Provided for non-commercial research and education use.
Not for reproduction, distribution or commercial use.

This article appeared in a journal published by Elsevier. The attached copy is furnished to the author for internal non-commercial research and education use, including for instruction at the authors institution and sharing with colleagues.

Other uses, including reproduction and distribution, or selling or licensing copies, or posting to personal, institutional or third party websites are prohibited.

In most cases authors are permitted to post their version of the article (e.g. in Word or Tex form) to their personal website or institutional repository. Authors requiring further information regarding Elsevier's archiving and manuscript policies are encouraged to visit:

http://www.elsevier.com/copyright

Author's personal copy

Sleep Medicine 12 (2011) 454–462

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original article

Short sleep in young adults: Insomnia or sleep debt? Prevalence and clinical description of short sleep in a representative sample of 1004 young adults from France

Damien Léger [a,*], Enguerrand du Roscoat [b], Virginie Bayon [a], Romain Guignard [b], Joël Pâquereau [c], François Beck [b,d]

[a] Université Paris Descartes, APHP, Hôtel Dieu, Institut National du Sommeil et de la Vigilance, Paris, France
[b] INPES, Direction des Affaires Scientifiques, 42, Bd de la Libération, 93203 St. Denis Cedex, France
[c] Hôpital La Milétrie, Poitiers, France et Institut National du Sommeil et de la Vigilance, Paris, France
[d] Cermes3 – Equipe Cesames, Centre de recherche Médecine, Sciences, Santé, Santé mentale, Société, Université Paris Descartes/CNRS UMR 8211/Inserm U988/EHESS, France

ARTICLE INFO

Article history:
Received 31 August 2010
Received in revised form 1 November 2010
Accepted 8 December 2010
Available online 6 April 2011

Keywords:
Short sleep
Sleep debt
Insomnia
Daytime consequences
Epidemiology
Youth

ABSTRACT

Background: Increasing evidence suggests an association between short sleep with adverse health outcomes: obesity, type 2 diabetes and hypertension. But there are few or no data on "who these short sleepers are" in the general population.
Objectives: To describe short sleepers and the associated sleep disorders in young adults.
Methods: Cross-sectional telephone survey in a representative sample of 1004 French young adults (25–45 years old). Total sleep time (TST), insomnia, snoring, sleepiness and daytime consequences were assessed using subjective validated tools. Short sleepers were defined as sleeping <6 h a weekday (sleep + nap + pauses). Sleep debt was defined as those who "sleep 90 min less than the sleep they need to be in good shape."
Results: Prevalence of short sleep was 18%, insomnia 12%, and sleep debt 20% in the total group. Among short sleepers, 16% had insomnia, 45% sleep debt, and 39% neither. Short sleepers were significantly mostly males, blue collar workers and more overweight and obese compared to nonshort sleepers. Working >10 h per day, smoking and drinking coffee after 5 p.m. were also significantly associated with short sleep. Short sleepers had higher Epworth sleepiness scale ESS scores (7.8 vs 6.7; $p = 0.0058$) and more sleepiness while driving (11.5% vs 2.9%; $p < 0.0001$).
Conclusion: Short sleep is highly prevalent in young adults but is not an homogeneous group, including both insomniacs and subjects with or without sleep debt. Short sleep has to be defined more precisely in order to better understand its impact on public health.
Crown Copyright © 2011 Published by Elsevier B.V. All rights reserved.

1. Introduction

Increasing evidence suggests an association between short sleep and major comorbidities (diabetes, obesity and hypertension) and higher mortality [1–4]. Short sleep is usually defined as reporting sleeping less than 6 h per day including sleeping, napping and resting [3–7]. In a representative sample of 3158 subjects living in the Detroit area (USA), the adjusted (socioeconomics, age, sex and comorbidities) prevalence of obesity was found to be 24.8% higher in short sleepers than in controls [6]. In a meta-analysis including 10 studies and 1,07,756 males and females and 3586 subjects with type 2 diabetes, the risk ratio of diabetes in short sleepers (<5–6 h of sleep) was 1.28. In this study, however, long sleep and insomnia were also significant risk factors [3]. Observing trends in the prevalence of short sleepers in the USA from 1975 to 2006, a recent review combining the results of eight national studies concluded that unadjusted percentages of short sleepers ranged from 7.6% in 1975 to 9.3% in 2006 [5]. But the increased odds of short sleep over the 31-year period was significant only among full-time workers but did not change significantly for part time workers, retired/homemakers, or unemployed, and decreased in students. Reported short sleep significantly increased in 7 of the 8 registered industrial sectors in the USA [7].

Insomnia is also known to be associated with comorbidities (e.g., depression, anxiety, pain, prostatic diseases) [8,9] but is generally considered secondary to these comorbidities (ICSD DSM IV) [10,11] and so called "comorbid insomnia." Some authors, however, have hypothesized that insomnia by itself may be the cause of developing or maintaining some of these comorbidities. In a

* Corresponding author. Address: Centre du Sommeil et de la Vigilance, Hôtel Dieu de Paris, 1 pl du Parvis Notre Dame, 75181 Paris, Cedex 04, France. Tel.: +33 1 42 34 82 43.
E-mail address: damien.leger@htd.aphp.fr (D. Léger).

1389-9457/$ - see front matter Crown Copyright © 2011 Published by Elsevier B.V. All rights reserved.
doi:10.1016/j.sleep.2010.12.012

Author's personal copy

longitudinal study of 591 young adults in Switzerland, Buysse et al. confirmed the persistent nature of insomnia and the increased risk of subsequent depression among individuals with insomnia [12]. Insomnia also increases pain sensitivity and contributes to chronic pain [13]. The mechanism of how insomnia promotes the development of comorbidities, however, is not clear. Sleep duration may be one factor, but the number of awakenings or the decreased percentages of slow wave sleep or REM sleep or a combination may all be factors. A recent study tried to answer this question and concluded that insomnia with objective short sleep recorded by polysomnography (5–6 h and <5 h per night) seems to be the most significant predictor of type 2 diabetes. In a population sample of 1741 adults, diabetes was most frequent in the < or =5 h sleep duration group (odds ratio [2.95[1.2–7.0]] than in the insomniacs who slept 5–6 h (2.07 [0.68–6.4]) [14]. Moreover, insomnia with objective short sleep is also associated with deficits in neuropsychological performance observed such as processing speed, attention, visual memory and verbal fluency [15].

Finally, short sleep and insomnia do not concern homogeneous groups of subjects. As mentioned by Grandner et al. in a recent review, "short sleepers" comprised both of individuals with less need for sleep and those not sleeping enough, voluntary and involuntary [16].

This paper would therefore discuss problems associated with the terminology used to describe "short sleep" and would try to assess how short sleepers may be insomniacs, normal sleepers or sleep deprived subjects. We believe also that it is necessary to better understand how short sleepers may be voluntarily or involuntarily restricted. This is a major issue for planning short sleep prevention among young adults.

The goal of our study was therefore to use epidemiology in order to describe short sleepers, the associated sleep disorders (insomnia, sleepiness and sleep debt) and daytime consequences in a representative group of young adults.

2. Method

2.1. Design

This was a national, non-interventional, cross-sectional, observational survey conducted in a representative sample of the general population of French adults aged 25–45 years old. A national scientific committee including three sleep experts of the French National Sleep and Wake Institute (Institut National du Sommeil et de la Vigilance) and three epidemiologists of the National Institute for Prevention and Health Education (INPES) were responsible for advice and recommendations on all scientific aspects of the survey. The survey was conducted in accordance with the 18th World Medical Assembly (Helsinki, 1964) principles and subsequent amendments and with the guidelines for Good Epidemiological Practice [27].

Data were collected by computer-assisted telephone interviews carried out by BVA (an European opinion poll institute). Phone numbers (including mobile phone numbers) were selected randomly using an automated dialing system based on files stratified by region and city size. Only one person in each household was randomly selected among the eligible persons comprising the household. In case of refusal, the individual was not replaced. Within households reluctant to participate in the survey, it is often impossible to assess the household eligibility (presence of at least one person aged 25–45 years old within the household). The response rate can thus only be approximated by estimating the number of eligible household members among those who refused to participate in the survey. Such an approximation leads to a response rate of 60%. Data were weighted on age, gender and head of the family employment status, based on national socio-demographic and socioeconomics statistics.

A semi-structured questionnaire (a survey regularly carried out in the general population) that consisted of an extensive series of standardized 30–45-min interviews was conducted over the telephone by professional interviewers. When subjects were not available at the moment of the call, a telephone interview schedule was proposed at a more convenient time for the interviewee.

2.2. Subjects

Inclusion criteria for the cases were men or women aged 25–45 years. This age group was voluntarily selected in order to focus on young and active subjects who may be sensitive to focussed short sleep prevention in future public health campaigns. In younger subjects, we believe that sleep debt may be too irregular and/or difficult to assess. In older subjects, however, comorbidities may be a factor of confusion in the analysis. All respondents were eligible to take part of the study whatever the quality and the quantity of their sleep. The survey quantitatively assessed the type, frequency, and natural history of nighttime and daytime symptoms.

2.3. Assessing insomnia and other sleep troubles

Insomnia and other sleep disorders were assessed by self-administered questionnaires: the "Sleep Disorders Questionnaire – French version" (SDQFV) and the "Epworth Sleepiness Scale" (ESS) score.

The SDQFV is a 42-item questionnaire based on DSM-IV and ICSD-2 criteria of insomnia [10,11] [17]. This French version has been validated in several epidemiological studies [18,19]. It covers sleep habits, sleep disorders, alertness during the daytime and psycho-behavior items such as mood, memory and sexual behavior.

All but one of the items were derived from questions and possible responses in the SDQFV. The selection of sleep disorders was based on two reference documents: the International Classification of Sleep Disorders (ICSD-2) [27] and the Diagnostic and Statistical Manual of Mental Disorders, 4th revision (DSM-IV) [11].The SDQFV also collected data on four specific sleep complaints:

- Difficulties falling asleep
- Frequent nocturnal awakenings
- Early awakenings
- Nonrestorative sleep

Sleep complaints are essentially drawn from the DSM-IV definition of insomnia. In addition, the ICSD-90 minimum criteria for insomnia, idiopathic hypersomnia, snoring and sleep apnea were used. Information was also collected on the duration of sleep disorders:

- Insomnia was defined according to the DSM-IV and ICSD-2 definitions [10,11].
- Subjects have first to complain of "difficulty initiating sleep, difficulty maintaining sleep, early awakenings, nonrestorative sleep".
- More than 3 nights per week and for more than one month.
- Daytime consequences listed according to the above definitions: (i) fatigue or malaise; (ii) attention, concentration, or memory impairment; (iii) social or vocational dysfunction or poor school performance; (iv) mood disturbance or irritability; (v) daytime sleepiness; (vi) motivation, energy, or initiative reduction; (vii) proneness for errors or accidents at work or while driving; (viii) tension, headaches, or gatrointestinal symptoms in response to sleep loss; (ix) concerns or worries about sleep.

Author's personal copy

2.4. Assessing total sleep time

The questionnaire was structured to question sleep schedules and several items focussed on total sleep time. The main questions were repeated for weekdays, weekends and holidays:

In general, (a = week days/b = week-ends/c = holidays)
At what time do you go to bed? /__/__/ hours /__/__/ min
At what time do you switch off the lights? /__/__/ hours /__/__/ min
How long it does take you to fall asleep? /__/__/ hours /__/__/ min
At what time do you wake up? /__/__/ hours /__/__/ min
At what time do you leave your bed? /__/__/ hours /__/__/ min

The interviewer instructions were "If the subjects give the same time between 'wake up' and 'leave the bed,' please ask 'do you leave the bed at the same moment you wake up?' If they answer 'no,' please repeat the question."

Do you sometimes have a nap? (a/b/c): YES /NO. If yes
How many times per week on average? /__/__/ times
How long do you usually nap each time? /__/__/ hours /__/__/ min

Total sleep time (TST) **(a/b/c)** per day was calculated by the addition of

- TST at night (time difference between falling asleep and waking up)
- Total nap time.

As recommended by Knutson et al. in their review [5], we focussed our study on short sleepers, defined as those reporting <360 min (6 h) of sleep, nap or rest per weekday. Epidemiology studies suggest that <6 h of sleep is associated with increased morbidity risk, while there is less evidence for having adverse effects on health associated with 6–6.5 h of TST [5]. We only used TST a(= during week days) to assess the subjects and to classify them as short sleepers; b and c were only used to assess sleep debt.

2.5. Assessing sleep debt

Based on the literature we found no consensual definition for sleep debt which may reflect voluntary (due to work conditions, transport or leisure) sleep shortening. We therefore added some items to the questionnaire. The questions aimed to quantitate the amount of sleep needed by each subject to be in good shape during the day. As previously reported, we also included questions about sleep schedules during weekends and holidays. The questions included:

Ideally, if you were able to decide the number of hours of sleep you need to be in good shape, how much time would you wish to devote to sleep?

/__/__/ hours /__/__/ min

In reality, how many hours of sleep do you need generally to be in good shape the next day?

Average/__/__/ hours /__/__/ min
Minimum/__/__/ hours /__/__/ min

Based on the answers collected by the interviewers, several sleep debt definitions were derived. First, these definitions were tested by calculation and the analysis of the prevalence for each subset. From these results one definition of sleep debt was retained. This is a subjective decision based on the clinical expertise of the three specialist members of the scientific board of the study who build their conviction on their clinical experience and on the analysis of the prevalence of subjects found for each possible definition.

The candidate definitions of sleep debt were (1) a difference between the averaged TST during vacations and the averaged TST during week days >60, 90, 120 min; (2) a difference between the averaged TST during weekends and the averaged TST during week days >60, 90, 120 min; (3) a difference between the averaged TST "needed to be in good shape" and the averaged TST during week days >60, 90, 120 min; (4) a difference between the averaged TST during weekends and the averaged TST during the week >60, 90, 120 min; (5) a difference between the averaged TST during vacations and the averaged TST during the week >60, 90, 120 min.

Insomniacs and subjects who filled the criteria for sleep apnea or restless legs syndrome were excluded from subjects with voluntary sleep debt.

2.6. Assessing sleepiness, fatigue and daytime consequences

Sleepiness was measured by the Epworth sleepiness scale (ESS), a self-administered questionnaire constructed and tested in the early 1990s [20,21]; the ESS has been validated against objective tests such as the Multiple Sleep Latency Test [22].

Subjects were also questioned during the same interview on possible daytime consequences of their poor sleep and particularly on (i) feeling not rested after their sleep; (ii) taking drugs to combat fatigue during the last 6 months; (iii) having negative effect of their sleep (answer = Yes or No) on daily activities, work, relationships with others, leisure, memory and concentration, irritability, mood (sadness, sorrowfulness); (iv) experiencing sleepiness whilst driving in the last 12 months; (v) having an accident due to sleepiness when driving in the same period.

2.7. Statistical analysis

Data management and statistical analysis were performed using the SAS software package (version 8, SAS Institute, North Carolina, USA). Descriptive analyses for qualitative variables included number, frequency, and the 95% CI, while quantitative variables were analyzed in terms of mean value, standard deviation, median and extreme values. Collected data were analyzed in the total population and by subgroups of short sleepers, insomniacs, and subjects with sleep debt.

A logistical model was created for short sleepers, insomniacs, and subjects with sleep debt. A general linear model was used to study the relationship between these sleep characteristics and other factors analyzed. Comparisons between groups of sleep disturbances were made using student *t*-test or Mann–Whitney non-parametric test for continuous data and χ^2 test or Fisher exact test for categorical data.

To describe quantitative variables, the Kruskal–Wallis test with Bonferroni-Dun's post hoc analysis was used.

Explanation factors for short sleep were determined using logistic regression analysis after adjustment for potential confounders (sex and age). The associations were then expressed using odds ratios (ORs). A step-by-step selection of socio-demographic and clinical criteria was performed by a univariate approach (χ^2 or Fisher's exact test for non-ordinal qualitative variables, Kruskal–Wallis test for ordinal data, and analysis of variance or Kruskal–Wallis test for quantitative variables).

Due to the small size of the samples, we were unable to test the effects of sleep debt on fatigue, sleepiness and daytime consequences; we therefore extended the analysis to the entire sample

Author's personal copy

to compare subjects with sleep debt, short sleepers and subjects with both short sleep and sleep debt. A general linear model was used to study the relationship between these sleep characteristics and other factors analyzed. Comparisons between groups of sleep disturbances were made using student *t*-test or Mann–Whitney non-parametric test for continuous data and χ^2 test or Fisher exact test for categorical data.

3. Results

From December 13 to December 22, 2008, a total of 1004 adults between the age of 25 and 45 were interviewed. These subjects were conformed to socio-demographic characteristics of the French population of these age groups: 49% were males, 87% were working, 23% belonged to the 25–29 years age group, 24% to the 30–34, 24% to the 35–39, and 29% to the 40–45 years old. Sixteen percent were living alone, 69% in couples, 6% were still living in their parents' homes and 9% in other settings. Thirty-three percent had children under 6 years old at home and 42% had children above 6.

3.1. Prevalence of short sleep, insomnia and sleep debt in the total group (n = 1004)

3.1.1. Short sleep, n = 185

The prevalence of short sleepers defined as subjects reporting sleeping less than 6 h per weekday (sleep + nap + rest) was 18% of the total group. The average TST per day during weekdays was 5 h 35 min (±63 min) in the group of short sleepers compared to 7 h 49 min (±70 min) in nonshort sleepers ($p < 0.001$).

Table 1 describes the explicative variables for short sleep in the total sample of young adults. Short sleepers were mostly males and blue collar workers, and a higher percentage of them were overweight and obese compared to nonshort sleepers. A higher percentage of short sleepers were also working more than 10 h per day. They also reported significantly higher rates of smoking and drinking coffee after 5 p.m. than nonshort sleepers and did not significantly report more snoring.

3.1.2. Insomnia, n = 121

Twelve percent of the total group had criteria for insomnia in which 59% were females. The prevalence of insomnia did not vary statistically with age groups (from 25–29 to 40–45 years old) or with marital status, and professional category.

3.1.3. Sleep debt, n = 200

Table 2 shows the prevalence of sleep debt in the total group with regard to the definitions previously derived and tested. Based on the expertise of the scientific committee, the third definition: "a difference between TST to be in good shape" and TST during week days" was consensually chosen as clinically relevant for sleep debt. According to this definition, the prevalence of sleep debt was 28% for a difference of 60 min, 20% for 90 min and 12% for 120 min. Based on the expertise of epidemiologists and clinicians, the 90 min was retained. Sleep debt concerned males and females equally (50% of each). It did not vary significantly with group age classes or with marital or professional categories. Subjects with sleep debt, however, lived preferentially in the Paris area (29%) than in other kinds of urban or rural environments. They also significantly considered themselves as "evening" types rather than "morning" types (52% vs. 39%, $p < 0.001$).

Table 1
Explicative variables of short sleep (TST < 6 Hours per weekday) in the group of 1004 young adults.

Explicative variables	%	OR	95% CI
Sex	***		
Males (Ref.) (*n* = 496)	22.9	-1-	
Females (*n* = 508)	11.2	0.5**	[0.3–0.7]
Age (categories)			
25–29 years old (Ref.) (*n* = 209)	18.4	-1-	
30–34 years (*n* = 245)	17.2	0.8	[0.5–1.5]
35–39 years (*n* = 253)	15.3	0.8	[0.4–1.4]
40–45 years (*n* = 297)	17.0	0.7	[0.4–1.3]
Blue collar	*		
No (Ref.) (*n* = 765)	15.4	-1-	
Yes (*n* = 239)	22.0	1	[0.6–1.6]
Average working time per day	**		
<8 h (Ref.) (*n* = 186)	17.6	-1-	
8 h 01–9 h (*n* = 213)	12.9	0.8	[0.4–1.4]
9 h 01–10 h (*n* = 190)	14.2	0.8	[0.4–1.4]
More than 10 h (*n* = 205)	25.3	1.5	[0.9–2.6]
Drinking coffee after 5 p.m	***		
No (Ref.) (*n* = 739)	13.6	-1-	
Yes (*n* = 265)	26.4	1.7*	[1.1–2.7]
Smoking after 5 p.m	***		
No (Ref.) (*n* = 720)	14.0	-1-	
Yes (*n* = 284)	24.4	2.0**	[1.3–3.1]
BMI	*		
Underweight <18.5 (*n* = 52)	18.0	1.8	[0.7–4.7]
Normal weight 18.5–24.9 (Ref.) (*n* = 622)	13.9	-1-	
25–29.9 overweight (*n* = 249)	22.1	1.7*	[1.1–2.7]
>30 obesity (*n* = 62)	25.0	2	[0.9–4.3]
Snoring loudly	*		
No (Ref.) (*n* = 871)	15.7	-1-	
Yes (*n* = 133)	24.8	1.2	[0.7–2.0]

% = percentage; OR = odds ratio; CI = confidence interval; Ref = reference; *n* = number; BMI = body mass index, TST = total sleep time.
* $p < 0.05$.
** $p < 0.001$.
*** $p < 0.001$.

Table 2
Prevalence of sleep debt in the total group of subjects (*n* = 1004) according to the definitions selected by the the scientific committee.

- A difference between TST during vacations and TST during week days
  Difference > 60 min: 41% Difference > 90 min: 41% Difference > 120 min: 21%
- A difference between TST during week-ends and TST during week days
  Difference > 60 min: 35% Difference > 90 min: 35% Difference > 120 min: 18%
- A difference between TST "I need to be in good shape" and TST during week days
  Difference > 60 min: 28% Difference > 90 min: 20% Difference > 120 min: 12%
- A difference between TST during week-ends and TST during the week (by averaging week days and week-ends)
  Difference > 60 min: 20% Difference > 90 min: 12% Difference > 120 min: 7%
- A difference between TST during vacations and TST during the week (by averaging week days and week-ends)
  Difference > 60 min: 42% Difference > 90 min: 25% Difference > 120 min: 13%

TST = total sleep time, min = minutes, % = percent.
Difference > 90 min: 20% was the definition retained by experts for "slep debt".

3.2. Insomnia and sleep debt among short sleepers compared to nonshort sleepers

Among the group of short sleepers, 30 were insomniacs (16%) and 83 had the criteria for sleep debt (45%). Seventy-two subjects did not complain of any insomnia or sleep debt (39%). Table 3 details the reciprocal prevalence of short sleep, insomnia and sleep debt in the total group. Insomniacs included a significantly higher

Author's personal copy

Table 3
Short sleep insomnia sleep debt: reciprocity prevalences.

Sleep characteristics of short sleepers	*n*	%		
TST < 6 h + insomnia	30	16		
TST < 6 h + sleep debt	83	45		
TST > 6 h without insomnia or sleep debt	72	39		
TST < 6 h + insomnia	185	100		
(*a*) *Prevalences of short sleep in insomniacs compared to non-insomniacs*				
$p < 0.001$	Insomnia		No insomnia	
TST < 6H	*n*	%	*n*	%
Yes	30	24.59	155	17.18
No	91	75.41	728	82.82
Total	121	100	883	100
(*b*) *Prevalence of sleep debt in subjects with short sleep compared to nonshort sleepers*				
$p = 0.0541$	Short sleep		Nonshort sleep	
Sleep debt	*n*	%	*n*	%
Yes	83	45	84	10
No	102	55	735	90
Total	185	100	819	100
(*c*) *Prevalences of sleep debt in subjects with insomnia compared to noninsomnia*				
$p < 0.0001$	Insomnia		No insomnia	
Sleep debt	*n*	%	*n*	%
Yes	0	0	167	18.91
No	121	100	716	81.09
Total	121	100	883	100

TST = total sleep time, h = hours, min = minutes, % = percent. Difference > 90 min between weekdays and sleep needed was the definition retained by experts for "slep debt".

prevalence of short sleepers (24.6%) than non-insomniacs (17.2%; $p < 0.001$; Table 3a). Among subjects who had sleep debt, there was also a higher but nonsignificant rate of short sleepers (45%) than in the nonsleep debt group (10%; $p = 0.0541$). Finally, due to the definition adopted, there was no subject with sleep debt in the insomniacs group, compared to 18.9% found in the non-insomniacs ($p < 0.0001$; Table 3c).

Table 4 shows there is almost no significant sociodemographic or professional difference between the three groups of short sleepers (insomnia, sleep debt or neither) except for gender. Males represented 80.7% of the noninsomnia and nonsleep debt group versus 60.6% of the sleep debt group and 37.8% of the insomniac group ($p < 0.001$).

3.3. Impact of short sleep on BMI and subjective daytime functioning

Table 5 describes the effect of short sleep (compared to sleep debt) on subjective daytime functioning. There were significantly more subjects overweight (24 < BMI < 30) or obese (BMI > 30) in short sleepers than in nonshort sleepers ($p = 0.0009$). BMI was not significantly higher in subjects with sleep debt (0.3867).

But short sleep, independently of being sleep deprived, had no significant impact on daytime consequences except regarding the following items:

- Short sleepers felt significantly "less rested" than nonshort sleepers (33.7% vs 23.1%; $p = 0.0033$).
- They reported significantly more "sleepiness while driving in the last 12 months" (11.5% vs 2.9%; $p < 0.0001$) but no more accidents due to sleepiness while driving.
- They have a greater ESS score: 7.8 vs 6.7 ($p = 0.0058$).
- Subjects with sleep debt, independently of being a short sleeper or not, reported significantly more daytime consequences than "nonsleep debt" in several domains:

Table 4
Sociodemographic characheristics and habits of short sleepers ($n = 161$) with insomnia, with sleep debt or without insomnia and sleep debt.

Sociodemographics and sleep habits	Insomniacs *n* = 28	Sleep debt *n* = 66	Non-insomniac, nonsleep debt *n* = 67
Sex	***		
Males	37.8	60.6	80.7
Females	62.2	39;4	19.3
BMI	ns		
Underweight < 18.5	10.1	7.7	1.6
Normal weight 18.5–24.9	62.5	50.7	47.0
25–29.9 overweight	20.7	34.3	37.2
>30 obesity	6.7	7.4	14.3
Age (categories)	ns		
25–29 years old	22.0	28.2	26.0
30–34 years	23.4	24.5	23.2
35–39 years	24.1	21.7	21.8
40–45 years	30.6	25.6	28.9
Professional categories	ns		
Farmen	0.0	0.0	0.0
Upper level executive	10.5	13.2	20.4
Mid level	30.6	31.2	21.0
White collar	23.3	18.9	18.2
Blue collar	17.6	26.7	37.7
Retired/nonworking	18.0	10.0	2.7
Working time per day (%)	ns		
Less than 8 h	22.2	20.0	28.7
8 h </ *x* < 9 h	16.4	25.1	15.0
9 h </ *x* < 10 h	22.1	10.8	26.4
>10 h	39.3	44.2	29.9
Transportation time per day (%)	ns		
Mean (minutes per day)	49.1	49.3	49.7
0–15 min	37.4	23.7	26.9
16–30 min	20.4	20.7	28.4
31–60 min	21.1	34.1	20.4
>1 h	21.2	21.5	24.3
Income per month	ns		
<1500 euros	16.8	12.9	13.0
1500–2499 euros	38.0	28.0	25.4
2500–3499 euros	15.4	33.5	25.1
>3500 euros	9.4	18.5	17.8
No answer	20.4	7.2	18.7
Agglomeration size	ns		
Rural	17.3	20.5	30.9
Less than 20.000 inhabitants	9.8	20.1	20.7
20.000 à 99.999 inhabitants	27.1	13.1	12.6
>100.000 inhabitants	28.8	15.9	17.7
Paris area (10 millions inh)	17.0	30.3	18.1
Family life	ns		
Living alone	31.0	26.3	29.1
Kids at home	20.4	34.4	29.5
Other habits	ns		
Drinking coffee after 5 p.m	34.2	43.0	42.6
Drinking alcohol after 5 p.m	24.0	29.8	28.7
Smoking after 5 p.m	56.2	35.7	41.2
Snoring loudly and sleepiness	ns		
Yes	6.6	22.2	20.7
Epworth sleepiness scale score	7.6	7.9	7.1

* $p < 0.05$.
** $p < 0.001$.
*** $p < 0.001$.

- They felt significantly "less rested" than subjects with no sleep debt (34.6% vs 17%; $p < 0.0001$).
- They used more treatments to combat fatigue (11% vs 4.3%; $p = 0.0015$).
- They reported more negative effects on daily activities (39.4% vs 24.9%; $p = 0.0009$).
- They assessed more "sleepiness while driving in the last 12 months" (8.3% vs 2.8%; $p = 0.0009$) and reported more accidents due to sleepiness while driving (6% vs 2.3%; $p = 0.0122$).
- They had a greater ESS score: 7.7 vs 6.6 ($p = 0.0094$).

Author's personal copy

Table 5
Respective effects of short sleep compared with sleep debt on daytime functioning.

Feeling nonrestored				
TST < 6 h	Yes	63	33.74	0.0033
	No	183	23.06	
Sleep debt	Yes	60	34.56	<0.0001
	No	118	17.02	
TST < 6 h		38	38.21	0.0672
TST < 6 h + sleep debt		25	28.3	
Sleep debt		35	40.74	
Taking drugs against fatigue				
TST < 6 h	Yes	17	9.527	0.0707
	No	47	5.736	
Sleep debt	Yes	18	10.98	0.0015
	No	30	4.35	
TST < 6 h		6	5.66	0.1297
TST < 6 h + sleep debt		11	14.13	
Sleep debt		7	7.87	
Negative impact on daily activities				
TST < 6 h	Yes	59	39.21	0.5374
	No	224	36.43	
Sleep debt	Yes	59	39.45	0.0009
	No	125	24.89	
TST < 6 h		25	32.27	0.1027
TST < 6 h + sleep debt		24	31.68	
Sleep debt		35	47.09	
Negative impact on work				
TST < 6 h	Yes	47	32.17	0.452
	No	216	35.58	
Sleep debt	Yes	43	29.13	0.6326
	No	129	27.04	
TST < 6 h		21	27.95	0.2514
TST < 6 h + sleep debt		17	22.65	
Sleep debt		26	35.49	
Negative impact on relationship with others				
TST < 6 h	Yes	62	40.58	0.2755
	No	221	35.69	
Sleep debt	Yes	43	28.83	0.9838
	No	143	28.92	
TST < 6 h		25	35.72	0.5318
TST < 6 h + sleep debt		19	27.08	
Sleep debt		24	30.55	
Negative impact on leisure				
TST < 6 h	Yes	44	29.83	0.5507
	No	166	27.3	
Sleep debt	Yes	33	22.34	0.5531
	No	101	20.02	
TST < 6 h		17	22.54	0.7897
TST < 6 h + sleep debt		15	19.86	
Sleep debt		18	24.78	
Negative impact on memory and concentration				
TST < 6 h	Yes	82	54.07	0.6032
	No	304	51.64	
Sleep debt	Yes	67	46.59	0.2765
	No	196	41.3	
TST < 6 h		36	47.52	0.9355
TST < 6 h + sleep debt		33	45.11	
Sleep debt		34	48.03	
Negative impact on irritability				
TST < 6 h	Yes	79	50.68	0.3373
	No	336	55.15	
Sleep debt	Yes	75	48.48	0.3513
	No	217	44.25	
TST < 6 h		39	49.31	0.1548
TST < 6 h + sleep debt		31	40.4	
Sleep debt		44	57	
Negative impact on mood (sadness, sorrowness)				
TST < 6 h	Yes	70	45.4	0.108
	No	324	52.91	
Sleep debt	Yes	61	41.05	0.9613
	No	201	40.82	
TST < 6 h		36	44.09	0.4553
TST < 6 h + sleep debt		26	36.03	
Sleep debt		35	45.98	

(*continued on next page*)

Author's personal copy

Table 5 (*continued*)

Feeling nonrestored								
Sleepiness at the wheel in the last 12 months								
TST < 6 h	Yes	21	11.47	<0.0001				
	No	25	2.936					
Sleep debt	Yes	14	8.3	0.0009				
	No	21	2.82					
TST < 6 h		10	9.86	0.6478				
TST < 6 h + sleep debt		11	13.37					
Sleep debt		3	3.35					
Accidents due to sleepiness at the wheel								
TST < 6 h	Yes	8	4.39	0.5583				
	No	24	2.8					
Sleep debt	Yes	10	5.99	0.0122				
	No	17	2.31					
TST < 6 h		4	4.09	0.7382				
TST < 6 h + sleep debt		4	4.84					
Sleep debt		6	7.13					
Sleep satisfaction								
TST < 6 h	Yes	137	81.65	0.254				
	No	623	85.31					
Sleep debt	Yes	112	79.36	<0.0001				
	No	604	92.25					
TST < 6 h		79	83.79	0.7064				
TST < 6 h + sleep debt		58	79.08					
Sleep debt		54	79.65					
BMI								
		<24		24 < x < 30		>30		p
TST < 6 h	Yes	10	5.45	95	51.82	77	42.73	0.0009
	No	42	5.12	527	66.32	234	28.56	
Sleep debt	Yes	11	6.51	96	58.86	58	34.63	0.3867
	No	36	5.09	446	64.55	217	30.36	
Epworth sleepiness scale score		*Average*	*p*					
TST < 6 h	Yes	7.81	0.0058					
	No	6.76						
Sleep debt	Yes	7.66	0.0094					
	No	6.63						

TST = total sleep time, h = hours, min = minutes, 0.0001 = significant difference.

4. Discussion

A major finding of our study is to confirm the high prevalence of "short sleep" (18%) in a representative sample of young adults (25–45 years old). Although the average TST per day was 5 h 35 min in this group, which is 25 min under the cut of 6 h, including night sleep, nap and rest, usually adopted to define short sleep [3–7], this percentage is higher than those (7.5–11.8%) mentioned by Knutson et al. in their review of the trends in the prevalence of short sleepers in the USA from 1975 to 2006 [5]. This last study, however, was carried out in older subjects (45±17 years old) compared to our younger group. Even if many studies have been devoted to short sleep and health in recent years, surveys directly focussed on the prevalence of short sleep are relatively rare and do not use extensive questionnaires to obtain average sleep duration [5]. This is, to our knowledge, the first study specifically designed to assess the prevalence of short sleep in the general population using sophistic questionnaires specifically designed to differentiate sleep time from time spent in bed. Recently, in their systematic review and meta-analysis of prospective studies on sleep duration and all causes of mortality, Capuccio et al. discussed that a major limitation of studies using short sleep as a risk factor is the lack of common methodology to assess sleep duration [23]. Of the 16 studies they reviewed, including 13,82,999 subjects and 1,12,566 deaths, sleep duration was assessed based on self reported questionnaires, which did not allow differentiation of time asleep from time spent in bed or estimation of numbers and duration of naps. Krueger and Friedman, who published a review on sleep duration in the USA based on pooled waves of the National Health Interview survey (NHIS-SAS) 2004–2007, assessed sleep duration based on a single question: "On average, how many hours of sleep do you get in a 24-h period?" [24] "How many hours do you sleep in 24 h" was also the single item used to define sleep time in the sleep duration report of the Finnish population (n = 7262 individuals) [25]. Conversely our study differentiated time spent in bed and time spent sleeping, taking naps and resting using questionnaires designed like sleep logs, which are frequently used in clinical settings to assess sleep disorders. Finally, Capuccio et al. also discussed the likelihood that most of the studies reviewed did not include in their analysis subjects with obstructive sleep apnea and insomnia [23]. Interestingly our study questioned subjects on insomnia, sleepiness and snoring, using previously validated tools based on international definitions of sleep disorders [10,11,18–20].

Another important issue we found was that short sleepers did not set up a homogeneous group at all. Among the group of short sleepers, 16% were insomniacs and 45% fit our definition of "sleep debt." But 39% did not complain of any insomnia or sleep debt. These three groups did not differ much regarding socio-demographic characteristics and habits (Table 4) except for gender. The non-insomniacs-nonsleep debt group was mostly male (80.7%) versus 37.8% of insomniacs and 30.6% of those with sleep debt ($p < 0.001$). But BMI, socioprofessional categories, transporting time, age categories, income, family structure, use of coffee, alcohol or smoking after 5 p.m. and snoring were not significantly different between the groups. The common use of "short sleep" to define a state which may lead to increased metabolic diseases seems inappropriate. As mentioned by Capuccio et al., there are few studies on short sleep morbidity and mortality that aim to assess common sleep disorders such as insomnia or sleep apnea [3].

Author's personal copy

In the analysis recording the prevalence of short sleep in the USA, there is interestingly no further analysis made on possible sleep disease as an explanation for short sleep [5]. Even in recent literature on the prevalence of short sleep duration classified by industry and occupation a possible sleep disorder partially explaining the effects of work on short sleep was not included in the logistic regression analysis [7]. Recently three papers have clearly shown the impact of being short sleepers (<5 h) while suffering from insomnia [14,15,26]. In a sample of 1741 subjects addressed in their sleep center, it was found that, compared with the normal sleeping and the > or =6 h sleep duration group, the highest risk of diabetes was in individuals with insomnia and the < or =5 h sleep duration group (odds ratio [95%CI] 2.95 [1.2–7.0]) and in insomniacs who slept 5–6 h (2.07 [0.68–6.4]) [14]. In the same group of subjects, the authors also demonstrated that compared to the normal sleeping and >6 h sleep duration group, the highest risk of hypertension was in the insomnia with <5 h sleep duration group (OR [95%CI] 5.1 [2.2, 11.8]). The second highest was in the insomnia group who slept 5–6 h (OR 3.5 [1.6–7.9] $p < 0.01$) [26]. In a third paper, in the same group, they found that short sleep in insomniacs had poor negative impact on neuropsychological performance, except for "set-switching attentional abilities," a key component of executive control of attention [15]. Nevertheless, to our knowledge, no study exists assessing precisely the prevalence of insomnia in short sleepers compared to nonshort sleepers. We found significantly more short sleepers in the insomniac group than in the non-insomniac group (24.6% vs 17.2%; $p < 0.0001$). We believe it would be interesting to better define in future studies how insomnia by itself may explain the relative risk attributed to short sleep. In our sample we found also no difference regarding the marital and professional status of insomniacs which may contribute to this impact. But it might also be partially explained by the younger age of your sample. Finally, we did not assess apnea in our survey but enquired about snoring loudly. Table 1 shows that snoring loudly does not explain short sleep (OR = 1.2; [0.7–2.0]). We recognize that we have no more information on possible sleep apnea in our sample. But we believe that future studies would have to clarify how sleep apnea may influence the reported "short sleep" in the general population. We also acknowledge that we did not assess the impact of being a morning or evening type person on short sleep. We did not use chronotype questionnaires but rather a single question. It would probably be interesting to take more careful account of chronobiological aspects in future studies.

Surprisingly, we found that short sleepers complained of relatively few daytime consequences of short sleep compared to nonshort sleepers. But they had a greater ESS score and recognized more sleepiness while driving. They also felt significantly less rested in the morning. We were surprised that almost all other items questioning possible daytime impact were not modified for short sleepers. One explanation may be linked to the high percentage of short sleepers who did not complain of insomnia or sleep debt (39%). If they did not complain of any sleep trouble, it is understandable that they did not have difficulties during the day. Subjects with sleep debt did complain of insufficient sleep and they also logically reported more significant daytime impairments: not feeling rested, needing drugs to combat fatigue, negative impact on daily activities, sleepiness while driving and accidents due to sleepiness while driving. They also had a greater ESS score and less sleep satisfaction. This is, in our opinion, a crucial issue for future creation of short sleep prevention programs. If short sleep is a risk factor for obesity, diabetes and hypertension [1–6,14–16], it seems important to inform adults of the need for longer sleep [3,23,27]. But based on the results of our group, despite higher BMI in the short sleeper group, a large amount of short sleepers did not complain of any problems and would probably not be sensitive to any suggestion of sleeping more. But it has to be studied more extensively. It could be interesting, for example, to study how short sleep is linked to the subjective representation of sleep's benefits. Most of the noncomplainers were young males. It has been shown that males complained of a moderate (but significant) impact of short sleep [5,23]. Females complained more of insomnia and therefore of the daytime consequences of their sleep troubles [8,9,12,13]. Depression has been found to be an independent explicative factor of this gender effect [12]. In this study, we were not able, due to the length of telephone interview, to assess anxiety and depression. We recognize that this is a study limitation. Finally it is not possible to conclude, based only on subjective tools, that short sleepers with no complaint of sleep debt are objectively sleep deprived or not. Klerman and Dijk have shown in a group of 18 young adults, registered by polysomnography, that those individuals with shorter habitual sleep durations carry a higher sleep debt than those with longer habitual sleep duration. Inter-individual variation in sleep duration may primarily reflect variation in self-selected sleep restriction or wake extension [28].

The definition we finally retained to take account of sleep debt in the general population of young adults (Table 2) is also a crucial point of discussion in our results. Acute sleep debt or sleep deficit is easy to define at the laboratory level. When one individual is used to sleeping 7 h a day, an acute sleep deprivation may impact cognitive functioning, emotional balance and biology [1,29,30]. But there is, to our knowledge, no consensus on the definition of chronic sleep debt at an epidemiological level. There is even more of a controversy on the existence of a chronic sleep debt in the general population [31,32]. "Sleep difference of at least 180 min, between usual sleep time and sleep before long distance driving," was the definition retained by Philip et al. to evaluate the risk of accidents with sleepy driving in a sample of 2196 drivers [33]. Based on objective and subjective measurements of sleepiness, Anderson et al. recently showed that a sleep debt lower than 47 min was not sufficient to disturb alertness [32]. Regestein et al. recently retained a two hour sleep debt from usual sleep time to test the link between sleep deficit and depression [33]. Facing this lack of consensus we tested five definitions, based on the sleep schedules collected from subjects regarding their sleep during weekdays, weekends, vacations, and the sleep they need to be in good shape. The definition we finally settled on, which was decided by the scientific committee based on their clinical expertise and on the primary results on the prevalence of using each definition, was that a 90-min difference between TST during workdays and TST needed to be in good shape would more accurately reflect chronic sleep debt than other definitions. We acknowledge that this definition does not reflect a large consensus advice. But we showed that subjects who responded to that definition, who may or not be short sleepers, found a significant impact on daytime functioning, including the risk of accidents and a greater ESS score.

Our study showed finally that young subjects with short sleep are not a homogeneous group which could be easily convinced by a public health campaign encouraging them to get more sleep. Some suffer from insomnia and need appropriate treatments, some complain of sleep deficit and others have no complaints with their short sleep and do not ask for specific help. Facing increased awareness on the potential effects of short sleep on morbidity and mortality, more data are needed to understand to what extent short sleep (under 6 h per day) impacts health in the general population of our countries.

5. Source of funding

The study was funded by INPES (Institut National de Prévention et d'Education pour la Santé) (French National Institute of Prevention and Health Education).

Author's personal copy

Conflict of Interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: doi:10.1016/j.sleep.2010.12.012.

References

[1] Spiegel K, Tasali E, Penev P, Van Cauter E. Brief Communication: sleep curtailment inhealthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. Ann Intern Med 2004;141:845–50.

[2] Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, et al. Sleep duration as a risk factor for diabetes incidence in a large US sample. Sleep 2007;30:1667–73.

[3] Capuccio FP, D'Elia L, Strazullo P, Miller LA. Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and meta-analysis. Diab care 2010;33:414–20.

[4] Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Opler MG, et al. Sleep duration associated with mortality in elderly, but not middle-aged, adults in a large US sample. Sleep 2008;31:1087–96.

[5] Knutson KL, Van Cauter E, Rathouz PJ, DeLeire T, Lauderdale DS. Trends in the prevalence of short sleepers in the USA: 1975–2006. Sleep 2010;33:37–45.

[6] Singh M, Drake CL, Roehrs T, Hudgel DW, Roth T. The association between obesity and short sleep duration: a population-based study. J clin sleep Med 2005;1:357–63.

[7] Luckhaupt SE, Tak S, Calvert GM. The prevalence of short sleep duration by industry and occupation in the national health interview survey. Sleep 2010;33:149–59.

[8] Leger D, Guilleminault C, Levy E, Paillard M. Medical and socio-professional impact of insomnia. Sleep 2002;25:625–9.

[9] Leger D, Poursain B. Under-recognition and under-treatment of insomnia : a polysymptomatic condition. Curr Med Res Opin 2005;21:1785–92.

[10] American Academy of Sleep medicine. International classification of sleep disorders, 2nd ed. Diagnostic and coding manual. Westchester, Illinois, USA: American.

[11] Academy of Sleep medicine, 2005: 297p. American Psychiatric Association. Diagnostic and statistical manual of mental disorders, 4th Edition, Text Revision (DSM-IV-TR®). Arlington, VA: American Psychiatric Publishing; 2000.

[12] Buysse DJ, Angst J, Gamma A, Ajdacic V, Eich D, Rössler W. Prevalence, course, and comorbidity of insomnia and depression in young adults. Sleep 2008;31:473–80.

[13] Ohayon MM. Pain sensitivity, depression, and sleep deprivation: links with serotoninergic dysfunction. J Psychiatry Res 2009;16:1243–5.

[14] Vgontsas AN, Liao D, Pejovic S, Calhoun S, Karataraki N, Bixler EO. Insomnia with objective short duration is associated with type 2 diabetes: a population based study. Diab Care 2009;32:1980–5.

[15] Fernandez Mendosa J, Calhoun S, Bixler EO, Pejovic S, Karataki M, Liao D, et al. Insomnia with objective short sleep duration is associated with deficits in neuropsychological performance. a general population study. Sleep 2010;33:459–65.

[16] International Society for pharmacoepidemiology. Guidelines for Good Pharmacoepidemiology Practices (GPP), 2nd ed., 2007.

[17] Ohayon M, Caulet M, Priest R, Guilleminault C. DSM-IV and ICSD insomnia symptoms and sleep dissatisfaction. Brit J Psychiatry 1997;171:382–8.

[18] Leger D, Guilleminault C, Dreyfus JP, Delahaye C, Paillard M. Prevalence of insomnia in a survey of 12,778 adults in France. J Sleep Res 2000;9:35–42.

[19] Leger D, Guilleminault C, Defrance R, Domont A, Paillard M. Blindness and sleep patterns. Lancet 1996;348:830–1.

[20] Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep 1991;14:540–5.

[21] Johns MW. Reliability and factor analysis of the Epworth Sleepiness Scale. Sleep 1992;15:376–81.

[22] Chervin RD, Aldrich MS, Pickett R, Guilleminault C. Comparison of the results of the Epworth Sleepiness Scale and the Multiple Sleep Latency Test. J Psychosom Res 1997;42:145–55.

[23] Capuccio FP, D'Elia L, Strazzulo P, Miller M. Sleep duration and all-cause of mortality: a systematic review and meta-analysis of prospective studies. Sleep 2010;33:585–92.

[24] Krueger PM, Friedman EM. Sleep duration in the United States: a cross sectional population based survey. Am J Epidemiol 2009;169:1052–63.

[25] Kronholm E, Härmä M, Hublin C, Aro A, Partonen T. Self-reported sleep duration in Finnish general population. J Sleep Res 2006;15:276–90.

[26] Vgontzas AN, Liao D, Bixler EO, Chrousos GP, Vela-Bueno A. Insomnia with objective short sleep duration is associated with a high risk for hypertension. Sleep 2009;32:491–7.

[27] Grandner MA, Patel NP, Gehrman PR, Perlis ML, Pack AL. Problems associated with short sleep: bridging the gap between laboratory and epidemiological studies. Sleep Med Rev 2010;14:239–47.

[28] Klerman EB, Dijk DJ. Interindividual variation in sleep duration and its association with sleep debt in young adults. Sleep 2005;28:1253–9.

[29] van der Helm E, Gujar N, Walker MP. Sleep deprivation impairs the accurate recognition of human emotions. Sleep 2010;33:335–42.

[30] Donga E, van Dijk M, van Dijk JG, Biermasz NR, Lammers GJ, van Kralingen KW, et al. A single night of partial sleep deprivation induces insulin resistance in multiple metabolic pathways in healthy subjects. J Clin Endocrinol Metab 2010;95:2963–8.

[31] Anderson C, Horne JA. Do we really want more sleep? A population-based study evaluating the strength of desire for more sleep. Sleep Med 2008;9:184–7.

[32] Anderson C, Platten CR, Horne JA. Self-reported 'sleep deficit' is unrelated to daytime sleepiness. Physiol Behav 2009;96:513–7.

[33] Philip P, Taillard J, Guilleminault C, Quera Salva MA, Bioulac B, Ohayon M. Long distance driving and self-induced sleep deprivation among automobile drivers. Sleep 1999;22:475–80.