the night when improvement of
sleepiness after treatment did occur. In both groups
improvement of sleepiness in SSS after treatment was more
marked until 02:00 than after: until 02:00 28% of the subjects
in the chewing group declared the heaviest sleepiness, but 41%
of all relief in SSS occurred after the treatment; in the

![Figure 2](https://example.com/figure2.png)

Figure 2. Relief of sleepiness (SSS) in healthy medical professionals (nurses and technicians) during night shiftwork while temporarily (15 minutes) chewing (N=60) and standing/walking (N=27).
standing/walking group 22% of the subjects declared the heaviest sleepiness in the period until 02:00, but 32% of all relief occurred after the treatment.

**DISCUSSION**

The results obtained in the study show that chewing can alleviate the subjective feeling of sleepiness (SSS) in persons professionally and nonprofessionally exposed to night watch. In accordance with the results of other authors (Richardson et al., 1982; Akerstedt, 1995b; Gillberg et al., 1994, 1996), the feeling of sleepiness in the examined subjects, student volunteers and medical professionals, was most distinct in the second half of the sleepless night, towards the morning. In student volunteers who did chew, sleepiness was most relieved at 01:00 and 04:00 in comparison with the students who did not chew. At 07:00 in the morning, when the subjective feeling of sleepiness was greatest in all sleep deprived student volunteers, the feeling of sleepiness was reduced in the chewing group, although the improvement was not statistically significant. It should be noted here that the experiment with the control group of students, who did not chew, was performed in April/May, i.e., the middle of Spring. The experiment was performed with the experimental group of students who did chew at the end of September, i.e., at the beginning of Autumn. Thus, the day began about an hour later for the experimental group than for the control group (time of sunrise for Zagreb on April 23rd: 04:55; May 7th: 04:35; September 23rd: 05:43; September 30th: 05:52).

Medical professionals exhibited the greatest work disturbing sleepiness in the experimental night in the period between 02:00 and 05:00. Relief of sleepiness was significant after 15 minutes of standing/walking-but highly significant after 15 minutes of chewing.

It seems that alleviation of sleepiness by means of chewing is more marked after a short, but probably more intensive, chewing (the differences were more obvious in medical professionals who were exposed to a 15-minute period of chewing at the time when they felt sleepy, versus students who chewed through the whole night and were assessed at the standardized time).

Irrespective of when the participants in the experiment chewed, improvement in sleepiness was obtained for any period through the night, but this improvement of sleepiness was more marked in the earlier periods of the night. In both groups of student volunteers, i.e., those who chewed and those who did not chew, sleepiness gradually increased from 01:00 until 07:00, but it was not the case with the medical professionals, the smaller, but yet significant, number of whom declared the heaviest sleepiness in the experimental night from late evening until 02:00. Therefore, a better effect of chewing during earlier parts of the night cannot be explained solely by circadian influences. The psychological disposition to maintain wakefulness plays an important role. Some medical professionals, because of the cumulative deficit of sleep from previous shifts, may express greater sleepiness in late evening or early night hours, but also greater motivation to stay awake until the professionally less demanding periods of the shift.

According to Horne and Reyner (1995), most sleepy persons during the night are aware of their sleepiness, but they underestimate the possible consequences of sleepiness. This means that most sleepy persons exposed to night wakefulness could recognize the time when chewing might be helpful. However, it cannot be stated with certainty that chewing, besides subjective relief of sleepiness as expressed in the SSS, contributes to the improvement of psychomotor performances. According to Seidel et al. (1984), in healthy subjects the speed in card sorting correlated with daily tendency to sleep objectivized in MSLT, but not with the subjective feeling of sleepiness assessed by SSS. On the other hand, Gillberg et al. (1994) found out that subjective assessment of sleepiness in KSS (Karolinska Sleepiness Scale), ATS (Accumulated Time for Sleepiness) and VAS (Visual Analogue Scale) correlated highly with single reaction task.

Although SSS is a well validated sleepiness scale, without an adequate trial it is difficult to predict whether the results obtained in the study could indicate improvement of physiological sleepiness and psychomotor performances in deprivation of sleep while chewing. Without an adequate trial it is also difficult to say whether the effect of chewing on night sleepiness could match other countermeasures for sleepiness suggested so far, i.e., short nap (Rosenthal et al., 1991; Bonnet, 1994; Bonnet et al., 1995; Rosekind et al., 1995; Muzet et al., 1995; Sallinen et al., 1998), caffeine (Zwyghuizen-Doorenbos et al., 1990; Johnson et al., 1991; Rosenthal et al., 1991; Walsh et al., 1995), melatonin (Arendt et al., 1995), or bright light exposure (Czeisler and Dijk, 1995). Alleviation of sleepiness through chewing lasts as long as the chewing itself, i.e., there is no delayed awakening effect (Hodoba et al., 1998, published only as a summary). This means that chewing, unlike caffeine for example, does not interfere with sleep which might follow. This might be relevant for short-term duties which alternate with short sleep in a night shift. Chewing might also help shorten or avoid sleep inertia, which may cause difficulties in arousing (Dinges, 1992; Muzet et al., 1995) after a short night nap. Chewing is a simple activity which mostly does not interfere with other professional physical and/or mental activities, therefore it is applicable in almost all professional occasions. The fact that chewing seems to be superior to standing and walking as far as reduction of sleepiness is concerned, as indicated by the results of this experiment, and the fact that other forms of more complex physical activities (exercises) during the night shifts had no significant effect on sleepiness (Horne and Reyner, 1995), and, of course, inapplicability in all professional occasions, suggests that the arousing effect of the relatively small group of highly active masticatory muscles could be the same or even more marked in comparison with the activity of the body musculature.

While chewing during the meal, we do not fall asleep easily; therefore, choking on food is unlikely to be caused by sleepiness. During chewing, masticatory muscles have a sufficient arousing effect. On the contrary, weakened muscular tone of masticatory muscles can explain yawning when sleepy; because of sleepiness the jaw begins to sink. When yawning, we have mastered, at least for a short time, the masticatory
muscles, restored their tone, and thus achieved a brief arousal. Mastering the tone of masticatory muscles by yawning is in itself a pleasant experience, the same as stretching in the morning after waking and mastering the sleep-relaxed musculature, which immediately upon awakening is not completely toned. By stretching after awakening sleep inertia may disappear.

Sensoric input from muscular receptors of voluntary muscles is the potentially most massive impulse affecting the arousal during a certain period of time. Sleep and muscular tone of voluntary musculature are inversely related. Lack of coordination of these processes has unpleasant consequences. Consciously, we never experience complete muscular atonia. If we do experience this state when ill, then it is extremely disagreeable (sleep paralysis, for example). In the case of a mild desynchronization of falling asleep and the loss of muscular tone when muscular relaxation is too quick, one experiences a sudden, alarming arousal, while deeply sleepy mental elaboration of consciously unrecognized state of muscular atonia could be a well known dreamlike hypnagogic experience (sinking, stumbling, etc.). The person immediately awakens and masters the voluntary muscles. Aside from the sudden rising of muscular tone, the accompanying fear of a dreamlike experience also has its share in awakening.

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