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Agreement analysis of sleep patterns between self-reported questionnaires and actigraphy in adults

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Abstract

Purpose To investigate the agreement in sleep pattern recording by self-reported sleep questionnaires and actigraphy in adults.

Methods This is a cross-sectional study. Men and women who met inclusion criteria were recruited for this study. The inclusion criteria were apparently healthy Omani nationals ages 19 to 50 years. Sleep questionnaires were randomly distributed in Muscat either directly or via electronic and paper announcements. Data were collected from the participants using the self-reported questionnaires with four piloted questions for sleep pattern identification and through the actigraphy wristband given to subjects to wear for a week. Cohen's kappa test was performed for agreement analysis.

Results A total of 964 Omani subjects between ages 18 and 59 years of both genders were recruited and completed the questionnaires successfully. Out of these, only 321 subjects wore the actigraphy wristband for 1 week (response rate = 33%). Agreement analysis reported a mild level of agreement for the monophasic (41%), moderate level for biphasic (59%), and good level for polyphasic (70%) sleep patterns. The overall agreement level of sleep patterns between the two methods was 57%. There is a low specificity of self-reported assessment in reporting sleep pattern.

Conclusion The average agreement level of subjective versus objective assessments of sleep patterns was moderate at 57% and self-reported sleep pattern is not specific. The study recommends the use of actigraphy along with sleep questionnaires for accurate assessment of sleep patterns in cohort studies.

Keywords Sleep patterns · Sleep study · Validity · Agreement analysis

Introduction

Rapid development and lifestyle transitions have changed work-life, nutrition, and socialization, as well as altered sleep behavior and patterns [1]. An individual's sleep pattern is defined as the clock-hour schedule/plan of sleep and wake up times including nap habits as well as any sleep disruptions [2]. It is important to study an individual's sleep patterns as they are an indication of one's physiological and psychological performances [3]. Short sleep duration and poor sleep quality cause adverse effects on the body's physiological processes and are associated with increased risk of cardiometabolic disorders [4]. It means that poor sleep pattern characterized by short night duration, long siesta, and segmented sleep is associated with poor sleep quality, daytime sleepiness, and increased risk of cardiovascular disorders (physiological performance). Poor sleep pattern is also linked to depression, lack of attention, concentration, memory, and logical thinking in a person's day-to-day life (psychological performance). A study by Al-Abri et al [1] showed that biphasic and polyphasic sleep patterns were associated with short night sleep duration and long siesta and represented fragmented sleep in terms of frequent sleep episodes per day. These behavioral sleep patterns may alter sleep homeostasis and impair the circadian rhythm

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and can cause sleep phase shift that may negatively affect body physiological functions [3, 4].

Convenient self-reported questionnaires such as the Epworth Sleepiness Scale (ESS) [5] and Pittsburgh Sleep Quality Index (PSQI) [6] are evaluation tools that can be used to assess sleep quality, patterns, and timing. These subjective assessments of sleep are useful in research and routine practices, require slight supervision, and can easily be scored and maintained [7]. Several studies reported the reliability and validity of these questionnaires for sleep assessment, though only to a certain degree, due to their reliance on the cognitive and understanding capacity of subjects to reflect on their sleeping habits over the past week or month in answering the questions [8]. These retrospective tools could lead to a recall bias resulting in reduced accuracy or precision of sleep quality results [9]. Furthermore, these tools are lengthy to administer and are cumbersome for epidemiologic studies [10]. On the other hand, objective tools such as actigraphy allow 24-h recording in a home setting and are recommended by the American Academy of Sleep Medicine as an acceptable accurate estimate of sleep parameters [10]. It is advised to use actigraphy concurrently with the self-reported questionnaires to ensure accurate and consistent estimation of sleep timing and duration [11]. Investigating the agreement between subjective and objective sleep assessments is vital in population-based sleep research for accurate measurements, hence better diagnosis and treatment [12]. The previous reported validity assessments measured the agreement in sleep duration and latency and wake after sleep onset and nocturnal waking but not on sleep pattern recordings [13]. Given the increasing number of studies showing low or poor agreement between subjective and objective assessments of sleep parameters [9], the current study aimed to assess the validity of subjective versus objective assessments of sleep patterns in adults.

Methods

Study population

The study design is a cross-sectional study and no allocation was performed into multiple groups, and we described that subject recruitment was based on a random enrollment to the study with no selection method applied. For actigraphy sample, random enrollment was also based on random call to accept to wear actigraphy wristband. The method of study was reported earlier in previous publication [1]. A total of 946 apparently healthy adult participants of both genders completed the sleep questionnaires successfully. Out of these participants, 321 agreed to wear the actigraphy wristbands (SOMNOwatch™ plus, SOMNOmedics, Germany, 2014) for 7 consecutive days. The following instructions were given to each participant: to wear the watch day and night for a full week; to make sure that the watch is in contact with skin; to press on the marker button daily when in bed before sleep, whether it is night or day sleep; to not remove the watch unless taking a bath; and to return the device to the clinic after 1 week for data upload. Data collection was done in summer between months of April to October to limit seasonal variation in sleep patterns and also to avoid the Muslim fasting month of Holy Ramadhan. Participants were Omani nationals of 18–59 years of age and individuals were excluded if they met any of the following criteria: past/present medical history of cancer, stroke, compensated cardiovascular disease, psychiatric illness, pregnant, breast-feeding women, mothers having children below 1 year, and shift workers. The study was approved by the Medical Research Ethics Committee at Sultan Qaboos University (#MREC- 878).

Study parameters

The demographic and anthropometric data were collected from each participant. They were asked to fill the ESS [5] and PSQI [6] to measure sleep latency, usual sleep duration, and daytime sleepiness. Four additional questions were added to the sleep questionnaires to collect information on usual sleep patterns and sleep duration at night, at dawn, before sunset, and in the afternoon during the week. The questions were piloted prior actual implementation to ensure their internal validity and consistency, and as follows: (1) Do you sleep after dawn prayer usually? (Yes or No); (2) How long do you sleep after dawn prayer in minutes usually? (3) Do you sleep in the afternoon usually? (Yes or No); (4) How long do you sleep in the afternoon in minutes usually? The actigraphy wristband was also given at the same day to the participants to wear for a week and they were asked to return the completed questionnaires and the actigraphy after the week. The actigraphy was used to collect data on sleep patterns, sleep latency, and duration using the DOMINO light software (SOMNOmedics, Germany, 2014) supplied with the sleep watch. The generated report will provide information related to many parameters such as sleep patterns, time in bed, wake up time, sleep latency, total night sleep duration, total day sleep duration, and total siesta duration. Manually scored timing and duration were performed in all records to ensure accuracy. For each individual, the objective sleep pattern per week was generated and visualized via the software as images or figures post scoring. For individuals with variable sleep patterns in a week, the predominant sleep pattern was used, defined as four or more times of the same sleep pattern per week, which is more than 50% [14]. For example, a person who practiced a single sleep episode per day for ≥ 4 times per week was considered a monophasic sleeper. Another person who showed night sleep and dawn sleep for ≥ 4 times per week was categorized as a biphasic-dawn sleeper. An individual who showed night sleep and siesta sleep for ≥ 4 times per

week was classified as a biphasic-siesta sleeper, and expressing multiple sleep including night sleep plus both dawn sleep and siesta for ≥ 4 times per week was considered a polyphasic sleeper.

Statistical analysis

Descriptive analysis was performed to calculate the frequency, percentages, medians, and ranges of the continuous data. Cohen's kappa test was used to test the agreement level in sleep patterns identified by self-reported sleep questionnaires and actigraphy. Actigraphy sleep pattern was taken as the gold standard. Percentage positive agreement in a given sleep pattern was calculated from the number of individuals identified with the given sleep pattern self-reported questionnaire while percentage negative agreement for a given sleep pattern was calculated from the number of participant which was not identified for the sleep pattern by the two tests. Total agreement is the average for positive and negative agreements. p values of < 0.05 were considered statistically significant. The Statistical Package for the Social Sciences (SPSS, version 21) (IBM, Chicago, USA) was used for all statistical analysis.

Results

A total of 964 subjects (42.8% male and 57.2% female) completed the questionnaires, out of which only 321 subjects agreed to wear the actigraphy wristband for 1 week (53.3% male and 46.7% female). The median age of the subjects who completed the self-reported questionnaires was 27 years (range: 41) in which 79.6% were young adults (18–39 years old). The rest of the demographic data are described in Table 1.

Sleep patterns measured by self-reported questionnaires versus actigraphy

Reported sleeping patterns were classified into three fundamental groups: monophasic (single episode of sleep per day), biphasic (two episodes of sleep per day), and polyphasic (≥ 3 episodes of sleep per day). An example of each sleep pattern is shown in the actigraphy wristband results in Fig. 1. The sleep questionnaire analysis showed prevalence of polyphasic sleep pattern as 46%, biphasic as 42.6%, and monophasic as 11.4%. The subjective biphasic sleep pattern was further split into two subgroups: (a) biphasic-dawn (21.6%), who sleeps at night once and another period of sleep after dawn prayer and (b) biphasic-siesta (21%), who sleeps at night once and also in the afternoon as siesta (Fig. 1). Actigraphy reports showed the same with different distributions for sleep patterns (Fig. 2 and Table 2): monophasic (24.3%), biphasic-dawn (9%), biphasic-siesta (36.1%), and polyphasic sleep pattern (30.5%). We observed gender difference in distribution of different sleep patterns measured by actigraphy (p value 0.037) as shown in Table 2. Male subjects had more polyphasic (53.1%) and biphasic-siesta (62.1%) sleep patterns, while female subjects had more monophasic (55.1 %) and biphasic-dawn (58.6) sleep patterns.

Agreement in sleep pattern recording between self-reported and actigraphy assessments

We tested the agreement between the sleep pattern by self-reported and actigraphy assessments of 321 subjects using Cohen's kappa test. The total number of sleep pattern reported by each assessment is listed in Table 3. The overall agreement levels observed for three different sleep patterns based on both assessments were 40.9% for monophasic (p value 0.001), 59.1% for biphasic (p value 0.001), and 69.5% for polyphasic

Table 1 Descriptive data of study subjects based on self-reported questionnaires

	Total	Men	Women	p value
n (%)	946	405 (42.8%)	541 (57.2%)	
Age in years	27 (41)	32 (41)	23 (41)	
Age groups, n (%)				
18–39 years (young adults)	753 (79.6)	297 (73.3)	456 (84.3)	< 0.0001
40–59 years (middle age)	193 (20.4)	108 (26.7)	85 (15.7)	
Educational status, n (%)				
Pre-college school	60 (6.2)	23 (5.6)	36 (6.6)	0.587
Undergraduate	793 (82.8)	345 (83.3)	448 (82.4)	
Postgraduate	93 (11)	36 (8.9)	57 (10.5)	
Employment status, n (%)				
Employed	898 (94.9)	395 (97.5)	503 (93)	0.003
Unemployed	48 (5.1)	10 (2.5)	38 (7)	

Data shown are median and range. Categorical data are reported as count (%) and were analyzed using the chi-square test

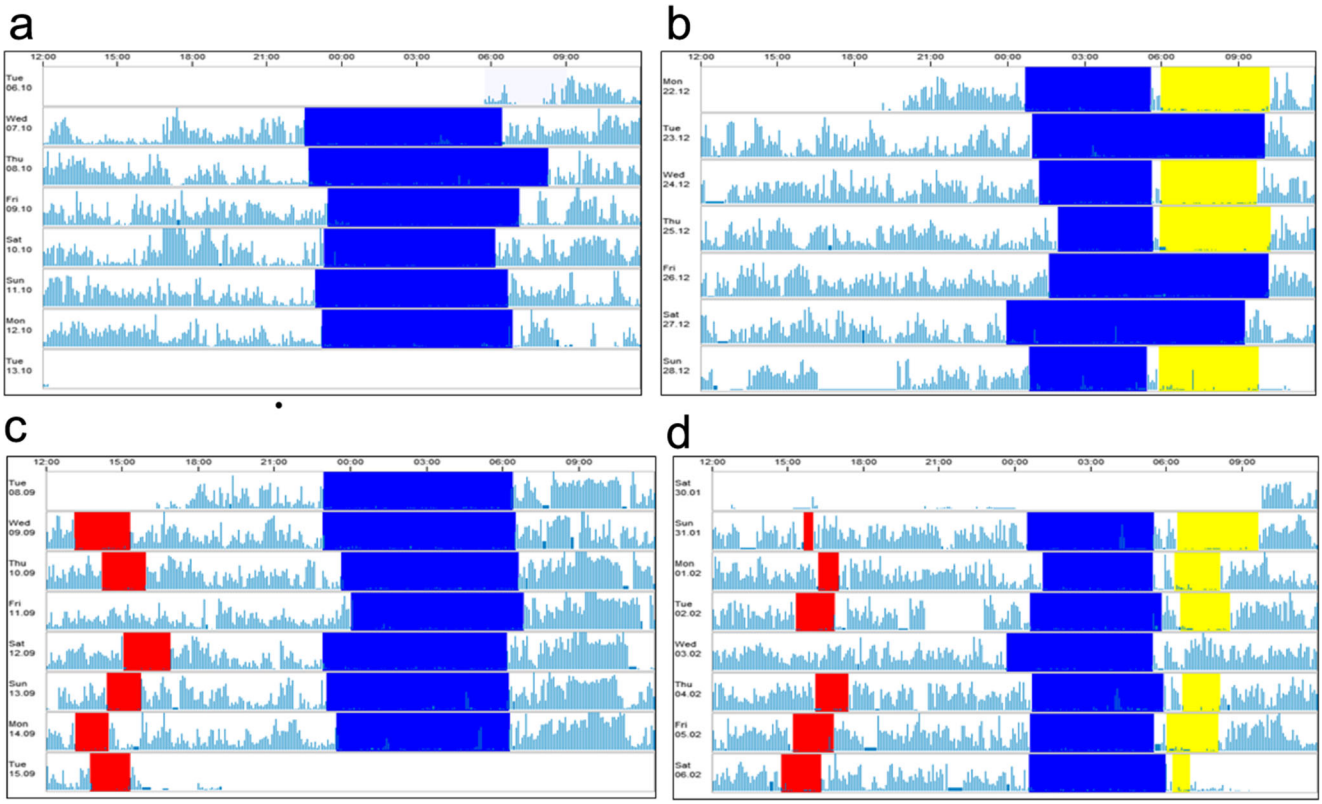

Fig. 1 Sleep patterns reported by actigraphy. Each row is a sleep recording of 1 day. Blue-colored regions are night sleep, red-colored regions show the afternoon siesta sleep, and yellow-colored regions show the after dawn sleep. **a** Monophasic sleep pattern. **b** Biphasic-dawn sleep pattern. **c** Biphasic-siesta sleep pattern. **d** Polyphasic sleep pattern

(p value < 0.0001) sleep pattern. The average agreement level for all sleep patterns between the two methods was moderate (56.5%). Positive agreement between the two assessments was higher in reporting monophasic sleep pattern and was lower when reporting biphasic and polyphasic sleep patterns (Table 3). Because of the objective nature of actigraphy assessment and quality (http://somnomedics.eu/solutions/sleep_diagnostics/actigraphy/somnowatch-plus-actigraphy/), we considered it as reference assessment and reported the specificity of the self-reported questionnaire method. A higher specificity of 70.2% (95% CI: 63.8–76.1%) was reported for polyphasic sleep pattern (Table 3). Lower specificity was observed for other sleep patterns.

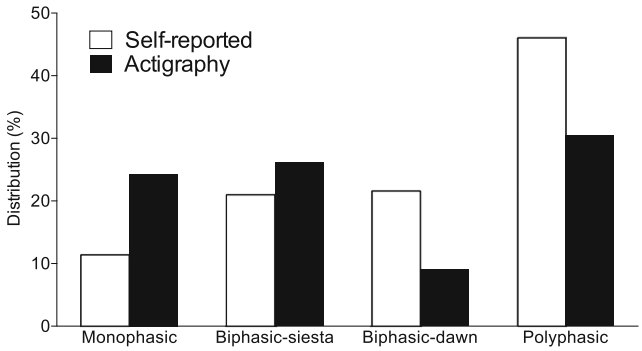

Fig. 2 Distribution of sleep patterns in the study sample measured by self-administered sleep questionnaires and actigraphy. Data shown are % out of total. n = 946 (questionnaire) and 321 (actigraphy)

To test the effect of age, gender, and education levels, we analyzed the total agreement between the two assessments (Table 4). Percentage agreement in monophasic sleep reporting was higher in subject below 40 years old (46.2% vs. 29.4%), while agreement in reporting biphasic and polyphasic sleep patterns was lower in this age group. A similar pattern was observed in male subjects in which a lower agreement was observed in reporting biphasic and polyphasic sleep patterns. Participants with education levels of high school diploma and below had higher agreement in reporting the biphasic and polyphasic sleep patterns. The difference observed in the agreement between the groups of each of the three confounding factors was not significant.

Discussion

The current study assessed the level of agreement between subjective (self-reported) and objective (actigraphy) sleep patterns in adults. We observed differences in reported sleep pattern distributions and moderate overall agreement between the two methods. Both methods reported more biphasic and polyphasic sleep patterns in adults. The results showed mild level

Table 2 Characteristics of subjects with different sleep patterns recorded by actigraphy

	Total	Monophasic	Biphasic-dawn	Biphasic-siesta	Polyphasic	*p* value
n (%)	321	78 (24.3)	29 (9.0)	116 (36.1)	98 (30.5)	
Gender, *n* (%)						
Men	171 (53.3)	35 (44.9)	12 (41.4)	72 (62.1)	52 (53.1)	0.037
Women	150 (46.7)	43 (55.1)	17 (58.6)	44 (37.9)	46 (46.9)	
Age (years)	31 (41)	31 (38)	31 (34)	29 (38)	34 (40)	0.071
Age groups, *n* (%)						
18–39	223 (69.5)	60 (76.9)	19 (65.5)	85 (73.3)	59 (60.2)	0.042
40–59	98 (30.5)	18 (23.1)	10 (34.5)	31 (26.7)	39 (39.8)	

Data shown as count (*n*) and percentage (%), for age: median and range in brackets are shown. Categorical data were analyzed using the chi-square test

of agreement for monophasic sleep pattern, moderate level of agreement for biphasic sleep pattern, and good level of agreement for polyphasic sleep pattern. Sleep patterns and sleep quality including sleep adequacy are well studied and put out by our recent paper published on April 14, 2020 [1]. Therefore, we sought to focus on the validation of sleep patterns using two different methods in the current study.

Several reasons may exist as to why actual objective sleep does not reflect self-reported sleep. The mild level of agreement in monophasic sleep pattern could be attributed to unexpected pattern changes in the usual sleep pattern on certain days or weeks. For example, some subjects stated that their usual subjective sleep pattern is monophasic. However, actigraphy reported biphasic sleep as the predominant pattern in that particular week. This may be attributed to recall bias regarding what the participants used to do, but in reality, they were not practicing it at the time of the study. Another reason that led to moderate but not strong agreement of biphasic and polyphasic sleep patterns is dawn sleep. For instance, some participants stated that their usual sleep pattern subjectively is polyphasic including night sleep, dawn sleep, and siesta, yet this pattern was found to be biphasic based on actigraphy assessment. The main reason was that those subjects with usual polyphasic sleep pattern based on questionnaires did not get up for dawn prayer at that particular week for more than 3 times, and therefore had only a consolidated night sleep and siesta in the afternoon, thus, showing a biphasic-siesta sleep pattern rather than polyphasic. This particular reason increased the prevalence of biphasic-siesta sleep pattern based on actigraphy as compared to questionnaire-basis in this study. It is obvious that our results imply that sleep patterns among adults are not absolute or fixed. In fact, it can be influenced by various factors such as technology, environmental, behavioral, cultural, and religious aspects, and hence might reduce the association strength of sleep pattern based on subjective and objective assessment tools and may not signify a complete representation of sleep habits [12]. Moreover, individuals cannot recall exactly their usual sleep pattern including sleep duration based on a self-reported tool, and can be affected by experiences, memories, and recall bias on the information provided subjectively which certainly reduced the agreement levels of sleep patterns and habits between both methods [9]. Although there was a difference observed in the agreement between the groups of each of the three confounding factors—age, gender, and educational level—it was not significant.

Table 3 Agreement analysis of reported sleep patterns by self-reported and actigraphy assessments in 321 subjects

	Monophasic	Biphasic	Polyphasic
Actigraphy (*n*)	147	138	100
Self-reported (*n*)	187	147	135
Positive agreement (%)	42.5	53.3	57.9
Negative agreement (%)	39.2	63.6	76.1
Overall agreement (%)	40.9	59.1	69.5
Kappa *p* value	0.001	0.001	< 0.0001
Specificity of self-reported (95% CI)	34.8 (27.9–42.3)	62.0 (54.7–69.0)	70.2 (63.8–76.1)

n, number of positive reported sleep pattern; % Positive agreement, percentage of total subjects reported the assigned sleep pattern by both assessments; % Negative agreement, percentage of total subjects not reported the assigned sleep pattern by both assessments; % Overall agreement, percentage of positive and negative agreements by both assessments; Kappa *p* value, *p* value of Cohen's kappa test

Table 4 Effect of confounding factors on sleep pattern agreement between self-reported and actigraphy assessments

Factor	Group	Number	Sleep pattern agreement		
			Monophasic	Biphasic	Polyphasic
Age	< 40 years	220	46.20%	53.80%	65.90%
	40 years and above	101	29.40%	70.60%	77.40%
Gender	Male	171	42.70%	57.20%	66.50%
	Female	150	38.80%	61.20%	73.00%
Education level	Below Bachelor's degree	56	37.90%	62.10%	74.10%
	Bachelor's degree and above	265	41.50%	58.40%	68.50%

Agreement shown as percentage total agreement between the two tests

To our knowledge, the findings of our study in relation to the subjective versus objective agreement levels of sleep patterns are unique and not revealed by any previous studies. We assessed the validity of sleep patterns subjectively and objectively in terms of sleep frequency per day for one full week and found moderate validity between the two methods; however, other studies that examined other sleep parameters such as night and day sleep durations rather than sleep patterns related to frequency found poor or no agreement between both methods [12]. For example, a Brazilian study with a small sample size showed no agreement in nocturnal sleep duration between self-reported questionnaires and 1-week actigraphy assessment in thirty-seven subjects, aged 12–17 years [15]. Another study stated similar findings to the Brazilian study which reported that the agreement levels of total sleep duration from questionnaires and actigraphy were insufficient and were subjectively influenced by recall bias when compared with our study findings [16, 17]. Apparently, the findings of mild agreement in relation to monophasic sleep patterns are partially consistent with the estimated discrepancies between the two assessment methods of the previous studies that showed poor agreement level [15–17]. On the contrary, the results of biphasic and polyphasic sleep patterns, which revealed moderate and good agreement levels, contradict with the previous studies among both tools.

Interestingly, biphasic sleep pattern at night was practiced by Omani residents of Muscat in the early nineteenth century as stated by Shaik M. Seyd Said, Sultan of Muscat. They were said to be lying down before 10 pm so that before midnight, their first sleep is usually over. The second sleep was experienced post-midnight wake up [18]. However, the current practice of biphasic sleep is to wake up for Dawn pray which is around 4 am during summer time and many people go back to sleep again for the second phase of sleep until late morning [1]. This could be attributed to an inherited tradition or acclimatization by the local people to the hot weather particularly in summer, and sometimes it is of necessity to wake up early to avoid excoriating heat during the day.

Biphasic sleep is well known since a long time and it is also mentioned in holy Quran (and among his signs is your sleep by night and day, and your cravings are among his virtues indeed in that are signs of a people who hear) Chapter 30, Verse 23. Nevertheless, it has never been reported in scientific literature particularly in this part of the world. In the text book by John Booth, published 1819, there is only one sentence describing the pattern of sleep in people of Muscat (p. 108). There were no details or indication if that was a common tradition among the people of Oman. The objective of this study is to validate a questionnaire-based sleep pattern with an objective method such as actigraphy which clearly indicates that there might be recall bias with self-reporting.

The clinical relevance of validating sleep patterns can be explained in context by patients presenting with insomnia. In our local community, people's sleep patterns and habits might be different from other communities and we have presented that in previous publications. Many patients reported insomnia or lack of sleep, but apparently, they have a sleep pattern with phase shift or long siesta and that can only be confirmed with actigraphy. Furthermore, knowing and validating sleep patterns can increase the awareness related to the role of healthy sleep as a public health issue and therefore can lower the prevalence of poor sleep hygiene.

The majority of participants included in the study are young adults (18–39 years) and were more than the middle-aged group. This inequality in the age group distribution could have affected the findings of the study and limited the outcome to a certain age group that could not reflect the definite characteristics of middle- and old-aged groups. In conclusion, moderate agreement of 56.6% was observed in sleep pattern measurement between sleep questionnaires and actigraphy. Objective assessment of sleep patterns using actigraphy should be used concurrently with the self-reported questionnaires to ensure accurate and consistent estimation of sleep parameters.

Authors' contribution All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Ibtisam Al Lawati, Fahad Zadjali, and Mohammed A Al-Abri. The first draft of the manuscript was written by Ibtisam Al Lawati and all authors commented on the previous version of the manuscript. All authors read and approved the final manuscript.

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Data availability Not applicable

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval The questionnaire and methodology for this study were approved and supported by the Medical Research Ethics Committee at Sultan Qaboos University under MREC- 878.

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

Code availability Not applicable

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