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Self-reported versus actigraphy-assessed sleep duration in the ELSA-Brasil study: analysis of the short/long sleep duration reclassification

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Abstract

Purpose This study was aimed to determine the magnitude and predictors of self-reported short/long sleep duration (SDUR) reclassifications using objective measurements.

Methods Adult participants from the ELSA-Brasil study performed self-reported SDUR, 7-day wrist actigraphy, and a portable sleep study. We explored two strategies of defining self-reported SDUR reclassification: (1) short and long SDUR defined by <6 and ≥8h, respectively; (2) reclassification using a large spectrum of SDUR categories (<5, 5–6, 7–8, 8–9, and >9 h).

Results Data from 2036 participants were used in the final analysis (43% males; age: 49±8 years). Self-reported SDUR were poorly correlated (r=0.263) and presented a low agreement with actigraphy-based total sleep time. 58% of participants who self-reported short SDUR were reclassified into the reference (6–7.99 h) or long SDUR groups using actigraphy data. 88% of participants that self-reported long SDUR were reclassified into the reference and short SDUR. The variables independently associated with higher likelihood of self-reported short SDUR reclassification included insomnia (3.5-fold), female (2.5-fold), higher sleep efficiency (1.35-fold), lowest O_2 saturation (1.07-fold), higher wake after sleep onset (1.08-fold), and the higher number of awakening (1.05-fold). The presence of hypertension was associated with a 3.4-fold higher chance of self-reported long SDUR reclassification. Analysis of five self-reported SDUR categories revealed that the more extreme is the SDUR, the greater the self-reported SDUR reclassification.

Conclusion In adults, we observed a significant rate of short/long SDUR reclassifications when comparing self-reported with objective data. These results underscore the need to reappraise subjective data use for future investigations addressing SDUR.

Keywords Sleep duration, Epidemiology, Self-reported · Actigraphy · Measurement error

Introduction

In the last decades, we have observed growing research interests in understanding the magnitude and consequences of the short and long sleep duration (SDUR) on metabolic [1], cardiovascular diseases [2, 3], and mortality [4]. Previous evidence pointed out that short and/or long SDUR hae been associated with hypertension [5, 6], weight gain [7], glucose intolerance [2], and cardiovascular mortality [8]. Specifically, virtually, all these investigations used pragmatic questions about SDUR and not daily diaries detailing their sleep schedules. This strategy may not be ideal for reflecting real sleep time due to the possibility of recall bias [1, 2, 5]. Recent data using objective SDUR have not consistently reproduced some of the potential consequences of short

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SDUR [3]. In a scenario of the growing use of technology for monitoring sleep, an appropriate description of SDUR may help us to understand the real impact of short and long SDUR on several domains [9]. However, little attention has been devoted to evaluating the short and long SDUR reclassification after comparing self-reported data with actigraphy-assessed data. Wrist actigraphy is a validated and acceptable method for estimating SDUR by presenting a high correlation with polysomnography data [10]. In addition, there are clear advantages to being used for several days in the subject's routine [10]. Previous studies found low to moderate correlations (r=0.28–0.47) between self-reported and actigraphy data suggesting the presence of both random error and systematic bias in self-reporting SDUR [11, 12].

This study explored the frequency and predictors of self-reported short and long SDUR reclassification comparing subjective and objective data. We hypothesized that a significant proportion of participants would have reclassification of both self-reported short and long SDUR status.

Methods

Our investigation was ancillary to the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). The cohort profile and routines were previously reported [13]. The SDUR analysis was performed in the Sao Paulo center of the ELSA-Brasil cohort, as previously described and detailed below [3]. The local ethical committee approved the study (1166/11), following the Declaration of Helsinki All participants provided informed consent. We performed the following evaluations:

Clinical evaluation

Each participant was interviewed in their workplace and visited the research center for clinical examination according to the standard protocols. Trained personnel conducted interviews and physical examinations under strict quality control [13].

Self-report SDUR

Each participant was interviewed at the research center and asked about the usual bed/waking hours and the mean SDUR in a typical week [3]. Self-reported SDUR was described as a continuous variable using the exact time reported by each participant. Important to note, subjective data were collected without access to the objective SDUR measurement data. As previously described [3] and defined by the National Sleep Foundation as inappropriate for adults [14], we defined short SDUR when the mean SDUR was <6h. As used by our group [3] and others [15], long SDUR was set at ≥8h. Therefore, SDUR 6 to <8 h was considered the reference group. In addition, we performed a self-reported SDUR reclassification using a large spectrum of SDUR categories (<5, 5–5.99, 6–7.99, 8–9, and >9 h) to address other classifications.

Wrist actigraphy

As previously described [3], the SDUR was measured using an Actiwatch model 2^{TM} (Philips Respironics, Murrysville, PA). All participants were instructed to continuously wear the actigraphy over a period of seven consecutive days and nights on the nondominant wrist during a typical week. During the actigraphy study period, the participants completed a sleep diary. The participants were asked to press the event marker button on the actigraph when they began trying to fall asleep and again when they woke up (regardless of the period of the day). The same definitions used in the subjective definitions for short and long SDUR were applied here. See more details of wrist actigraphy and studied variables in the online supplement.

Home sleep study

To evaluate whether or not obstructive sleep apnea (OSA) or its components are predictors of short and long SDUR reclassification, we performed an overnight home sleep study using the Embletta Gold^{TM} (Natus Medical Inc., Ontario, Canada). This standardized level 3 portable diagnostic device was previously described [3]. All the studies were manually scored by an expert in sleep medicine, according to the American Academy of Sleep Medicine (AASM) 2012 criteria [16]. We used 3% oxygen desaturation for hypopnea definition as previously reported [3]. The sum of the apneas and hypopneas per hour determined the apnea-hypopnea index (AHI). We recently performed a pragmatic validation of this portable monitor in 300 participants of the ELSA-Brasil using simultaneous actigraphy recording for defining sleep time [17]. A high concordance of the AHI was observed when comparing the sleep monitor alone versus coupled with actigraphy (Kappa: 0.95) [17]. Considering growing evidence suggesting that mild OSA may not be associated with increased risk in several domains [18], we used a more conservative AHI cutoff of ≥15 events/h to define participants with OSA. We excluded participants with predominantly (>50%) central sleep apnea.

Insomnia

The occurrence of moderate or severe insomnia was assessed using the adapted Brazilian version of the Clinical Interview Scheduled Revised (CIS-R) [3, 19]. Moderate or severe insomnia was defined as spending at least 1 h trying to get to sleep or trying to get back to sleep on at least four occasions

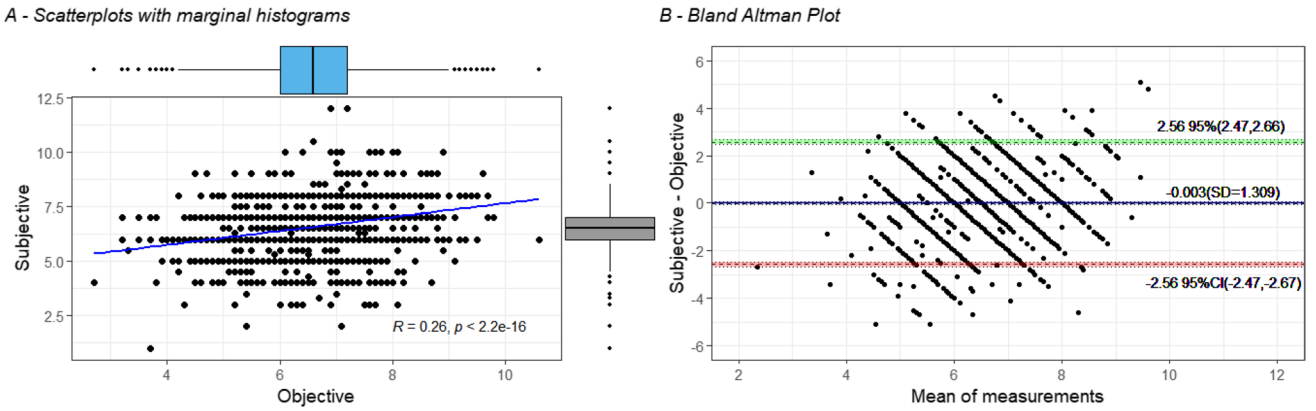

Fig. 1 Relationship and agreement between self-report and objective measures of sleep duration. **A** Scatterplots with marginal histograms of the subjective and objective sleep duration. SDUR was reported in hours for both subjective and objective data. **B** Bland–Altman plot: the blue solid line represents the mean difference of sleep duration at −0.003 h (standard deviation = 1.309 h). The blue dotted lines represent limit of agreement (LOA): (−2.57, 2.56)

in the previous week. Please see the online supplement for details.

Statistical analysis

Sociodemographic, health, and sleep characteristics were first summarized with descriptive analyses for the study population. For comparisons of categorical variables, the χ^2 test was performed. Normally distributed continuous variables were compared using one-way ANOVA and were presented as the means and standard deviation. For skewed variables, medians and interquartile ranges were reported, and Kruskal–Wallis tests were performed. A Scatter plot and Pearson's correlations were performed to assess the potential strength and extent of the relationship between self-report and actigraphy-based SDUR. Bland–Altman plots and statistical information were used to assess the level of agreement between the two measurements.

A cross-tabulation was performed to analyze the relationship between self-reported and objective SDUR categories (short, reference, and long) classifications. The agreements were examined using weighted Kappa. Also, we defined SDUR reclassification when (1) participants previously classified as having short SDUR by self-reported were reclassified as reference or long sleepers; (2) participants previously classified as having long SDUR defined by self-reported SDUR were reclassified into reference or short sleepers. Univariate and multivariate analyses were conducted to identify independent factors associated with each SDUR reclassification. The variables for which p <0.20 in the univariate analysis were included in the multiple logistic regression. Stepwise logistic regression was undertaken with the probability of entry and removal as 0.05 and 0.10, respectively. To detect multicollinearity in the regression analyzes, we used the variance inflation factor (VIF) method. VIF less than 10 was considered indicative of low multicollinearity among the predictor variables. A p-value of <0.05 (two-sided) was considered statistically significant. The SPSS software (IBM Corporation, Chicago, IL) version 24.0 was used to carry out the analyses.

Results

A total of 2429 were invited to perform sleep evaluations during a 2-year recruitment period. After the exclusion of refusals, technical issues during sleep monitoring, predominant (>50%) central apnea, previous OSA treatment, nocturnal/shift workers, and medications that directly influence the SDUR, 2036 participants (43% males; mean age: 49±8 years; 16% of them retired) were included in the final analysis (see details on Figure S1).

Overall, 16% of the participants self-reported their sleep time <6 h, 63% between 6 and 7.99 h, and 21% ≥8 h. Figure 1A showed that the within-subject relationship between mean subjective and objective sleep duration was poor (Pearson's correlation r=0.263). The Bland–Altman plot showed no significant systematic difference between subjective and objective sleep duration (Bias= −0.003h, standard deviation=1.309). However, the limit of agreement extended over 5.13 h, ranging from overreporting standard deviation by 2.56 h to under-reporting by −2.57 h (Fig. 1B).

Short SDUR reclassification

Table 1 represents a cross-tabulation comparing the three SDUR categories according to the self-reported and objective SDUR classifications. Among the participants that

self-reported being short sleepers, almost 60% were reclassified into usual or long SDUR by actigraphy (Table 2). The frequency of men and participants that perform vigorous physical activity was lower in the reclassified group. Table S1 (online supplement) reports the sleep characteristics of the studied population. Participants that reclassified self-reported short SDUR had lower AHI (and expected less severe forms of OSA), hypoxemic parameters, and higher time in bed, sleep efficiency, WASO, number of awakenings, and higher frequency of insomnia than the non-reclassified group. Excessive daytime sleepiness was slightly lower in the reclassified group. Table 3 describes the independent variables selected from the univariate analysis (Table S2, online supplement). The variables independently associated with higher self-reported short SDUR reclassification included the presence of insomnia, female, a higher percentage of sleep efficiency, lowest O_2 saturations, longer WASO, and highest number of awakenings. Interestingly, variables associated with a lower chance of self-reported short SDUR reclassification included mixed and Asian race and vigorous physical activity.

Long SDUR reclassification

The reclassification rate was even higher among long sleepers (Table 1). Participants who reclassified this category tended to be younger and presented lower per capita family income than non-reclassified (Table 2). Concerning sleep parameters (Table S1, online supplement), participants that reclassified the self-reported long SDUR had lower time in bed, lower sleep latency, lower sleep efficiency, and lower WASO than the non-reclassified group. Table 4 describes the independent variables selected from the univariate analysis (Table S3, online supplement). The presence of hypertension was associated with a 3.4-fold higher chance of self-reported long SDUR reclassification. Higher income, higher sleep efficiency, lower sleep latency, and lower WASO were associated with a lower chance of self-reported long SDUR reclassification (Table 4).

Analysis using five SDUR categories

Table 5 showed a cross-tabulation exploring the comparison of self-reported and actigraphy-based SDUR stratified in 5 categories (<5, 5–6, 7–8, 8–9, and >9 h). The more extreme is the objective SDUR, the greater the self-reported SDUR reclassification.

Discussion

In a large multiethnic study of adults that underwent a comprehensive sleep evaluation, we confirmed the poor correlation and agreement between self-reported and actigraphy-based SDUR. The main novel study findings are (1) we observed a significant rate of short and long SDUR reclassifications when comparing self-reported with objective data: 56% and 3% of participants that self-reported short SDUR were reclassified in the reference and long SDUR groups, respectively. In the other extreme, 74% and 14% of participants that self-reported long SDUR were reclassified in the reference and short SDUR groups, respectively; (2) Predictors of higher self-reported short SDUR reclassification included the presence of insomnia, being female, markers of

Table 1 Classification of participants according to the categorization of sleep duration (SDUR)–based self-reported SDUR (subjective) and cross-tabulation with actigraphy data (objective). In blue are participants with short SDUR reclassified as reference or long (n=193; 58%); in orange are participants with long SDUR reclassified in the reference or short (n=369; 89%); in green are participants with short or long SDUR that were considered as the "Accurate-estimators" of sleep duration. Agreement between self-report and actigraphy-based sleep duration: agreement=51%, weighted Kappa=0.12 (95% CI: 0.09–0.15, p<0.001). Considering only the short SDUR, the agreement was 42%, and it was 12% for long SDUR

n (%)		Sleep Duration by actigraphy			Total (self-reported)
		Short	Reference	Long	
		< 6	6 to <8	>= 8	
Self-report SDUR	Short	138 (41.7)	**184 (55.6)**	**9 (2.7)**	331 (16.3%)
	Reference	358 (27.9)	858 (66.8)	69 (5.4)	1285 (63.1%)
	Long	**57 (13.6)**	**312 (74.3)**	51 (12.1)	420 (20.6%)
Total (actigraphy)		553 (27.2%)	1354 (66.5%)	129 (6.3%)	2036

Table 2 Main characteristics of the total sample and according to the sleep duration (SDUR) reclassification category.

	Total	*Self-reported short SDUR n=331 (16.3%)*			*Self-reported long SDUR n=420 (20.6%)*		
		Reclassified		*p value**	*Reclassified*		*p value**
		No	*Yes*		*No*	*Yes*	
***n*, (%)**	2036 (100.0%)	138 (41.7)	193 (58.3)		51 (12.1)	369 (87.9%)	
Male sex	870 (42.7)	78 (56.5)	72 (37.3)	0.001	23 (45.1)	156 (42.3)	0.703
Age, years	49 (8)	49 (8)	49 (8)	0.546	51 (8)	49 (8.0)	0.054
Self-reported race				0.184			0.647
White	1,240 (61.5)	53 (39.3)	96 (50.5)		37 (72.5)	239 (65.5)	
Mixed	406 (20.1)	42 (31.1)	48 (25.3)		9 (17.6)	81 (22.2)	
Black	250 (12.4)	27 (20.0)	35 (18.4)		3 (5.9)	35 (9.6)	
Asian/other	121 (6.0)	13 (9.6)	11 (5.8)		2 (3.9)	10 (2.7)	
Education beyond high school	1,006 (49.4)	55 (39.9)	87 (45.1)	0.334	20 (39.2)	172 (46.6)	0.320
***Monthly per capita* family income, US$**	1,653	1,416 (837)	1,507 (938)	0.367	1,820 (881)	1,541 (895)	0.037
Body mass index, kg/m^2	27.0 (4.7)	28.0 (5.0)	27.0 (4.8)	0.073	26.7 (5.6)	27.1 (4.7)	0.595
Hypertension	533 (26.2)	35 (25.4)	51 (26.4)	0.828	11 (21.6)	113 (30.6)	0.184
Diabetes	316 (15.5)	22 (15.9)	41 (21.2)	0.226	6 (11.8)	63 (17.1)	0.338
Dyslipidemia	1,097 (54.2)	72 (52.2)	106 (55.2)	0.585	28 (54.9)	200 (54.6)	0.972
Anxiety/depression symptoms	79 (3.9)	9 (6.5)	14 (7.3)	0.796	4 (7.8)	12 (3.3)	0.108
Current smoking	289 (14.2)	26 (18.8)	30 (15.5)	0.430	5 (9.8)	61 (16.5)	0.216
Excessive drinking	188 (9.2)	18 (13.0)	17 (8.8)	0.217	7 (13.7)	40 (10.8)	0.540
Physical activity intensity				0.036			0.074
Insufficient	1,480 (77.1)	99 (76.7)	143 (78.6)		36 (75.0)	273 (78.7)	
Moderate	267 (13.9)	10 (7.8)	25 (13.7)		11 (22.9)	45 (13.0)	
Vigorous	173 (9.0)	20 (15.5)	14 (7.7) §		1 (2.1)	29 (8.4)	
Married	1,388 (68.2)	96 (69.6)	128 (66.3)	0.534	34 (66.7)	248 (67.2)	0.938
Retired	246 (12.1)	18 (13.0)	26 (13.5)	0.910	9 (17.6)	51 (13.8)	0.464

*Comparison between reclassified and non-reclassified participants. $^{\S}p < 0.05$ comparison of the subcategories between the two groups

Table 3 Independent predictors of sleep duration reclassification for participants subjectively classified as short sleepers

	Adjusted odds ratio	*95% Confidence interval*	*p value*	*VIF**
Female sex	2.53	1.32–4.84	0.005	1.19
Self-reported race				1.01
White	Reference	Reference	Reference	
Mixed	0.34	0.16–0.72	0.004	
Black	0.55	0.24–1.24	0.150	
Asian/other	0.30	0.09–0.99	0.049	
Physical activity intensity				1.05
Insufficient	Reference	Reference	Reference	
Moderate	2.16	0.77–6.08	0.145	
Vigorous	0.25	0.09–0.68	0.006	
Lowest SpO_2, %	1.07	1.02–1.13	0.007	1.07
Sleep efficiency, %	1.35	1.24–1.47	<0.001	1.71
WASO, min	1.08	1.05–1.11	<0.001	2.75
Number of awakenings, *n*	1.05	1.01–1.10	0.017	2.29
Insomnia	3.45	1.56–7.62	0.002	1.03

SpO_2, pulse oxygen saturation; *VIF*, variance inflation factor; *WASO*, wake after sleep onset

*Considering that all VIF were less than 10, the hypothesis of the presence of multicollinearity between the predictor variables was not assumed

Table 4 Independent predictors of sleep duration reclassification for participants subjectively classified as long sleepers

	Adjusted odds ratio	*95% Confidence interval*	*p value*	*VIF**
Hypertension	3.36	1.18–9.55	0.023	1.03
Physical activity intensity				1.02
Insufficient	Reference	Reference	Reference	
Moderate	0.48	0.18–1.28	0.142	
Vigorous	5.44	0.62–47.47	0.125	
Monthly per capita family income, US$[(1)]	0.94	0.90–0.99	0.013	1.02
Sleep efficiency, %	0.35	0.25–0.48	<0.001	2.31
Sleep latency, min	0.84	0.80–0.89	<0.001	1.46
WASO, min	0.83	0.79–0.88	<0.001	1.75

VIF, variance inflation factor; *WASO*, wake after sleep onset

*Considering that all VIF were less than 10, the hypothesis of the presence of multicollinearity between the predictor variables was not assumed

Table 5 Classification of participants according to the categorization of sleep duration (SDUR) based on actigraphy (objective) and cross-tabulation with self-reported SDUR (subjective). Blue was considered as the "Under-estimators" of sleep duration (n=423; 20.8%); Orange was considered as the "Over-estimators" of sleep duration (n=1033; 50.7%); Green was considered as the "Accurate-estimators" of sleep duration (n=580; 28.5%). Agreement between self-report sleep duration and sleep duration by actigraphy: agreement=28.49%, weighted Kappa=0.14 (CI95%: 0.11–0.17, p<0.001)

n (%)		Sleep Duration by actigraphy						Total (self-reported)
		< 5	5 - 6	6 - 7	7 - 8	8 – 9	> 9	
Self-report ~~SD~~SDUR	< 5	13 (11.6)	22 (5.0)	25 (3.0)	20 (3.9)	5 (4.5)	0 (0.0)	85
	5 -6	28 (25.0)	75 (17.0)	102 (12.1)	37 (7.2)	3 (2.7)	1 (5.3)	246
	6 - 7	36 (32.1)	201 (45.6)	294 (35.0)	132 (25.7)	32 (29.1)	5 (26.3)	700
	7 - 8	23 (20.5)	98 (22.2)	270 (32.1)	162 (31.5)	27 (24.5)	5 (26.3)	585
	8 - 9	10 (8.9)	41 (9.3)	138 (16.4)	141 (27.4)	35 (31.8)	7 (36.8)	372
	> 9	2 (1.8)	4 (0.9)	11 (1.3)	22 (4.3)	8 (7.3)	1 (5.3)	48
Total (actigraphy)		112	441	840	514	110	19	2036

sleep fragmentation (greater sleep efficiency, longer WASO and greater number of awakenings) as well as higher values of lowest O_2 saturations detected by the portable sleep monitor; (3) The presence of hypertension was independently associated with higher chance of self-reported long SDUR reclassification; (4) Analysis of five SDUR categories (<5, 5–5.99, 6-7.99, 8–9, and >9 h) revealed that the more extreme is the SDUR, the greater the SDUR reclassification.

Our study confirms previous evidence showing poor correlations and agreement of subjective vs. objective SDUR either by using PSG [20] or actigraphy [12, 20–22]. In a recent investigation comparing various forms of SDUR measurements, Matthews and colleagues [20] showed that subjects estimated their usual SDUR as 20 to 30 min longer by self-reports and daily diaries compared with SDUR assessed by PSG and actigraphy. On the other hand, SDUR from PSG was slightly higher than obtained by actigraphy (7 to 20 min, depending on the number of nights evaluated). In our study, the mean SDUR estimated by actigraphy and self-reported were similar, but the Bland–Altman plot showed a limit of agreement that extended approximately 2.5 h up and down. This finding is consistent with previous studies. For instance, Schokman and colleagues [22] observed that self-report consistently over-reporting SDUR on average by almost half an hour compared to objective measures, but wide individual variation in disagreement, ranging from over-reporting by 3.3h to under-reporting by 2.4h. In a highly educated Brazilian population, Campanini and colleagues [21] found that sleep diary and actigraphy showed moderate agreement in assessing SDUR and that participants overestimated SDUR by 23 min compared to actigraphy measures. However, in two other studies, self-report

inquiry underestimated SDUR compared to actigraphy [23, 24]. Thus, the evidence is consistent in questioning the reliability of using self-reported SDUR.

Self-report SDUR depends on the people's ability to remember and retrospectively report this measure accurately. Our findings underscore the limitation of this procedure. Although PSG performed in the sleep laboratory and assisted by sleep technologists is considered the gold standard method for measuring SDUR, objective assessment of SDUR by PSG may not reflect the reality due to the unusual sleep environment, multiple channel monitoring, and limited analysis (usually only one night). Wrist actigraphy [10] and some wearable devices [25] were validated against PSG for measuring SDUR. Although these devices have some limitations regarding the calculation of sleep efficiency [26], these simple tools allowed multiple days of monitoring in the participants' routine. The high frequency of self-reported short and long SDUR reclassification may partially explain the lack of reproducibility of some of the potential consequences of short SDUR evaluated by self-reported when using objective data [3].

One of the main novelties of the present study is the detailed characterization of self-reported short and long SDUR reclassification. It found a considerable overall rate of self-reported SDUR reclassification for short sleepers (59%) and long sleepers (88%). These findings were compatible with the low correlation between self-reported and actigraphy-based SDUR observed in our study (r=0.263). This correlation was similar to observed in a recent report from the Jackson heart sleep study (r=0.28) [12]. Our subanalysis showed that the reclassification was even higher at the extremes of SDUR (Table 5). Previous investigations explored potential factors that may influence SDUR perceptions [9, 23]. Lauderdale and colleagues [9] found the following variables associated with significant discrepancies between self-reported and actigraphy data: younger, Blacks, lower socioeconomic status, participants with general health problems, and lower sleep efficiency. In addition, racial/ethnic disparities in SDUR have been gaining attention [27]. In our study, we found a distinct profile for self-reported short and long SDUR reclassification. For self-reported short SDUR reclassification, the independent predictors of higher reclassification included the presence of insomnia, female, markers of sleep fragmentation (greater sleep efficiency, higher wake after sleep onset and higher number of awakenings), and a hypoxemic parameter related to OSA (lowest O_2 saturation). Interestingly, variables associated with a lower chance of self-reported short SDUR reclassification included mixed and Asian race and vigorous physical activity. For self-reported long SDUR reclassification, while the presence of hypertension was associated with a 3.4-fold higher chance of having reclassification, higher income, higher sleep efficiency, lower sleep latency, and lower WASO were associated with a lower chance of self-reported SDUR reclassification. The precise reasons for explaining why the aforementioned variables were associated with short/long SDUR reclassifications are beyond the scope of this epidemiologic investigation. Insomnia is associated with misperceptions about sleep [28]. Fragmented sleep might also impair our ability to report SDUR appropriately [29]. On the other hand, it is curious that hypertension was associated with a higher frequency of self-reported long SDUR reclassification in our study. Hypertension is usually associated with increased sympathetic activity [30], which may contribute to fragmented sleep (and not reporting long SDUR). The impact of antihypertensive medications, especially at bedtime, might also contribute to our findings, but future studies are necessary to explore this complex scenario.

Our cohort has strengths and limitations to be addressed. We studied a large cohort of a non-referred population with low refusal rates and sleep monitoring failure. We carefully excluded participants under specific OSA treatment as well as medications or job particularities that may interfere in sleep-related symptoms and SDUR (Fig. 1). In addition, the sample allowed us to explore racial/ethnic differences as well as other social and environmental factors associated with SDUR. The following limitations should be acknowledged: (1) the definitions of short and long SDUR vary among studies. As we previously described [3], we based the current definition based on the distribution of SDUR observed in the ELSA-study. A similar definition was used by others [15]. Our sub-analysis stratifying the SDUR in 5 categories showed the SDUR reclassification is huge mainly in the extremes (such as <5 and >9 h); (2) the actigraphy uses movement as a surrogate for sleep. It is conceivable that some periods of low activity in patients with insomnia may be scored as sleep, contributing to self-reported SDUR reclassification. Therefore, the results obtained for participants with insomnia (11% of our sample) may be interpreted with caution. However, a recent investigation using polysomnography data in patients referred to sleep studies consistently reported that insomnia was an independent predictor of SDUR misperception (defined by the ratio of subjective and objective values) [31]; (3) like observed in other investigations [11, 12], we did not use sleep diary to define subjective SDUR. This option followed the usual way by which physicians and several epidemiological studies captured SDUR; (4) we did not report the actigraphy analysis on a daily basis but the mean of 7-day period data. Future studies addressing night–night variability will be interesting to understand the magnitude of self-reporting SDUR reclassification on weekdays versus weekend.

In conclusion, self-reported and objective sleep measures are weakly associated. We observed a significant rate of self-reported short/long SDUR reclassification when using objective data. These findings may affect the interpretation

of studies addressing the consequences of short/long SDUR using subjective data.

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Declarations

Ethics approval This study has been approved by the local Ethics Committee, under number 1166/11, in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Informed consent Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare no competing interests.

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