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CLINICAL REVIEW

Has adult sleep duration declined over the last 50+ years?

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SUMMARY

The common assumption that population sleep duration has declined in the past few decades has not been supported by recent reviews, which have been limited to self-reported data. The aim of this review was to assess whether there has been a reduction in objectively recorded sleep duration over the last 50+ years.

The literature was searched for studies published from 1960 to 2013, which assessed objective sleep duration (total sleep time (TST)) in healthy normal-sleeping adults. The search found 168 studies that met inclusion criteria, with 257 data points representing 6052 individuals ages 18–88 y. Data were assessed by comparing the regression lines of age vs. TST in studies conducted between 1960 and 1989 vs. 1990–2013. Weighted regression analyses assessed the association of year of study with age-adjusted TST across all data points. Regression analyses also assessed the association of year of study with TST separately for 10-y age categories (e.g., ages 18–27 y), and separately for polysomnographic and actigraphic data, and for studies involving a fixed sleep schedule and participants' customary sleep schedules.

Analyses revealed no significant association of sleep duration with study year. The results are consistent with recent reviews of subjective data, which have challenged the notion of a modern epidemic of insufficient sleep.

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Introduction

It has been widely stated that modern industrialized societies have become sleep-deprived. Some studies have suggested that average sleep duration has declined over the last few decades [1–4]. Such findings, combined with extensive epidemiologic evidence associating short sleep with health risks [5–7] and experimental evidence of adverse effects of sleep deprivation [8–10], have provoked widespread concern that chronic insufficient sleep has become a public health crisis.

However, recent reviews of self-reported data have cast doubt on whether nighttime sleep or 24-h sleep has decreased in recent decades, and whether there has been an increased prevalence of short sleep (<6 h), for which risks have been most clearly established. For example, a review of eight studies by Knutson et al. found no significant 31-y trend (1975–2006) towards a higher prevalence of self-reported nighttime sleep of ≤6 h [11]. Bin et al. reviewed 12 studies from 15 countries assessed from the 1960s–2000s, and found that sleep duration had increased in seven countries, decreased in six countries, and had not clearly changed

Abbreviations: PSG, polysomnography; TIB, time in bed; TST, total sleep time.

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in two countries [12]. In a subsequent meta-analysis of 38 studies conducted in 10 countries in the 1970s–2000s, Bin et al. [13] found that average 24-h sleep duration had increased in most countries (including the US), and that the prevalence of sleeping ≤ 6 h had decreased in most countries (including the US). Rowshan Ravan et al. studied 36-y trends (1968–2004) in sleep duration among Swedish women, and found no change in 50-y old women, and a decline of only 15 min in 38-y old women [14]. Moreover, Bonke reviewed five representative time-use studies spanning 1964–2009, and concluded that "the same number of hours is slept today as in the mid-1960s, with nearly the same prevalence of short and long sleepers" [15].

Discrepancies between studies of population temporal trends in sleep duration can be attributed to multiple factors, including characteristics and representativeness of the respondents, wording of the questions, and instructions given to respondents [16,17]. Perhaps the biggest limitation of this literature is that it has been limited to self-reports of sleep duration (some of which were retrospective), which can be inaccurate [18,19] due in part to response biases. The aim of this review was to examine whether there has been a decline over the past five decades in sleep duration, as indexed by objective data.

Methods

The search of the literature was modeled after a previous meta-analysis by Ohayon et al., which assessed objective sleep patterns across age [20]. PubMed, PsychLit, selected journals, and reference lists of located manuscripts were searched for studies published between 1960 and 2013 which met the following criteria: 1) inclusion of presumably healthy adults (as described by the authors), participant ages ≥18 y without sleep problems; 2) report of all-night average total sleep time (TST) measured by polysomnography (PSG) or actigraphy; 3) assessment of sleep under minimally-disturbed conditions, including baseline or placebo conditions, and not involving particularly invasive procedures (e.g., catheterization). Many of the studies included a control group of normal sleepers who had been compared with participants with sleep disorders. Studies involving individuals with extremely high levels of physical fitness were excluded under the assumption that sleep of such individuals might not be representative of the population. Key search words were sleep with normal, normative, healthy, controls, and adults.

The literature searches were performed by two of the authors: EEG or NK. Questions regarding whether a study met inclusion criteria were resolved in discussions between EEG and SDY or AMR and SDY. Data from the studies were extracted by EEG and AMR.

The search identified >3500 studies, of which 168 met the inclusion criteria, generating 257 data points across 6052 individuals. Studies were separated into PSG (Table 1) and actigraphic studies (Table 2). Citations for all included studies are listed in the reference list [54–221]. Coding for each study included the mean sample age (or mid-point of the age range if the mean age was not available), number of men and women subjects, mean sample total sleep time (min), and estimated year of study. Studies with multiple age groups generated multiple data points for the analyses. When available, separate data points for men and women were used. Since most of the studies recorded sleep in the laboratory, only the laboratory data were used for studies that included both home and laboratory data, except for separate analysis of the actigraphy data.

Since the year of publication of a study often differed from the year in which a study was conducted, the following rules were used to estimate the year that a study had been conducted. 1) Year of study was estimated by subtracting 10 mo from the posted date of journal receipt of the manuscript for studies with <50 subjects, 14 mo for studies with 50–99 subjects, 18 mo for studies with 100–149 subjects, and 22 mo for studies with ≥150 subjects. 2) If information was available regarding the date a paper was accepted, but not the date that it was received, the median across-the-literature duration in months between date received and date accepted (4 mo) was subtracted from the date of publication, and Rule 1 was followed. 3) If neither date accepted nor date received information was available, the median number of months between date received and date published (11 mo) was subtracted from the date of publication, and Rule 1 was followed.

The TST data were first assessed by comparing the intercepts of the regression lines of age vs. TST for studies conducted between 1960–1989 vs. 1990–2013. We chose this split to obtain a more balanced number of data points across the years split. Another reason for the1989/1990 split was that it has been posited that the obesity epidemic, which started shortly after this time, can be partly attributed to declines in sleep [21]. Examining the intercepts allowed an assessment of temporal differences in TST across all data points (without adjustment for age). A temporal decline in TST would be revealed by a smaller intercept for the 1990–2013 studies compared with the 1960–1989 studies.

To further assess a temporal trend of TST across all data points, a linear regression analysis of year of study (weighted for sample size) and participants' age vs. TST was calculated. To plot these data, age-adjusted TST was determined based on the slope of the linear regression between TST and age across all data points. An *a priori* decision was made to remove outlying samples, for which mean age-adjusted TST was ≥2 standard deviations from the mean value across the literature. Two data points were removed based on this criterion. Weighted linear regression analyses were also conducted for year of study vs. TST across 10-y age categories (e.g., ages 18–27 y, 28–37 y, etc.).

Separate weighted linear regression analyses were conducted for data from studies in which participants followed their usual sleep schedules and for studies involving a fixed sleep period; for polysomnographic and actigraphic data; and for data involving men only and women only. Plots of year of study vs. age-adjusted TST were performed for each of these analyses.

Results

The intercepts and slopes of the regression lines of age vs. TST did not differ for studies conducted between 1960–1989 and 1990–2013 (Fig. 1). In the regression analysis across all data points ($n = 257$), there was no significant association of year of study with TST ($b = 0.03$, $p = 0.56$) (Fig. 2), nor was there a significant association of study year with TST for any of the 10-y age categories (Fig. 3) ($p = 0.40–0.92$). Likewise, there was no significant association of year of study in analyses restricted to PSG ($n = 225$) ($b = 0.03$, $p = 0.63$) or to actigraphic data ($n = 32$) ($b = -0.17$, $p = 0.38$) (Fig. 4); or in analyses involving only men ($n = 71$) or only women ($n = 17$) (Fig. 5). Finally, there was no significant association in analyses derived from studies in which subjects followed their usual sleep periods ($n = 154$) ($b = 0.13$, $p = 0.10$) or a fixed sleep period ($n = 68$) ($b = -0.14$, $p = 0.24$) (Fig. 6).

Discussion

The results indicate relative stability of objectively-recorded sleep durations in healthy sleepers assessed over the last half-

Table 1
Polysomnography studies reviewed for the present paper. (F=female; M=male; n=number of participants; SD=standard deviation)

Authors	Year published	Estimated year of study	Sample size	Sample age (y)	Gender	Total sleep time ±SD (min)	Time in bed ±SD (min)	Excluded first night	Comments
Fixed sleep schedule									
Ryback, Lewis [56]	1971	1970	n = 8	18–24	not stated	405	480	Yes	Baseline data only
Brezinova [58]	1975	1974	n = 24	42–66 20–30	M-5 F-9 M-6 F-4	484 ± 22 455 ± 31	540	Yes	
Nicholson, Stone [66]	1980	1978	n = 6	24	not stated	443	480	Not stated	Placebo data only
Okuma et al. [71]	1982	1982	n = 8	21.1	M-8	444	480	Not stated	Baseline data only
Bixler et al. [75]	1984	1984	n = 100	19–29 30–49 50–80	M-10 F-11 M-16 F-21 M-14 F-28	440 432 407	480	Yes	
Carskadon, Dement [81]	1985	1985	n = 10	69.3	M-2 F-8	467 ± 54	600	Yes	Baseline data only
Roehrs et al. [84]	1986	1986	n = 12	28	M-12	433	480	Yes	Placebo group only
Libert et al. [88]	1988	1988	n = 6	20–29	M-6	444 ± 20	480	Yes	Baseline data only
Gillberg, Akerstedt [111]	1994	1993	n = 7	19–21	No Data	456 ± 6	480	Yes	8-hour treatment data only
Walsh et al. [112]	1994	1993	n = 12	23.5	M-9 F-3	465	510	Not stated	ND (no sleep disruption condition) night two data only
Carrier, Dumont [113]	1995	1995	n = 23	22.8	M-18 F-5	464	480	Not stated	Baseline data only
Landolt et al. [115]	1995	1995	n = 9	22.4	M-9	453	480	Yes	Placebo, baseline night data only
Mann et al. [117]	1996	1995	n = 11	24.8	M-11	394 ± 19	480	Yes	Baseline data only
Landolt et al. [120]	1996	1994	n = 10	61.6	M-10	413	480	Yes	Baseline data only
Landolt et al. [121]	1996	1995	n = 16	20–26 57–64	M-8 M-8	450 ± 5 409 ± 8	480 480	Yes	
Cajochen et al. [126]	1997	1995	n = 8	23–32	M-8	444 ± 11	480	Yes	Placebo, pretreatment night data only
Martin et al. [128]	1997	1996	n = 12	25	M-7	419 ± 27	450	Yes	Disregarding data from fragmented sleep night
Rao et al. [134]	1998	1998	n = 17 n = 10 n = 30 n = 16	African American 30.9 Asian 28.4 Caucasian 42.2 Hispanic 27.7	M-6 F-11 M-6 F-4 M-16 F-14 M-7 F-9	417 ± 46 404 ± 29 406 ± 52 441	480 480 480 480	Not stated	
Harma et al. [132]	1998	1996	n = 2	28.9	F-2	421 ± 24	480	Yes	Controls only
Yassouridis et al. [133]	1999	1997	n = 30	27.5	M-30	432 ± 16	480	Yes	
Sharkey et al. [146]	2001	2000	n = 21	27	M-12 F-9	459 ± 12	480	Yes	Baseline, placebo data only
Onen et al. [147]	2001	2000	n = 9	31	M-9	426 ± 12	480	Yes	Baseline data only
Gaudreau et al. [150]	2001	1999	n = 54	19–29 36–60	M-10 F-5 M-10 F-5	503 ± 46 439 ± 35	570 480	Yes	>18 y old data plotted only
Huber et al. [152]	2002	2002	n = 16	22.3	M-16	446 ± 3	480	Yes	Sham data only
Mukai et al. [154]	2003	2001	n = 8	24.5	M-8	456 ± 16	480	Yes	Normal sleepers only
Brandenberger et al. [155]	2003	2002	n = 24	21.1 64.9	M-10 F-2 M-10 F-2	449 ± 4 410 ± 85	480	Yes	
Waters et al. [156]	2003	2002	n = 77	26.5	M-77	407	480	Yes	Placebo data only

(*continued on next page*)

Table 1 (*continued*)

Authors	Year published	Estimated year of study	Sample size	Sample age (y)	Gender	Total sleep time ±SD (min)	Time in bed ±SD (min)	Excluded first night	Comments
Fixed sleep schedule									
LaJambe et al. [165]	2005	2004	n = 8	18–35	no data per group	390 ± 24	480	Yes	Placebo data only
Drapeau et al. [166]	2006	2005	n = 12 n = 12	23.8 50.3	M-6 F-6 M-5 F-7	460 ± 12 395 ± 15	480	Yes	Placebo data only
Hornyak et al. [169]	2007	2006	n = 35	19–69	M-16 F-29	425 ± 34	480 ± 30	Yes	Controls only
Wong et al. [175]	2008	2007	n = 9	27.8	M-9 F-1	390	480	Yes	Control data only
Schmid et al. [176]	2008	2007	n = 9	24.2	M-9	418 ± 11	420	Not Stated	Seven hour TIB data only
Cote et al. [178]	2009	2008	n = 12	21	M-4 F-13	450	480	Yes	Baseline data only
Bixler et al. [179]	2009	2007	n = 66	23.5 24.2	M-32 F-34	432 430	480 480	Yes	Baseline data only
Vandekerckhove et al. [186]	2011	2010	n = 13	19–56	M-6 F-7	457 ± 33 445 ± 46	480	Yes	Baseline (first data point) neutral data (second data point)
Brower et al. [187]	2011	2010	n = 10	20–40	no data	389 ± 10	420	Yes	Baseline data only for healthy control
Schmid et al. [198]	2012	2011	n = 23	23.2	M-23	462 ± 1	480	Yes	Sham data only
Schmid et al. [202]	2012	2011	n = 30	23	M-30	457 ± 2	480	Screening night included	Sham data only
Flausino et al. [205]	2012	2011	n = 18	27.2	M-18	339.1 ± 54.9	480	Not stated	Baseline data only. Data deleted as outlier
Holz et al. [208]	2012	2012	n = 20	27.1	M-10 F-10	418.7	480	Yes	Baseline data only
Rosipal et al. [210]	2013	2012	n = 148	20–86	M-67 F-81	384 408	474 474	Yes	Data from two nights; used only 2nd night
Tonetti et al. [220]	2013	2012	n = 11	24.75	M-4 F-7	401.18 ± 48	480	Not stated	PSG data only, WS device data not included
Usual sleep schedule									
Feinberg et al. [54]	1967	1966	n = 30	19–36 65–96	M-9 F-6 M-9 F-6	394 ± 28 384 ± 37	421 ± 2 469 ± 38	Yes	Healthy control data only
Walker et al. [61]	1978	1976	n = 10	18–22	M-10	441 ± 28	479 ± 3	Yes	Nonrunner, baseline data only
Gaillard [62]	1978	1977	n = 40	19–21 22–24 25–27 28–30	n = 12 n = 11 n = 11 n = 6	504 ± 36 505 ± 45 491 ± 49 460 ± 49	529 ± 38 525 ± 38 517 ± 43 507 ± 40	Yes	
Browman [63]	1980	1979	n = 8	19–22	M-8	407 ± 43	419 ± 51	Yes	Baseline data only
Adam [64]	1980	1979	n = 16	59	M-6 F-10	455 ± 25	Normal sleep patterns	Yes	Placebo capsule data
Philipson et al. [65]	1980	1978	n = 46	24	M-37 F-9	439	481.3	Yes	
Coates et al. [67]	1981	1981	n = 12	23–60	M-6 F-6	388 ± 55	Normal sleep patterns	Yes	Night two data only
Montgomery et al. [68]	1982	1982	n = 12	23.3	M-4 F-4	428	455	Yes	Unfit subjects, however still fit healthy criteria
Trinder et al. [69]	1982	1982	n = 6 n = 6	22.3 31.8	not stated not stated	401 420	452 449	Yes	Unfit subjects, however still fit healthy criteria
Paxton et al. [72]	1983	1983	n = 9	20.7	M-9	416 426	446 454	Yes	Normal, unfit data only. Used average of two nights
Bunnell et al. [73]	1983	1983	n = 9	25	M-4 F-5	436 ± 11	Normal sleep patterns	Not stated	Baseline data only

Horne, Staff [74]	1983	1983	n = 8	25.4	M-8	465 ± 21	Normal sleep patterns	Yes	Baseline data only
Matsumoto et al. [76]	1984	1984	n = 6	20–24	M-6	389 ± 12	Normal sleep patterns	Not stated	No exercise group
Paxton et al. [77]	1984	1984	n = 17	20	M-17	449 ± 49	489 ± 25	Yes	Non-athlete. Baseline data only
Reynolds et al. [78]	1985	1985	n = 24	69.5	M-8 F-16	367 ± 45	Normal sleep patterns	Yes	Healthy control data only
Bonnet [79]	1985	1985	n = 11	18–32	not stated	389	Normal sleep patterns	Yes	Baseline data only
Kupfer et al. [80]	1985	1985	n = 10	24.8	M-10	397 ± 48	Normal sleep patterns	Yes	No exercise group
Nakagawa [85]	1987	1987	n = 6	19–23	M-6	502 ± 28	523 ± 31	Yes	Baseline data only
Naifeh et al. [87]	1987	1987	n = 23	30–40	M-6 F-6	386 ± 40	404 ± 46	Not stated	
				60+	M-5 F-6	364 ± 47	422 ± 58		
Hudson et al. [89]	1988	1988	n = 18	20–55	M-8 F-10	385 ± 31	421 ± 27	Yes	Controls only
Schiavi, Schreiner-Engel [90]	1988	1988	n = 40	23–29	M-11	404 ± 36	441 ± 36	Yes	
				30–39	M-5	411 ± 34	448 ± 41		
				40–49	M-8	387 ± 42	434 ± 26		
				50–59	M-7	332 ± 51	398 ± 39		
				60–73	M-9	317 ± 53	397 ± 39		
Hoch et al. [91]	1988	1988	n = 19	60–82	M-9 F-10	350 ± 65	467	Yes	
						371 ± 30	456		
Mellman, Uhde [92]	1989	1989	n = 7	26–49	M-5 F-2	440 ± 45	Normal sleep patterns	Yes	Controls only
Bonnet [93]	1989	1989	n = 24	22	M-12	372	411	Yes	
				63	M-12	363	430		
Lydiard et al. [94]	1989	1989	n = 14	30.1	No Data	385 ± 31	Normal sleep patterns	Yes	Controls only
Saletu et al. [95]	1990	1990	n = 16	23–39	M-8 F-8	386 ± 79	426.6 ± 19	Yes	Baseline data only
Vitiello et al. [96]	1990	1990	n = 24	63.6	M-11 F-13	385	456	Yes	Controls only
Brendel et al. [97]	1990	1990	n = 10	83	M-6 F-4	396 ± 70	491 ± 56	Yes	Nights two and three
			n = 14	23.9	M-10 F-4	430 ± 31	445 ± 42		
Hoch et al. [98]	1990	1990	n = 34	60–69	M-21 F-13	335 ± 62	431	Yes	
			n = 33	70–79	M-17 F-16	329 ± 56	432		
			n = 38	80–89	M-19 F-19	318 ± 81	437		
Lauer et al. [100]	1991	1991	n = 13	18–24	M-26 F-25 total	414 ± 16	422	Not stated	Controls only
			n = 10	25–34	Not specified for	418 ± 24	429		
			n = 10	35–44	age groups	405 ± 34	424		
			n = 9	45–54		363 ± 44	397		
			n = 9	55–65		350 ± 36	386		
Monk et al. [101]	1991	1991	n = 34	80–91	M-16 F-18	368 ± 50	478	Yes	
			n = 30	21–30	M-21 F-9	426 ± 39	507		
Van Coevorden et al. [99]	1991	1990	n = 8	20–27	M-8	479 ± 48	Normal sleep patterns	Yes	Non-catheter data only
			n = 8	67–84	M-8	454 ± 53			
Wauquier et al. [102]	1992	1992	n = 7	88–102	F-7	438 ± 27.6	566 ± 23	Yes	
			n = 7	88–98	F-7	328 ± 14.1	462 ± 15		
Bonnet, Arand [103]	1992	1992	n = 12	18–30	M-12	445	472	Yes	Baseline data only
Hudson et al. [104]	1992	1992	n = 19	24.5	M-7 F-12	407 ± 35	437 ± 32	Yes	Controls only
Monk et al. [105]	1992	1992	n = 25	71–91	F-25	366 ± 37	Normal sleep patterns	Not stated	
			n = 20	71–97	M-20	338 ± 48			
			n = 21	19–28	M-10 F-11	415 ± 47			
Buysse et al. [106]	1992	1992	n = 45	>78	M-21 F-24	365 ± 62	Normal sleep patterns	Yes	

(*continued on next page*)

Table 1 (*continued*)

Authors	Year published	Estimated year of study	Sample size	Sample age (y)	Gender	Total sleep time ±SD (min)	Time in bed ±SD (min)	Excluded first night	Comments
Fixed sleep schedule									
			n = 33	20–30	M-20 F-13	426 ± 36			
Hirshkowitz et al. [107]	1992	1992	n = 44	20–29	M-44	347 ± 62	405 ± 44	Yes	
			n = 23	30–39	M-23	340 ± 71	393 ± 58		
			n = 49	40–49	M-49	329 ± 55	404 ± 49		
			n = 41	50–59	M-41	332 ± 64	393 ± 51		
			n = 29	>60	M-29	298 ± 61	396 ± 43		
Montmayeur, Buguet [108]	1992	1992	n = 6	36	M-6	358 ± 16	Normal sleep patterns	Not Stated	Data from intermediate temperature only (March)
Dijk, Czeisler [109]	1993	1993	n = 9	21–30	M-9	432 ± 6	Normal sleep patterns	Yes	Baseline data only
Hoch et al. [110]	1994	1994	n = 27	<75	M-21 F-29	379 ± 41	Normal sleep patterns	Yes	Baseline data
			n = 23	≥75		364 ± 57			
Buguet et al. [114]	1995	1994	n = 6	24	No data	441 ± 5	489 ± 2	Not stated	Placebo, baseline night data only
Hajak et al. [116]	1996	1995	n = 10	25.6	M-5	419 ± 62	483 ± 16	Yes	Placebo data only
				49.4	M-5	389 ± 45	455 ± 20 min		
Carrier et al. [119]	1996	1995	n = 24	82.2	M-10 F-14	370 ± 8	460	Yes	Baseline data only
Vitiello et al. [122]	1996	1995	n = 68	55–80+	F-68	393 ± 6	466 ± 6	Yes	Non-catheter data only
			n = 45	60–80+	M-45	367 ± 7	445 ± 8		
Ehlers, Kupfer [123]	1997	1996	n = 61	20–29	M-18	448	478	Yes	
					F-14	458	483		
				30–40	M-15	413	446		
					F-14	416	439		
Haimov, Lavie	1997	1996	n = 17	65–75	M-17	330 ± 33	Normal sleep patterns	Yes	
			n = 8	19–26	M-8	354 ± 38			
Carrier et al. [125]	1997	1997	n = 39	30	M-52 F-58	458 ± 44	461 ± 4	Yes	
			n = 37	348		423 ± 36			
			n = 33	47.6		406 ± 38			
Edinger et al. [127]	1997	1997	n = 32	67.5	M-16 F-16	364 (Home)	Normal sleep patterns	No	Used only night two in the lab
						348 (Home)			
						372 (Lab)			
						361 (Lab)			
Cajochen et al. [130]	1998	1997	n = 10	27	M-10	424 ± 5	Normal sleep patterns	Yes	Placebo, treatment night data only
Lushington et al. [135]	1999	1997	n = 16	65.4	M-5 F-11	449 ± 8	530 ± 6	Yes	
Armitage et al. [140]	2000	1999	n = 23	22–40	M-15	385	Normal sleep patterns	Yes	Controls only
					F-8	410			
Carrier et al. [141]	2001	1999	n = 100	20–39	M-31 F-27	429	Normal sleep patterns	Yes	
				40–60	M-22 F-20	404			
Nicolas et al. [142]	2001	2000	n = 30	20–29	M-3 F-3	433 ± 33	Normal sleep patterns	Yes	
				30–39	M-3 F-3	452 ± 47			
				40–49	M-3 F-3	431 ± 22			
				50–59	M-3 F-3	448 ± 39			
				60–69	M-2 F-4	379 ± 41			
Edinger et al. [143]	2001	2000	n = 35	40–59	M-17 F-18	378 ± 10	Normal sleep patterns	Yes	Controls only (home)
Roky et al. [145]	2001	1999	n = 8	20–28	M-8	422 ± 9	Normal sleep patterns	Yes	Baseline data only
Means et al. [158]	2003	2002	n = 49	55.4	M-27 F-22	377 ± 46 (Home)	452 ± 63	Yes	Disregarded insomnia patient data
						371 ± 41 (Lab)	431 ± 46		
Kato et al. [162]	2004	2003	n = 10	24.6	M-4 F-6	452 ± 17	Normal sleep patterns	Yes	Baseline data only
Penev [168]	2007	2006	n = 12	68.9	M-12	383 ± 58	436	Yes	

Carrier et al. [171]	2007	2006	n = 17	37.2	M-7 F-10	426 ± 16	504	Not stated	Placebo data only
Peters et al. [174]	2008	2007	n = 28	20.1	M-7 F-7	483 ± 35	Normal sleep patterns	Yes	Baseline data only
				69.8	M-7 F-7	445 ± 72			
O'Donnell et al. [177]	2009	2008	n = 24	64	M-11 F-13	378 ± 38	Normal sleep patterns	Yes	Baseline data only
Paterson et al. [180]	2009	2008	n = 12	24.9	M-12	458 ± 12	Normal sleep patterns	Yes	Placebo data only
Robillard et al. [181]	2010	2008	n = 87	23.3	M-26 F-22	438	Normal sleep patterns	Not stated	
				51.9	M-18 F-21	404			
Morgan et al. [182]	2010	2008	n = 12	39	M-12	416 ± 15	Normal sleep patterns		Placebo data only
Marzano et al. [183]	2010	2009	n = 20	23.8	M-10 F-10	441 ± 38	485 ± 63	Yes	Baseline data only
Ferri et al. [184]	2010	2009	n = 15	24.6	M-12 F-3	450 ± 18	483 ± 16	Not stated	
Herbst et al. [185]	2010	2009	n = 26	39.8	M-13 F-13	387 ± 84	Normal sleep patterns	Yes	Night one and night two data
						395 ± 68			
Nissen et al. [192]	2011	2009	n = 26	46.3	M-14 F-12	390	Normal sleep patterns	Not stated	Controls only
Hebert et al. [193]	2011	2009	n = 22	60.4	M-8 F-14	377 ± 60	Normal sleep patterns	No	Controls only
Danker-Hopfe et al. [194]	2011	2009	n = 30	25.3	M-30	456 ± 17	Normal sleep patterns	Yes	Sham data only
Marzano et al. [195]	2011	2009	n = 50	24.3	M-29 F-21	443	Normal sleep patterns	Yes	Baseline data only
Gonzalez et al. [196]	2011	2010	n = 20	28–64	F-20	357 ± 41	421 ± 21	Not stated	Control data only
Bianchi et al. [197]	2012	2011	n = 32	18–32	M-16 F-16	474 ± 48	516	Recorded	Baseline data only
			n = 12	60–76	M-5 F-7	402 ± 48	485	as baseline	
Ferri et al. [199]	2012	2011	n = 98	29.7	M-12 F-13	394	439	Not stated	>18 y old data only
				62.2	M-4 F-6	411	527		
				73.4	M-3 F-6	345	488		
Frey et al. [201]	2012	2011	n = 8	20–31	F-8	446 ± 27	Normal sleep patterns	Yes	Disregarded depression data, baseline data only.
			n = 8	57–74	F-8	409 ± 42			
Kobayashi et al. [206]	2012	2011	n = 22	22.6	M-15 F-8	373 ± 136	Normal sleep patterns	Yes	Non-PTSD subjects only used
						408 ± 82			
Ferri et al. [211]	2013	2012	n = 18	69.4	M-10 F-8	383 ± 53	517 ± 64	Yes	
Chellappa et al. [212]	2013	2012	n = 30	25.2	M-16 F-14	391 ± 3	Normal sleep patterns	Not stated	Classic light data only
Robey et al. [216]	2013	2012	n = 11	26	M-11	411 ± 14	439 ± 8	Yes	Control data only
Richards et al. [218]	2013	2012	n = 43	30.4	M-22 F-21	404	Normal sleep patterns	Not stated	Control data only
Saxvig et al. [219]	2013	2012	n = 19	21.1	M-5 F-14	507 ± 69	551 ± 67	Yes	Control data only
Sleep schedule not stated									
Kahn et al. [55]	1970	1968	n = 10	76.7	F-10	383 ± 47	Not stated	Yes	
Williams et al. [57]	1972	1970	n = 10	41–46	M-10	377 ± 36	Not stated	Yes	
Browman, Tepas [59]	1976	1975	n = 9	18.9	M-9	456	Not stated	Yes	Relaxation data group only
Karacan et al. [60]	1976	1975	n = 18	20–30	M-18	416	Not stated	Yes	Baseline data only
Adam [64]	1982	1982	n = 7	58	M-4 F-3	457 ± 30	Not stated	Yes	Non-catheter night only
Berry, Webb [82]	1985	1985	n = 119	50–70	M-55	401	Not stated	Yes	
					F-64	404			
Reynolds et al. [83]	1986	1986	n = 20	70.1	M-10	374 ± 48	Not stated	Yes	Baseline data only
				68.7	F-10	362 ± 43			
James et al. [86]	1987	1987	n = 10	29.9	M-7 F-3	437 ± 33	Not stated	Yes	Placebo group only
Stone et al. [136]	2000	1999	n = 7	23.4	M-7	417 ± 27	Not stated	Yes	
Youngstedt et al. [139]	2000	1998	n = 8	24.5	M-8	424 ± 14	Not stated	Yes	
Crowley et al. [151]	2002	2001	n = 34	18–25	M-8 F-6	453 ± 93	Not stated	Yes	
				74.6	M-11	342 ± 65	Not stated		
				76.7	F-9				
Edinger et al. [159]	2003	2003	n = 34	46.5	M-16 F-18	371 ± 10 (Lab)	Ad Lib	Yes	Normal patient data only
						380 + 11 (Home)			
De Souza et al. [160]	2003	2001	n = 21	18–33	M-7 F-14	415 ± 43	Not stated	Yes	
Beaumont et al. [164]	2004	2002	n = 9	35.3	M-6 F-3	395 ± 25	Not stated	Yes	Placebo data only
Mahlberg, Kunz [172]	2007	2006	n = 29	24–86	M-13 F-16	397 ± 50	Not stated	Yes	Healthy subject only
Bonnet, Arand [173]	2007	2006	n = 12	18–20	M-3 F-9	439	Not stated	No	Data corrected for arousals associated with limb movements and apnea
			n = 13	21–30	M-7 F-6	446			
			n = 13	31–40	M-7 F-6	403			
			n = 10	41–50	M-6 F-4	395			
			n = 14	51–60	M-12 F-2	358			
			n = 14	61–70	M-12 F-2	350			
Jaehne et al. [200]	2012	2011	n = 44	18–52	M-29 F-15	431 ± 17	Not stated	Yes	Smoker data disregarded

Table 2
Actigraphic studies reviewed for the present paper. (F=female; M=male; n=number of participants; SD=standard deviation)

Authors	Year published	Estimated year of study	Sampl e size	Sample age (y)	Gender	Total sleep time ±SD (min)	Time in bed ±SD (min)	Excluded first night	Comments
Fixed sleep schedule									
Blagrove et al. [131]	1998	1996	n = 9	20	F-9	421 ± 12	480	Yes	
Hindmarch et al. [138]	2000	1998	n = 30	27.3	M-15 F-15	442	510	Yes	Placebo data only
Jean-Louis et al. [148]	2001	1999	n = 11	25.4	M-4 F-7	441	480	Yes	
Jean-Louis et al. [149]	2001	1999	n = 5	25	no data	449 ± 19	480	Yes	
Baskett et al. [153]	2003	2001	n = 20	71.7	M-4 F-16	443	480	Yes	Baseline data only
Yoon et al. [157]	2003	2002	n = 133	18–32	M-26 F-47	421 ± 48	475 ± 55	Yes	
				60–75	M-22 F-38	366 ± 53	476 ± 64		
O'Hare et al. [221]	2014	2013	n = 20	30	M-11 F-9	391 ± 49	450	Not stated	
Usual sleep schedule									
Jean-Louis et al. [118]	1996	1996	n = 20	30	M-11 F-9	391 ± 57	Normal sleep patterns	Not stated	Validation night only
Hume et al. [129]	1998	1997	n = 190	20–34	M-39 F-23	458 ± 54	Normal sleep patterns	Yes	
				35–49	M-22 F-42	422 ± 60			
				50–70	M-26 F-38	412 ± 55			
Pires et al. [144]	2001	2000	n = 6	22–24	M-6	559 ± 73	Normal sleep patterns	Yes	Placebo data only. Data from PSG
						512 ± 101			
						518 ± 39			
Youngstedt et al. [161]	2003	2002	n = 71	18–75	no data	381 ± 6	Not stated	No	
Benson et al. [163]	2004	2003	n = 20	35.4	M-7 F-13	384 ± 70	Normal sleep patterns	No	
Monk et al. [167]	2006	2005	n = 128	70–92	M-65 F-63	413 ± 83	449 ± 76	Not stated	
Robertson et al. [170]	2007	2006	n = 15	27.7	M-7 F-8	374 ± 57	Normal sleep patterns	Not stated	Normal sleepers only.
Rahman et al. [188]	2011	2010	n = 15	35.6	M-5 F-10	486 ± 54	Normal sleep patterns		Control data only.
Kogure et al. [189]	2011	2010	n = 45	50.2	M-16 F-17	436 ± 69	Normal sleep patterns	No	
				83.8	F-12	410 ± 73			
Myllymäki et al. [190]	2011	2010	n = 11	25	M-7 F-4	438 ± 45	486	Yes	Control data only
Scatena et al. [204]	2012	2011	n = 25	44.3	M-13 F-12	737 ± 122	Normal sleep patterns	Not stated	Data deleted as outlier
Robertson et al. [209]	2013	2012	n = 19	20–30	M-19	369 ± 40	Not stated	Not stated	Baseline data only.
Petersen et al. [217]	2013	2012	n = 28	41	M-7 F-21	382 ± 11	491	Yes	Low sensitivity, low stress data only
Sleep schedule not stated									
Naylor et al. [137]	2000	1999	n = 14	75.2	M-5 F-9	338 ± 19	Not stated	Yes	Controls only
Gooneratne et al. [191]	2011	2009	n = 100	72.5	M-37 F-63	371	Not stated	Yes	>18 y old data only
Wulff et al. [203]	2012	2010	n = 21	37.5	M-13 F-8	365 ± 37	Not stated	Not stated	Control data only.
Shambroom et al. [207]	2012	2010	n = 26	38	M-13 F-13	325 ± 11	Not stated	Yes	
Ju et al. [213]	2013	2012	n = 142	65.6	M-58 F-84	403 ± 45	486.4 ± 49.8	Not stated	
Winser et al. [214]	2013	2012	n = 39	26.5 27.9	M-12 F-27	428 ± 55	Not stated	Not stated	
						434 ± 40			
Lombardi et al. [215]	2013	2012	n = 23 n = 14	40.6 36.1	M-23 F-14	420	Not stated	Not stated	Sea level data only

century. Similar results were found across all age groups, in both men and women, for both PSG and actigraphic data, and under conditions of fixed sleep periods and participants' usual sleep schedules. These data are consistent with recent comprehensive reviews that found no consistent or compelling evidence of significant decrements in self-reported sleep duration and/or prevalence of short sleep over a similar range of years [11–15]. Together, these data cast doubt on the notion of a modern epidemic of insufficient sleep.

There were several limitations of the literature, which might have confounded demonstration of temporal changes in sleep duration. First, although virtually all of the studies failed to describe the racial/ethnic composition of the samples, it is a reasonable assumption that participants in most of these studies were not representative of the population. Recent research has suggested that the prevalence of short sleep is relatively high among Blacks, and that this prevalence might be increasing more among Blacks than among Whites [22]. Furthermore, most of the studies either excluded women or failed to report separate data for women and men. Thus, there was an insufficient number of data points (n = 17) to adequately assess whether there was a temporal decline in women's sleep duration, which might have occurred as more women have entered the workforce over the past 50 y [11,15]. Study samples have also likely been unrepresentative of the population in other factors which have been associated with sleep duration, including employment status, education, occupation, and socioeconomic status.

A second limitation is that most of the studies assessed sleep with PSG in the laboratory, a process that can result in curtailed sleep duration. The confound was reduced in most of the PSG studies by disregarding data obtained during the first night of laboratory recording (eliminating "first night effects") [23]. Interestingly, in a post-hoc assessment of studies that measured sleep objectively both at home and in the laboratory, the median difference between home and laboratory TST was only 3.2 min (Table 3). However, the use of PSG recording could have inhibited sleep, and sleep might have been more disrupted in earlier PSG studies due to greater novelty associated with PSG, as well as less technologically advanced methods, such as the use of collodion for securing electrodes.

Constraints of PSG recording might not capture a decline in nighttime sleep that has occurred at home when people are more able to follow their customary habits, which might involve staying up later. Roenneberg et al.'s surveys of thousands of adults assessed from 2002 to 2010 have found a decline of approximately 30 min in reported sleep duration on weekdays [24]. However, the present review did not find a similar change in home actigraphic sleep duration over the past 10–20 y. Likewise, a recent study by Gubelmann et al. found no decline in reported time in bed from 2005 to 2011 among a large Swiss sample (n = 3853) [25].

A third limitation is that studies with fixed sleep periods (usually 8 h) could have resulted in sleep restriction for some individuals, particularly if the timing of the sleep periods was not consistent with the participants' usual sleep schedule. This restriction could have been generally greater in earlier studies if sleep duration truly had declined. However, a similar age-adjusted mean TST was observed for studies involving fixed (443.3 ± 31.7 min) and habitual sleep schedules (435.1 ± 37.4 min), and there was a similar absence of a significant secular trend in TST for fixed and habitual sleep schedules (Fig. 6). Fig. 6A might reflect a societally-imposed or custom-imposed 8-h ceiling in how long people usually spend sleeping. It is also possible that PSG technicians have been reluctant to extend the night shift beyond 8 h.

A fourth limitation is that compared with more recent studies, earlier studies did not screen as well for absence of sleep apnea and other sleep disorders; this difference in screening methods might have resulted in lower estimates of sleep duration in earlier studies. However among adults above middle age, a small amount of sleep apnea or periodic limb movements is so common that it might be considered normal. Relatively more drug studies in recent years could have contributed to more extensive participant screening of normal sleepers, resulting in samples that sleep longer than population norms. However, a similar absence of a decline in sleep duration was found in the 18–27 y old adults, for whom the prevalence of sleep apnea and other sleep and health problems is relatively low. Also contrary to the hypothesis that more recent studies have had more homogenous samples of good sleepers, a post-hoc analysis showed

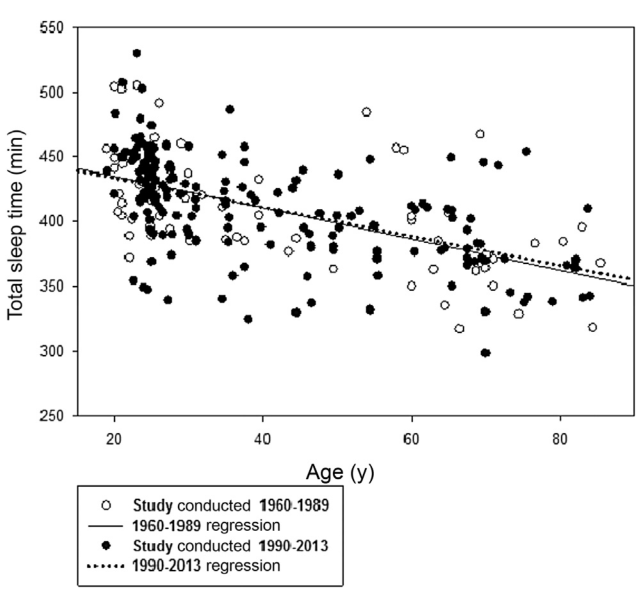

Fig. 1. Association of mean age of participants with total sleep time (min) for studies conducted between 1960 and 1989 (open circles) and 1990–2013 (closed circles).

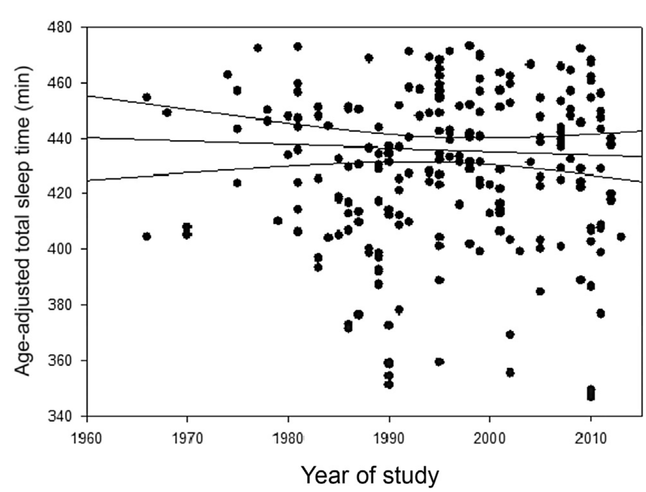

Fig. 2. Association of year of study with age-adjusted total sleep time (min) for all data points. The regression line and 95% confidence intervals are displayed.

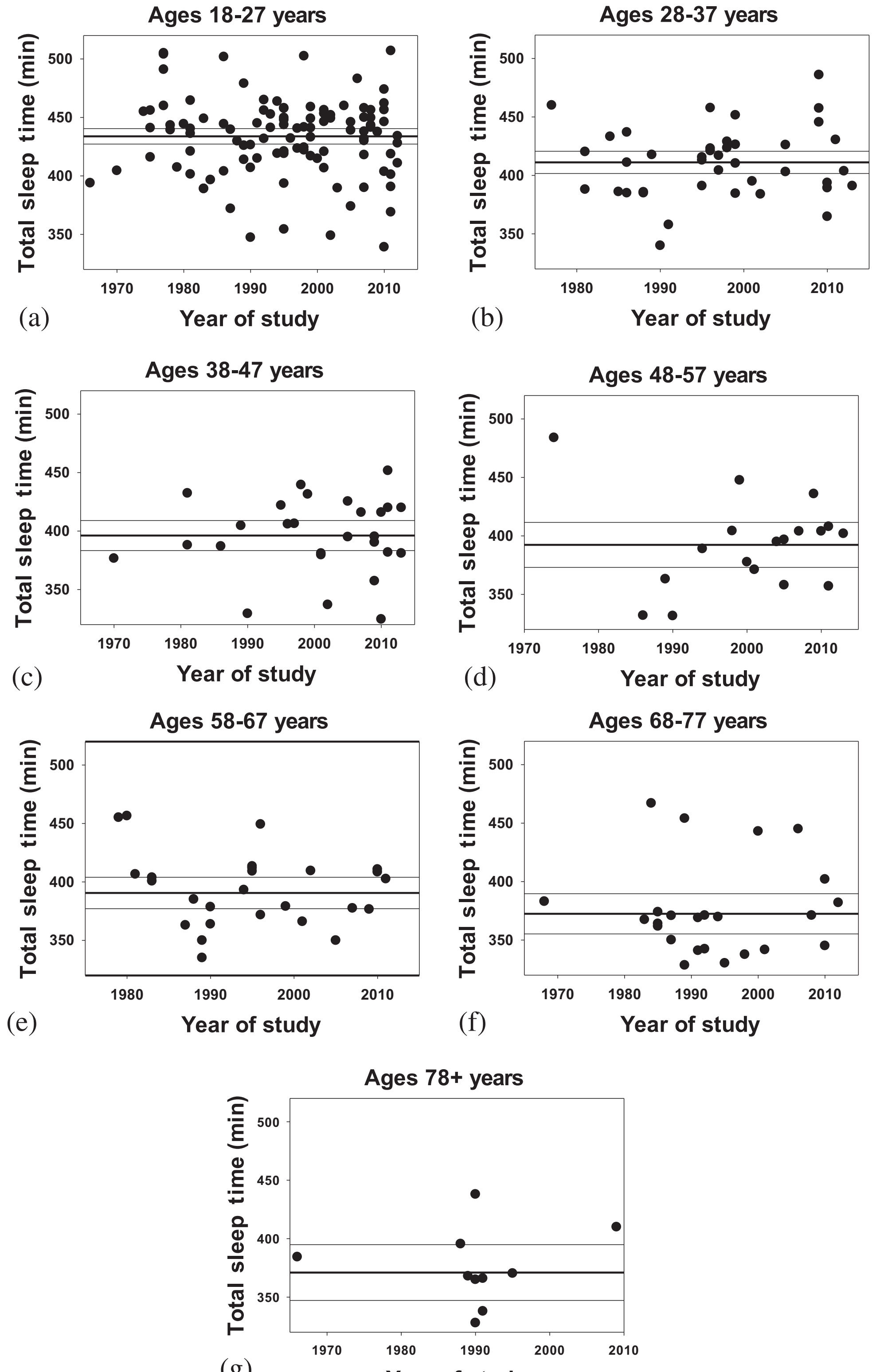

Fig. 3. Association of year of study with total sleep time (with regression line and 95% confidence intervals) for participants ages 18–27 y (a), 28–37 y (b), 38–47 y (c), 48–57 y (d), 58–67 y (e), 68–77 y (f), and ≥78 y (g).

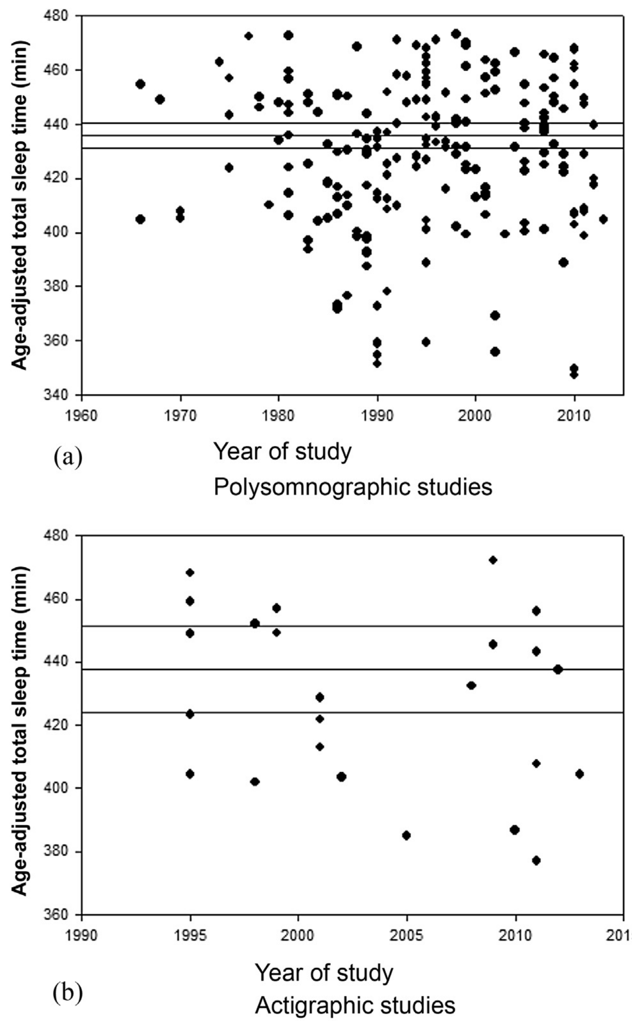

Fig. 4. Association of year of study with age-adjusted total sleep time (min) for polysomnographic data (a) and actigraphic data (b). The regression line and 95% confidence intervals are displayed.

no significant correlation between year of study and sample standard deviation of TST (r = −0.01).

A fifth limitation is that mean nighttime sleep duration data for a sample might not reflect temporal changes in the prevalence of short or long sleep, nor changes in 24-h sleep duration which might have occurred. Interestingly, Fig 1–6 suggest a higher prevalence of sleep of ≤6 h over the last 20 y, particularly among 18–27 y old participants, though the data might reflect the common phenomenon of a higher range with more data points.

In recent decades, the siesta tradition has waned considerably in some countries [26]. Without corresponding increases in nighttime sleep, this could have resulted in a temporal decline in 24-h sleep in these countries. Partial support for this hypothesis was provided by Bin et al., who found in a meta-analysis that 24-h sleep duration decreased by 22 min from 1989 to 2002 in Italy [13], whereas there was no decline in 24-h sleep in eight of the other nine countries assessed, none of which has had a notable siesta tradition (Australia, Canada, Finland, Germany, Netherlands, Norway, Sweden, United Kingdom, United States).

However, there has been limited empirical investigation of temporal trends in napping. Wolf-Meyer traces a historical decline in napping to the industrial revolution, increased structure of the work day, and the origins of sleep medicine which has promoted a theoretical need for 8 h of sleep at night [27,28]. Thus, through much of the 20th century, napping in many industrialized countries was regarded as a sign of laziness [28]. However, attitudes and practices of napping have apparently changed over the past 10–20 y, as evidenced by formal sanctioning of work-day napping and commercial napping services in some cities.

Napping is relatively more common among older adults who have less nighttime sleep and less consolidation of the sleep-wake cycle than young adults. Compared with previous older cohorts, some factors could have resulted in less napping in contemporary seniors, such as later retirement age, more physically and socially active lifestyles, and greater rates of residence in senior living facilities.

Nonetheless, the present review is the first to explore historical patterns of objective sleep duration, which has long been regarded as the gold standard for defining sleep duration [20]. Further, the findings have several implications. Although historically 8 h of sleep was thought to be optimal for health and well-being, an extensive epidemiologic literature has indicated that 7 h of self-reported sleep is associated with the lowest health risks [29], with progressively higher risks associated with shorter as well as

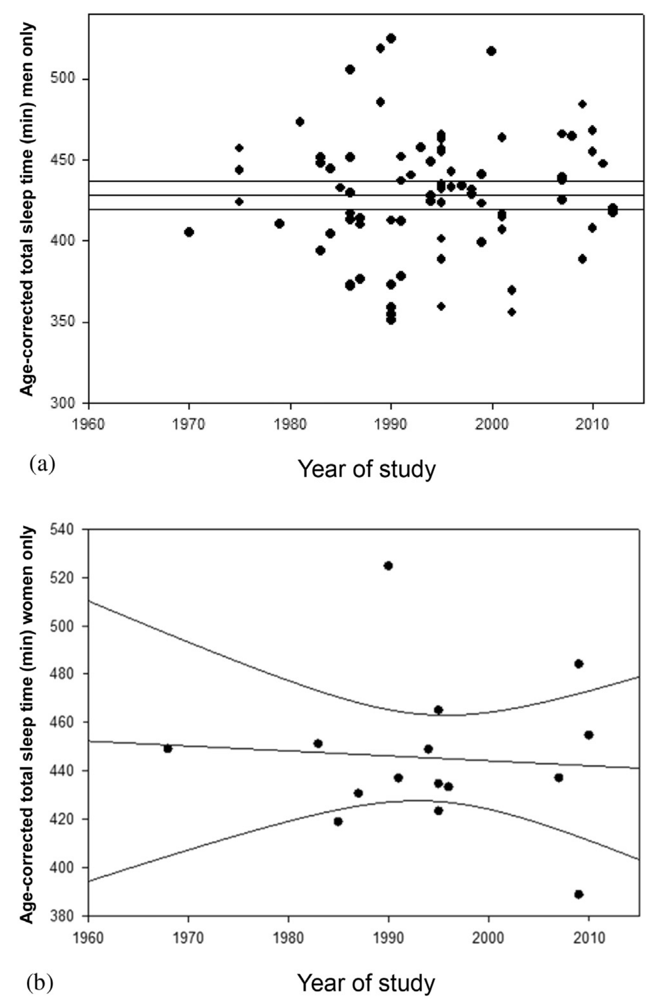

Fig. 5. Association of year of study with age-adjusted total sleep time (min) for men subjects only (a), and for women subjects only (b). The regression line and 95% confidence intervals are displayed.

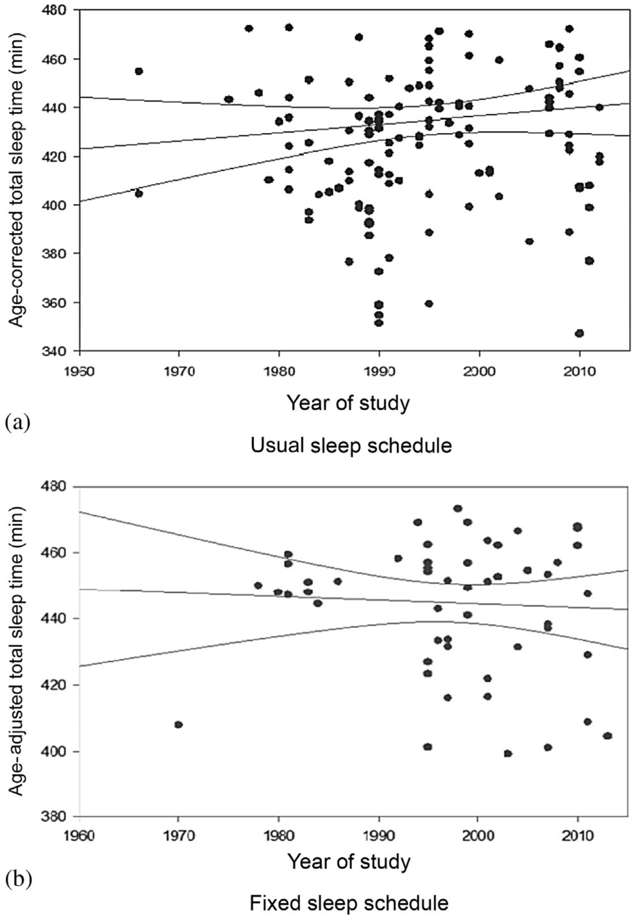

Fig. 6. Association of year of study with age-adjusted total sleep time (min) for studies in which subjects followed their usual sleep schedule (a), and for studies in which subjects followed a fixed sleep schedule of 470–480 min (b). The regression line and 95% confidence intervals are displayed.

longer reported sleep. However, since objectively-recorded sleep duration is generally 30–60 min less than self-reported sleep, optimal objective sleep duration for longevity and health might be only 6–6.5 h. For example, Kripke et al. recently found 5–6.5 h of actigraphic sleep was associated with lower mortality than <5 h and >6.5 h [30]. The present review adds to recent reviews of self-reported data, which have also indicated no decline in sleep duration over the last 50 y. If the optimal duration of objective sleep is indeed between 6 and 6.5 h, the review also suggests that more participants in these studies might be at risk due to long sleep than to short sleep.

Had sleep duration truly declined by 1–2 h over the last 50 y, as many sleep researchers have claimed, the signal to detect this would be at least as great as that associated with age, which shows a decline of only about 1 h from young adulthood to the elderly (Fig. 1). The results also contradict the hypothesis that such a decline in sleep is a probable culprit in modern epidemics of obesity and diabetes [21].

Notwithstanding these findings, assumptions about a steady decline in sleep duration over the past few decades persist, and could be explained by many factors. First, increased public awareness about sleep and the dangers of inadequate sleep, coinciding with an exponential increase in sleep disorders diagnoses with the emergence of sleep medicine [31], could have partly shaped these perceptions. Greater knowledge about sleep, perhaps especially a greater ability to distinguish between sleep and time spent in bed, could lead to perceptions of less sleep. Likewise, these factors could have led to an artifactual increase in the prevalence of short sleep in some studies, analogous to some of the factors which have led to estimates of an increased prevalence of autism.

Second, sleep is commonly considered in the context of leisure time and being a respite from daily stressors [32]. In what seems to many to be an increasingly fast-paced and stressful world, there is a perception of having less free time for “rest.” Third, evidence indicates that the prevalence of depression has increased over time [33], and depression is associated with reports of poor or inadequate sleep [34].

Fourth, self-reported behavior is influenced by perceived social norms [28,35], and the perception that we have become a sleep-deprived society has likely been shaped partly by promotion of this message in the popular media and by sleep scientists. However, much of the narrative regarding an epidemic of declining sleep has been based on arguments which have not been well-supported by empirical data. We address some of these arguments in the following section, although much of this discussion is also not well-supported by empirical observations.

Decline of sleep in children? A particularly poignant argument for an epidemic of insufficient sleep is that sleep among children and adolescents has declined, due to many factors, including greater use of electronic media at night and reduced parental enforcement of bedtimes. The fear that children are sleeping less has apparently existed for over a century [36], and in recent years this fear may have contributed to the increased rates of hypnotic prescriptions for children [37].

A recent empirical review by Matricciani et al. found that reported sleep duration of children and adolescents has declined by an average of 70 min per night since 1895 [38]. However, these data should be considered within the context of the tremendous difference in physical activity levels of modern children compared with children of over a century ago who were required to work on family farms, and for 60 h per week in mines, sweatshops, factories, etc. [39]. The Matricciani et al. review found that reported sleep duration of children and adolescents has declined by only about 15 min per night since 1970 [38], and this difference could also be partly explained by dramatic declines in children's physical activity levels during this period of time, as walking/cycling to school and playing outdoors have been largely replaced by car rides and sedentary indoor activities [40]. Changes in reported sleep duration of children should be verified with a review of objective sleep data analogous to the present review.

Twenty-four hour society? The cliché of an ever-expanding 24/7 society [41] is not well-supported by empirical evidence, at least not over the past 50 y. For example, evidence suggests that the prevalence of shift-work has remained stable at about 15–20% over this interval of years [42,43]. Such data might seem counterintuitive in light of the increased number of 24-h services and businesses. However, while many of these businesses (e.g., restaurants and convenience stores) can operate all-night with just a few employees, over the past half-

Table 3
Studies located which assessed sleep objectively both at home and in the laboratory. (TST=total sleep time; n=sample size of study)

Authors/Year	n	Home TST (min)	Lab TST (min)
Coates et al., 1979	8	381	364
Riley, Peterson, 1983	10	378	408
Edinger et al., 1997	32	372	361
Edinger et al., 2001	35	378	377
Edinger et al., 2003	35	380	371
Means et al., 2003	49	377	371
Penev, 2007	12	381	383
Kobayashi et al., 2012	22	373	404

century there has been a dramatic shutdown of factories which once employed thousands of shift-workers. Moreover, over the past 10–20 y, protective regulations and practices which limit shift-work and sleep deprivation and/or better accommodate individual's preferences (e.g., flex time and telecommuting), have been implemented for various occupations, including medical residents, truck drivers, and transportation workers [44,45].

A Decline in sleep over the centuries? It is a widely repeated hyperbole that never before in human history have we faced such challenges to our sleep [46]. It has been hypothesized that industrialization, urbanization, and technological advances have caused us to ignore or override our natural tendency to sleep more, and we do so at great costs to our health and quality of life. Wolf-Meyer has noted that this "fall from grace" sentiment can be traced at least as far back as the pioneering work of Nathaniel Kleitman [27,28]. However, historical accounts belie the myth that people slept longer or better centuries ago, when sleep was compromised by pestilence, fear of night marauders, poorer ability to control ambient temperature or treat illnesses, etc. [28,47]. By Ekirch's estimation, sleep centuries ago typically occurred in two nighttime in-bed periods, with each period lasting approximately 3–4 h, suggesting that average sleep duration probably did not exceed 7 h (personal communication, 24 June, 2014).

The light bulb has been blamed for sleep loss [48]. However, recent anthropologic studies of people in societies with little or no electricity have failed to indicate that these people sleep more than people in industrialized societies [49,50].

In summary, it is beyond dispute that disrupted and inadequate sleep are highly prevalent and associated with significant risks, and that experimental sleep deprivation has myriad negative effects [51,52]. Thus, the notion of a recent epidemic of insufficient sleep, and speculation that this is a primary contributor to modern epidemics of obesity, diabetes, metabolic syndrome, etc., rests largely on the question of whether sleep duration has declined in the last few decades. Consistent with recent reviews of subjective data [11–15,53], this review does not support this notion, at least not in healthy sleepers.

Practice Points:

1. Systematic reviews of the literature have generally not shown that average self-reported sleep duration has declined, nor that the prevalence of short sleep duration (<6 h) has increased over the past few decades [11–15].
2. Limitations of the objective-recording literature include unrepresentative samples, assessment of sleep mostly with PSG under laboratory conditions, and almost no studies of 24-h sleep patterns.
3. The data indicate no significant change in objective TST over the last 50+ years.
4. Reasons for persistent assumptions about a temporal decline in societal sleep duration could include a larger number of people assessed and diagnosed with sleep disorders with the emergence of sleep medicine; greater knowledge about sleep and the risks of inadequate sleep; increased prevalence of depression; misperceptions about population norms; and persistent claims in the popular and scientific literature regarding a so-called modern epidemic of insufficient sleep.

Research Agenda

1. A similar analysis of temporal trends in objective sleep duration in children and adolescents should be undertaken. A recent review indicated a decline in reported sleep duration of about 70 min per night among children and adolescents over the last century [38], which should be confirmed with objective data.
2. A similar analysis of temporal changes in other measures of objective sleep, such as sleep latency and sleep efficiency, should be conducted to address whether the quality of sleep has changed over time.
3. Further historical studies focused specifically on sleep duration and other sleep variables might uncover more information about sleep changes over time.
4. Future large-scale prospective, representative, multinational studies of objective sleep (using actigraphy) could address whether there are future population changes in sleep.

Conflict of interest

The authors do not have any conflicts of interest to disclose.

Acknowledgments

This manuscript is dedicated to Dr. Richard R. Bootzin, our dear friend and colleague who passed away on December 4, 2014. Dr. Bootzin contributed to earlier drafts of this manuscript. Research supported by RO1-HL095799; R01-MD007716; R01-AG034588; R01-AG026364; R01-CA160245; R01-DA032922 the Cousins Center for Psychoneuroimmunology. Susan Noh assisted with this study.

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