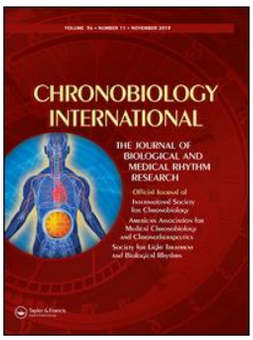

Taylor & Francis
Taylor & Francis Group

Chronobiology International

The Journal of Biological and Medical Rhythm Research

ISSN: 0742-0528 (Print) 1525-6073 (Online) Journal homepage: https://www.tandfonline.com/loi/icbi20

Is social jetlag similar to travel-induced jetlag? Results of a validation study.

Patrice de Souza Tavares, Marina Xavier Carpena, Caroline Maria de Mello Carone, Bianca Del-Ponte, Iná S. Santos & Luciana Tovo-Rodrigues

To cite this article: Patrice de Souza Tavares, Marina Xavier Carpena, Caroline Maria de Mello Carone, Bianca Del-Ponte, Iná S. Santos & Luciana Tovo-Rodrigues (2020): Is social jetlag similar to travel-induced jetlag? Results of a validation study., Chronobiology International, DOI: 10.1080/07420528.2020.1712413

To link to this article: https://doi.org/10.1080/07420528.2020.1712413

CHRONOBIOLOGY INTERNATIONAL
https://doi.org/10.1080/07420528.2020.1712413

Taylor & Francis
Taylor & Francis Group

Is social jetlag similar to travel-induced jetlag? Results of a validation study.

Patrice de Souza Tavares[a,b], Marina Xavier Carpena[b], Caroline Maria de Mello Carone[b], Bianca Del-Ponte[b], Iná S. Santos[b,c], and Luciana Tovo-Rodrigues [b]

[a]Postgraduate Program in Psychology, Laboratory of Experimental Psychology, Neuroscience and Behavior, Federal University of Rio Grande do Sul– UFRGS, Porto Alegre, Rio Grande do Sul. Brazil; [b]Postgraduate Program in Epidemiology, Federal University of Pelotas–UFPEL, Pelotas, Rio Grande do Sul, Brazil; [c]Postgraduate Program in Pediatrics and Child Health, School of Medicine, Pontifical Catholic University of Rio Grande do Sul – PUCRS, Porto Alegre, Rio Grande do Sul, Brazil

ABSTRACT

Social jetlag (SJL) is defined as the misalignment between the biological clocks and the social clock imposed by work and social constraints. In order to accomplish the workdays duties, people tend to not respect the internally sleep-wake cycle during the week, often using alarm clock to wake-up, which would lead to a chronic form of travel-induced jetlag. This circadian misalignment has been found to be associated with increased health risk and health-impairing behaviors. In this cross-sectional study, we aimed to explore whether the SJL is a valid concept for the travel-induced jetlag symptoms, as well as what is the cutoff point with best parameters for defining the presence of SJL, in a sample of undergraduate students of a university in Southern Brazil. We assessed SJL by the Munich ChronoType Questionnaire (MCTQ) and defined the concept as the difference between the midsleep point on free days and the midsleep point on classes days. The gold standard was defined as having at least one travel-induced jetlag symptom (fatigue, sleepiness or difficulty concentrating). Relative SJL, sensitivity and specificity were calculated for different cutoff points, plotted on ROC curves. A total of 452 students with complete sleep information were included in the analysis. The relative SJL mean was 2 h 23 min (SD = 1 h 24 min; range −3 h to 7 h 58 min) and 63.7% of the students had ≥2 h of relative SJL. All the tested cutoff points of the instrument had low sensitivity and specificity values, covering a small area under the ROC curve (0.487). The best parameters were for the cutoff point ≥2 h, with 63.4% sensitivity and 35.9% specificity. SJL did not revealed to be a valid concept for the studied sample comparing it to travel-induced jetlag symptomatology. One possible explanation for the lack of validity of our results regards the fact that SJL may not have the same apparent wide-term effects as the travel-induced jetlag. Then, the symptoms of SJL do not well represent the symptoms of travel-induced jetlag.

ARTICLE HISTORY
Received 17 August 2019
Revised 30 November 2019
Accepted 22 December 2019

KEYWORDS
Social jetlag; Validation study; University students; Circadian misalignment; School starting time

Introduction

Social Jetlag (SJL) is defined as the misalignment between biological preferences of an individual's sleep schedules (biological clocks) and social demands and obligations such as work, studies and events, which require specific sleep timing (social clock) (Wittmann et al. 2006). Individuals respect their biological preferences for sleep timing on free days and opt for alternatives that allow them to achieve with social demands, such as the use of alarm clocks during working days, which could generate misalignment (Roenneberg et al. 2012).

Sleep times becomes progressively later throughout puberty and adolescence (Roenneberg et al. 2004). These developmental changes in circadian timing, in combination with the fact that school start times are not tuned to the generally late sleep habits of teenagers, lead to a peak of SJL at around the end of adolescence (Roenneberg et al. 2019). This is why teenagers show the largest discrepancy in sleep duration between free days and workdays compared to all other ages (Roenneberg et al. 2012). Although SJL is most acute during adolescence, it typically continues throughout active work life until retirement (Roenneberg et al. 2019).

The SJL nomenclature derives from the analogy with the travel-induced jetlag syndrome caused by transmeridian flights (jetlag), as introduced by

CONTACT Luciana Tovo-Rodrigues luciana.tovo@gmail.com Postgraduate Program in Epidemiology, Federal University of Pelotas, Rua Marechal Deodoro, 1160, Centro, Pelotas, Rio Grande do Sul CEP 96020-220, Brazil
Supplemented data of this article can be publisher's website.

Roenneberg et al. (2012). Basically, the travel-induced jetlag results from a misalignment between the internal circadian clock and the external environment as a result of rapid travel across multiple time zones (Baron and Reid, 2014). This transitory circadian misalignment has symptoms that range from decreased concentration, tiredness (fatigue), daytime sleepiness to changes in cognitive function, malaise, and gastrointestinal upset (Fiebach et al. 2007). Thus, the analogy could be explained as if the same individual lived in two different time zones: one on working days (social clock) and one on free days (biological clocks) and needed to travel across time zones every week to accomplish her/his working duties (Roenneberg et al. 2019). The effects of SJL would be similar to those regarding traveling across several time zones toward west on Friday night and returning east on Monday morning (Roenneberg et al. 2019). Likewise, in SJL, the weekly occurrence of sleep deprivation pattern on days of activities and free days compensations would place the individual in a chronic circadian misalignment, leading to travel-induced jetlag symptoms and negative health outcomes in long-term exposure (Wittmann et al. 2006).

SJL has been associated with unhealthy behaviors and health problems, such as smoking (Lang et al. 2018), increased consumption of alcohol or caffeine (Roenneberg et al. 2012), physical inactivity (Rutters et al. 2010), obesity (Roenneberg et al. 2012), metabolic dysfunctions (Parsons et al. 2015; Wong et al. 2015), psychiatric disorders (Polugrudov et al. 2016) and the worst academic performance among university students (Haraszti et al. 2014). However, the criteria used in these studies to define who is experiencing SJL is unclear. A review study on SJL research across different populations and lifespan (Beauvalet et al. 2017) suggested that the role of SJL remains unclear, with some studies observing significant associations between SJL and health risks, but others not. The lack of homogeneity across populations and study methodologies has been identified as problematic in comparing research involving SJL (Beauvalet et al. 2017).

Given the heterogeneity across studies methodologies, another point that should be taken into account is the differences in the prevalence of SJL with the same cutoff points. For example, for a cutoff point of ≥1 h of SJL, the prevalence varies from 24% to 69% (Koopman et al. 2017; Roenneberg et al. 2012; Rutters et al. 2014). These differences enhance the need of validation studies for the establishment of cutoffs with appropriate and validated parameters. Therefore, the establishment of a cutoff point will not only contribute to the homogeneity of future studies but may also answer what are the limits of circadian misalignment for the onset of symptoms.

Thus, taking into account that no study has so far used the symptoms of travel-induced jetlag to assess the validity of the analogy suggested by the literature and to find a cutoff for SJL, the aim of the present study was to investigate the validity of the SJL concept, as well as to evaluate a cutoff point for SJL, taking the presence of travel-induced jetlag symptoms as the gold standard, in a population of university students in the southern Brazil.

Methods

Design

The present validation study is nested in the larger study "Health of the University Student of the Federal University of Pelotas". Federal University of Pelotas (UFPel) is a public institution of higher education, financed by the Brazilian Federal Government, located in the city of Pelotas, Rio Grande do Sul (Brazil). By the time of the study, UFPel had 16,461 undergraduate students, 2,603 postgraduate students and 1,455 faculty members.

Sample

The larger study included students who joined the UFPel in the first semester of 2017, being eligible those aged 18 or over, regularly enrolled in subjects of the second semester of the same year in any of the 83 undergraduate courses. For the current study, only those students who reported having had classes on Monday morning during the month before to the interview were eligible. This criterion was adopted based on the current knowledge about SJL (Roenneberg et al. 2012). Considering that during weekends or free days individuals meet the needs of their biological

clocks, those with social demands on Monday morning would be the most susceptible to presenting SJL symptoms (Roenneberg et al. 2012). The exclusion criteria used by Roenneberg et al. (2012) were also applied: Sleep duration of less than 3 h or greater than 13 h on classes days; sleep duration of less than 3 h on free days; use of alarm clock on free days; inability to freely choose rest times; having more than 6 days of activities per week; or work in night shifts.

Data collection occurred between November 2017 and July 2018 by self-administered questionnaires on tablets using the RedCap system (Harris et al. 2009). Prior to data collection, a pilot study was conducted among undergraduate students from another university, aiming to test the understanding of the questions.

Social jetlag

The SJL evaluation was performed using the Munich ChronoType Questionnaire (MCTQ) (Roenneberg et al. 2012). This instrument asks questions about sleep and wake behavior, carefully distinguishing between bedtimes and sleep times, separately for days of activities (including academic or work activities) and free days. This separation is unique to the MCTQ and turned out to be one of the questionnaire's most useful characteristics (Roenneberg et al. 2019). Also, MCTQ derived sleep parameters showed a good correlation with cortisol and melatonin rhythms (Lazar et al. 2013; Roenneberg et al. 2007), and a convergent validity against actigraphy (Santisteban et al. 2018; Ryu et al. 2018).

The SJL was defined as the difference between the midsleep point in the free days and the midsleep point on the classis's days, obtaining the measurement in real time (Wittmann et al. 2006), as follows:

$$\text{SJL} = (\text{Midsleep time on free days}) - (\text{Midsleep time on classes days})$$

$$\text{Midsleep time} = \text{Sleep onset} + (\text{sleep duration}/2)$$

We used the two SJL measurements that are frequently addressed in the literature: Relative SJL (relative difference between the midsleep point on free days and the midsleep point on classes days, which can be negative or positive) and the absolute SJL (the modulus of relative SJL).

Gold standard

The gold standard was defined as the presence in the last month of at least one symptom of the travel-induced jetlag on Monday mornings: 1) fatigue greater than usual, 2) diurnal sleepiness greater than usual, 3) difficulty concentrating (Fiebach et al. 2007). These symptoms were assessed by three questions: 1) On Mondays of last month, after getting out of bed, you felt: a) more tired than usual; b) less tired than usual; c) as tired as usual; 2) On Mondays of last month, after getting out of bed, you felt: a) more sleepy than usual; b) less sleepy than usual; c) as sleepy as usual; 3) Last month, your ability to concentrate during the first Monday morning class was: a) greater than usual; b) lesser than usual; c) same as usual. Those who replied that they felt more tired than usual or more sleepy than usual or that the ability to concentrate was lesser than usual, were considered as presenting jetlag symptoms.

Covariates

To characterize the sample, we included variables based on a theoretical model, adding demographic, socioeconomic and behavioral variables previously reported as associated with SJL. The following variables were used: Sex (male and female), age (in years, 18–19, 20–22, and 23 years old or more), paid work (yes/no), self-reported skin color (white, black or other), family socioeconomic status (A, B, C, D-E) (Associação Brasileira de Empresas de Pesquisa 2008), bedroom sharing (yes/no), physical activity in leisure time (<150 min per week or ≥150 min per week) (Matsudo et al. 2001), current smoking (yes/no), and harmful use of alcohol (yes/no) (Babor et al. 2001).

The economic status was assessed using the Brazilian Economic Classification Criterion instrument (Associação Brasileira de Empresas de Pesquisa 2008), which allows the stratification of the sample in five economic classes (A to E), based on the participants' answers, regarding the ownership of goods, presence of a monthly paid housekeeper and schooling of the householder. This variable was later categorized in four categories (A, B, C, D–E). The categories D and E were merged because of the small sample size of the last category (E).

The instrument used to measure the level of physical activity in leisure time was the leisure section of the International Physical Activity Questionnaire (IPAQ) (Matsudo et al. 2001), designed to assess physical activity during the last 7 days prior to the interview or during a "typical week." The questions investigate the frequency and duration of the moderate and vigorous physical activities and walking. Physically inactive participants were those who reported a duration of less than 150 min per week of moderate physical activity or less than 75 min per week of vigorous physical activity.

To define current smoking, we used a question about smoking during the last month, with the following answer options: a) Yes, I smoke one or more cigarettes per day; b) No, I have never smoked; c) I have already smoked, but I quit. Current smokers were defined as those who reported smoking one or more cigarettes per day.

The harmful use of alcohol was evaluated by the Alcohol Use Disorders Identification Test (AUDIT), a 10-item screening tool developed by the World Health Organization to assess alcohol consumption, drinking behaviors, and alcohol-related problems. The scores vary between 0 and 40. "Harmful use" was defined by score ≥8 points (Babor et al. 2001).

Data analysis

We described the sample presenting the absolute and relative frequencies, as well as the relative SJL means according to each covariate. Subsequently, the mean hours of SJL for each covariate were compared using Student's T-test and ANOVA, when necessary. For absolute SJL, considering that it was a variable with positive asymmetrical distribution, the median and interquartile range (IR) were calculated, as well as the Mann–Whitney *U* and Kruskal–Wallis tests were performed to test group differences. The relative frequencies of each of the jetlag syndrome symptoms were obtained, with their respective 95% confidence intervals.

The following validity parameters were calculated for different cutoff points of the relative SJL: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and Youden Index. Intervals of 30 min between the cutoff points were considered to evaluate changes in validation parameters. The values thus obtained were taken to the ROC (Receiver Operator Characteristic Curve), which identifies the cutoff points with the highest values of sensitivity and specificity.

Sensitivity analyses were also performed separately for three groups of students: those who had paid work, those with harmful alcohol use, and smokers. In addition, complementary analyses were performed to assess the validity of absolute SJL. The analyses were performed in the Stata® program (Stata Corporation, College Station, USA), version 14.0.

Ethical aspects

The project "Health of the University Student of UFPel" was approved by the Research Ethics Committee of the Faculty of Medicine of the Federal University of Pelotas (UFPel) under the number 79250317.0.0000.5317. All participants signed a Free and Informed Consent Form.

Results

Of the 1,865 participants of the larger study, 1,210 were excluded because they did not meet the eligibility criteria and 203 individuals due to problems filling out the questionnaire, not allowing the SJL calculation. Thus, 452 subjects were included in the analyses.

The mean age of the students included in our study was 20.2 years (SD = 3.2; range = 18–51 years). Most of them were white (73.7%) and 46.7% belonged to economy position B (Table 1). About 14% of the respondents were employed, 7.5% were smokers and 33.9% reported excessive consumption of alcoholic beverages. Most were not physically active (57.7%) and 30.3% used to share the bedroom with one or more person (Table 1).

The prevalence of each travel-induced jetlag symptom on Monday mornings in the last month was 36.1% (95% CI: 31.63, 40.68) for difficulty concentrating during the first Monday-morning class, 36.7% (95% CI: 32.27, 41.35) for daytime sleepiness and 30.1% (95% CI: 25.90, 34.54) for fatigue. Approximately half of the students (52.0%; 95% CI:

Table 1. Sample characteristics, means of relative SJL and median of absolute SJL, according to covariates. Pelotas, 2018 (N = 452).

	N (%)	Relative SJL (h) Mean (SD)	*p*	Absolute SJL (h) Median (IR)	*p*
Total sample	N = 452	2.38 (1.40)	.	2.50 (1.50; 2.50)	.
Sex	N = 452		0.272		0.130
Female	218 (48.2)	2.31 (1.29)		2.33 (1.50; 3.21)	
Male	234 (51.8)	2.45 (1.48)		2.68 (1.50; 3.42)	
Age	N = 449		0.492		0.387
18–19	241 (53.7)	2.44 (1.38)		2.54 (1.58; 3.33)	
20–22	150 (33.4)	2.40 (1.49)		2.45 (1.25; 3.42)	
23 or more	58 (12.9)	2.19 (1.71)		2.41 (1.38; 3.00)	
Brazilian Economic Classification Criterion	N = 437		0.327		0.463
A	90 (20.6)	2.44 (1.51)		2.53 (1.33; 3.50)	
B	204 (46.7)	2.46 (1.23)		2.58 (1.72; 3.25)	
C	135 (30.9)	2.25 (1.42)		2.33 (1.38; 3.20)	
D-E	8 (1.8)	1.81 (3.14)		2.18 (1.04; 3.02)	
Skin color	N = 451		0.594		0.417
White	328 (73.7)	2.40 (1.32)		2.50 (1.50; 3.25)	
Black	50 (11.1)	2.19 (1.60)		2.30 (1.12; 3.33)	
Other	73 (16.2)	2.44 (1.62)		2.70 (1.83; 3.43)	
Work	N = 452		0.174		0.101
Yes	65 (14.4)	2.16 (1.33)		2.12 (1.17; 3.02)	
No	387 (85.6)	2.42 (1.41)		2.50 (1.50; 3.33)	
Sharing bedroom	N = 452		0.239		0.099
Yes	137 (30.3)	2.27 (1.28)		2.27 (1.27; 3.14)	
No	315 (69.69)	2.43 (1.45)		2.49 (1.34; 3.23)	
Current Smoking	N = 452		0.966		0.938
Yes	34 (7.5)	2.39 (1.36)		2.50 (1.50; 3.33)	
No	418 (92.5)	2.38 (1.40)		2.50 (1.50; 3.33)	
Harmful consumption of alcohol	N = 419		0.455		0.624
Yes	142 (33.9)	2.49 (1.32)		2.58 (1.62; 3.25)	
No	277 (66.1)	2.38 (1.45)		2.58 (1.50; 3.33)	
Physically inactive	N = 452		0.254		0.254
Yes	191 (42.3)	2.47 (1.35)		2.50 (1.39; 3.33)	
No	261 (57.7)	2.32 (1.43)		2.54 (1.50; 3.33)	
Gold standard symptoms					
Difficulty concentrating	N = 452		0.381		0.499
Yes	163 (36.1)	2.46 (1.31)		2.50 (1.49; 3.42)	
No	289 (65.9)	2.34 (1.45)		2.50 (1.50; 3.25)	
Sleepiness	N = 452		0.392		0.249
Yes	166 (36.7)	2.52 (1.28)		2.45 (1.49; 3.25)	
No	286 (63.3)	2.45 (1.35)		2.59 (1.50; 3.33)	
Tiredness	N = 452		0.784		0.651
Yes	136 (30.1)	2.36 (1.38)		2.53 (1.50; 3.33)	
No	316 (69.9)	2.39 (1.41)		2.44 (1.42; 3.33)	
Difficulty concentrating + sleepness	N = 452		0.702		0.959
Yes	103 (22.8)	2.45 (1.23)		2.50 (1.50; 3.33)	
No	349 (77.2)	2.37 (1.44)		2.58 (1.50; 3.33)	
Difficulty concentrating + tiredness	N = 452		0.860		0.575
Yes	87 (19.3)	2.53 (1.29)		2.50 (1.49; 3.50)	
No	365 (80.7)	2.35 (1.42)		2.56 (1.50; 3.33)	
Sleepness + tiredness	N = 388		0.587		0.416
Yes	119 (26.3)	2.45 (1.24)		2.42 (1.46; 3.33)	
No	333 (73.7)	2.41 (1.45)		2.58 (1.50; 3.33)	
Difficulty concentrating + sleepness + tiredness	N = 452		0.814		0.427
Yes	79 (17.5)	2.51 (1.29)		2.50 (1.49; 3.42)	0.427
No	373 (82.5)	2.36 (1.42)		2.50 (1.50; 3.25)	
Presence of Symptoms	N = 452				
No symptoms	217 (48.0)	2.41 (1.45)	0.712[#]	2.58 (1.50; 3.33)	0.475[#]
At least 1 symptom	235 (52.0)	2.36 (1.34)		2.50 (1.46; 3.33)	
At least 2 symptoms	151 (33.4)	2.33 (1.31)	0.564[§]	2.43 (1.49; 3.33)	0.414[§]

SJL = Social Jetlag. *P* values refers to Student's t-test or Analysis of Variance (ANOVA) for Relative SJL and Mann–Whitney or Kruskal Wallis for the Absolute SJL. All tests were used to test the null hypothesis that there are no differences between the groups of covariates.
# At least 1 symptom compared with No symptoms; § At least 2 symptoms compared with One symptom or less.

42.27, 56.68) had at least one of the symptoms, one-third (33.4%, 95% CI: 29.07, 37.96) had two symptoms or more and 17.5% (95% CI: 14.09; 21.30) reported the presence of the three symptoms. As previously mentioned, gold standard variable for this study was defined as having at least one jetlag symptom.

Relative SJL

The relative SJL mean (M) was 2 h 23 min (SD = 1 h 24 min; range = −3 h to 7 h 58 min). Almost two-thirds of the participants (63.7%) presented SJL of 2 h or more. Only 4.7% of respondents presented negative SJL values.

Table 1 shows relative SJL in hours and decimals. The following groups presented the highest means of relative JLS: Men (M = 2.45 h; SD = 1.48 h), individuals aged between 18 and 19 years (M = 2.44 h; SD = 1.38 h), employed (M = 2.42 h; SD = 1.41 h), belonging to socioeconomic position classified as B (M = 2.46 h; SD = 1.23 h), of skin color different from black or white (M = 2.44 h; SD = 1.62 h), those that were not used to share the bedroom (M = 2.43 h; SD = 1.45 h), those that reported harmful consumption of alcohol (M = 2.49 h; SD = 1.32 h) and that were physically inactive (M = 2.47 h; SD = 1.35 h). There was no difference in means of relative SJL, according to any of the characteristics evaluated (Table 1).

Table 2 describes the values of sensitivity, specificity, PPV, NPV, and Youden Index for each relative SJL cutoff point in relation to the gold standard symptoms. Sensitivity decreased progressively as cutoff points increased, with a more evident decrease between ≥3 h and ≥4 h (from 35.3% to 5.1%), while specificity increased from 64.1% to 94.5% between these cutoff points. The best parameters values were observed for the SJL cutoff point ≥2 h category, with 63.4% sensitivity and 35.9% specificity. It was not possible to choose an acceptable cutoff point according to the ROC curve generated by the data of the present study, because this showed a linear visual tendency and a very small area under the curve (48%) (Figure 1a).

The results considering specific subsamples (workers, harmful alcohol users and smokers) were similar to the results observed for the total sample (Figure 1, Supplementary Table 1). For those who used to work by the time of the interview, the best cutoff point was ≥2 h 55 min of relative SJL, with a sensitivity of 48.1% and specificity of 81.6% (Figure 1b). When analyzing only students who had harmful consumption of alcohol, the best cutoff point was ≥2 h 26 min, with a sensitivity of 60.0% and specificity of 45.8% (Figure 1c). For smokers, the cutoff point with the best validation parameters was ≥2 h 13 min of relative SJL, with a sensitivity of 67.7% and specificity of 50.0% (Figure 1d).

Absolute SJL

In the whole sample, the absolute SJL median was 2 h 30 min (IR = 1 h 30 min; 3 h 20 min; range = 0 h to 7 h 58 min). The median and IR of the absolute SJL in hours and decimals can be seen in Table 1. Higher median values of absolute SJL were seen among males (Median = 2.68 h; IR = 1.50 h; 3.42 h), individuals aged between 18 and 19 years (Median = 2.54 h; IR = 1.58 h; 3.33 h), not employed (Median = 2.50 h; IR = 1.50 h; 3.33 h), belonging to socioeconomic position classified as B (Median = 2.58 h; IR = 1.72; 3.25 h), of skin color different from black or white (Median = 2.70 h; IR = 1.83; 3.43 h), those that were not used to share the bedroom (Median = 2.49 h; IR = 1.34; 3.23) and those that were physically inactive (Median = 2.54; IR = 1.50; 3.33). There was no difference in means of relative SJL, according to any of the characteristics evaluated (Table 1). There was no difference in medians of absolute SJL, according to any of the characteristics evaluated (Table 1).

The values of sensitivity, specificity, PPV, NPV, and Youden index were similar to those observed for the relative SJL (Supplementary Table 2 and Supplementary Figure 1). Similarly to the relative SJL, the cutoff point with the best parameters was ≥2 h, with 63.4% sensitivity, 35.5% specificity and Youden of −0.01. The area under the ROC curve with data from the whole sample was 48%.

Discussion

We aimed to evaluate the validity of the SJL concept regarding the classic symptoms of travel-induced jetlag, as well as to identify the cutoff point with the best sensitivity and specificity among young university students. Our results suggest that the SJL concept was not valid for the

Table 2. Sensitivity, specificity, PPV, NPV and Youden index for each cutoff point of relative Social Jetlag against gold standard symptoms. Pelotas, 2018 (N = 452).

Relative SJL cutoff point	N of people above cutoff point (%)	Sensitivity	Specificity	PPV	NPV	Youden
≥−3 h	452 (100%)	100%	0.00%	m.n.	m.n.	0.00
≥−2.5 h	451 (99.8%)	100%	0.50%	52.10%	100%	0.00
≥−2 h	451 (99.8%)	100%	0.50%	52.10%	100%	0.00
≥−1.5 h	451 (99.8%)	100%	0.50%	52.10%	100%	0.00
≥−1 h	450 (99.6%)	100%	0.90%	52.20%	100%	0.01
≥−0.5 h	449 (99.3%)	100%	1.40%	52.30%	100%	0.01
≥0 h	432 (95.4%)	97%	6.00%	52.70%	62%	0.03
≥0.5 h	407 (90.0%)	91.11%	11.10%	52.60%	53.30%	0.02
≥1 h	380 (84.1%)	84.30%	16.10%	52.10%	48.60%	0.00
≥1.5 h	341 (75.4%)	73.60%	22.60%	50.70%	44.10%	−0.04
≥2 h	288 (63.7%)	63.40%	35.90%	51.70%	47.60%	−0.01
≥2.5 h	233 (51.6%)	51.10%	47.90%	51.50%	47.50%	−0.01
≥3 h	161 (35.6%)	35.30%	64.10%	51.60%	47.80%	−0.01
≥3.5 h	91 (20.1%)	19.10%	78.80%	49.50%	47.40%	−0.02
≥4 h	49 (10.8%)	9.80%	88.00%	46.90%	47.40%	−0.02
≥4.5 h	24 (5.3%)	5.10%	94.50%	50.00%	47.90%	0.00

SJL = Social jetlag; m.n. = Missing numbers; PPV = Positive Predictive Value; NPV = Negative Predictive Value.

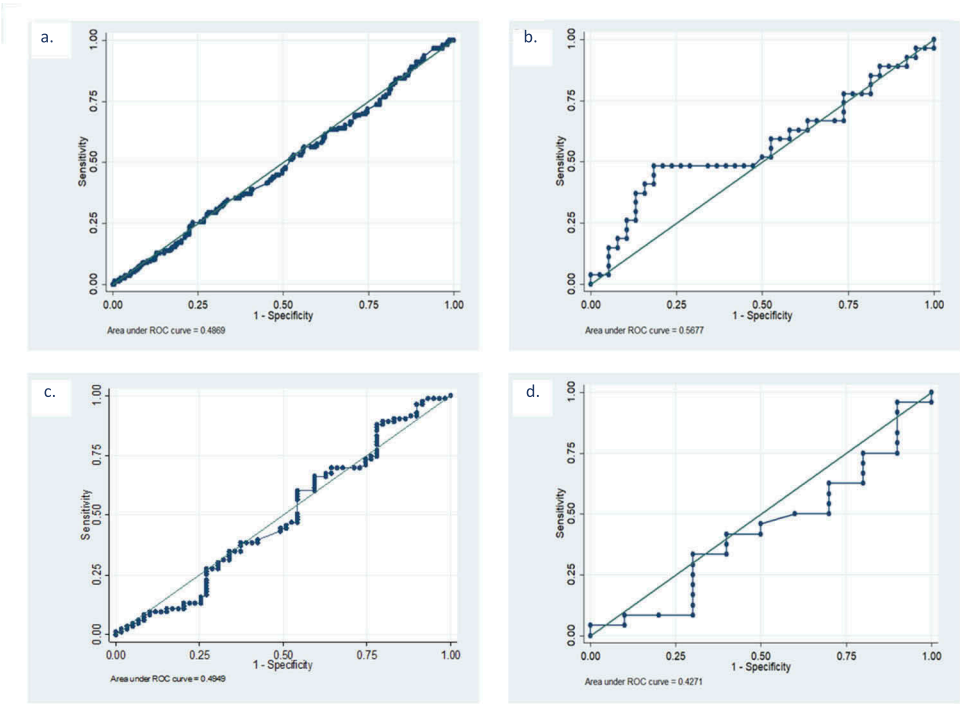

Figure 1. Receiver Operator Characteristic curve (ROC curve) for the performance of social jetlag compared to the presence of at least one of the travel-induced jetlag symptoms (gold standard), for the total sample and for different subgroups, Pelotas, 2018. (a) All sample (N = 452), area under the curve = 0.487; (b) only individuals with paid work (n = 27), area under the curve = 0.568; (c) only individuals with harmful consumption of alcohol (n = 83), area under the curve = 0.495; (d) only current smokers (n = 24), area under the curve = 0.427.

sample studied, nor it was possible to establish a cutoff point with adequate validation parameters.

The observed mean of relative SJL in our sample was similar to the reported means by other studies evaluating populations with similar age range (Lee et al. 2016; Randler and Vollmer 2013; Silva and Petroski 2011), with values between 2 and 3 h. Lee et al. (2016) evaluated a sample of 1,094 Korean university students aged 19 to 29 years and found an SJL mean of 2 h 30 min (SD = 1 h 42 min). Randler and Vollmer (2013), when studying a sample of 432 German university students with a mean age of 23.8 years (SD = 3.7 years) obtained a mean of 2 h 03 min (SD = 1 h 03 min). Silva and Petroski (2011) evaluated

204 Brazilian university students (mean age = 21.6 years, SD = 3.9 years) and obtained an SJL mean of 2 h 51 min (SD = 1 h 56 min).

Most of the studies in the literature regarding SJL aim to explore its association with health aspects (Lang et al. 2018; Levandovski et al. 2011; Rutters et al. 2010), and some use cutoff points for SJL measurement (Levandovski et al. 2011; Rutters et al. 2010). Although they are used in the literature, these cutoff points were not identified in validation studies as far as we know, and the choice was purely arbitrary (Haraszti et al. 2014; Johnsen et al. 2013; Levandovski et al. 2011; Roenneberg et al. 2012). The results of the present study show that all the tested cutoff points of the instrument had low sensitivity and specificity values, covering a small area under the ROC curve (0.487). The best values obtained were for the cutoff point ≥2 h, with 64.4% sensitivity and 35.9% specificity. Due to lack of consensus regarding the use of relative or absolute SJL, the data were analyzed using the two ways described in the literature to measure SJL (absolute and relative). However, no differences were observed between the results, so that cutoff points for both measures were not valid in comparison to the travel-induced jetlag symptoms.

Sensitivity analyses were performed in order to better explore the data. For these analyses, the characteristics that have been reported as important determinants of SJL in the literature (smoking and alcohol use) (Lang et al. 2018; Wittmann et al. 2009), as well as the variable "paid work" were included. In these analyses, individuals who worked, as well as those who had harmful consumption of alcohol and smokers, presented cutoff points with sensitivity and specificity values higher than those found for the general sample. However, the accuracy in these groups remained low.

An important implication of the present study is the question about the terminology attributed to the misalignment between the biological and social clocks, as discussed by Beauvalet et al. (2017). According to the authors, the measure of the discrepancy between the midsleep time in free days and the midsleep time on workdays was already used in some studies before the term JLS had emerged, using other terminology (Beauvalet et al. 2017). According to Vetter (2018), SJL could represent a proxy for circadian misalignment and as circadian disruption, this term has been used in the literature since the 1980s. In consonance to that, Beauvalet et al. (2017) suggested that the expression "social lag" might be more appropriate to describe this phenomenon, since the word "jet" reminds to travels and its associated symptoms. In this sense, our data may add evidences supporting this suggestion.

One possible explanation for the lack of validity of our results regards the fact that SJL may not have the same apparent wide-term effects as the jetlag. Then, the symptoms of SJL may not represent the symptoms of the jetlag syndrome. To date, the effects of SJL on the body are still poorly understood (Beauvalet et al. 2017; Vetter 2018). Some studies indicate that the weekly desynchronization of the circadian cycle would cause problems in the metabolic functioning of the individual and, therefore, would be associated with negative outcomes (such as obesity and cardiometabolic diseases) in a long-term exposure (Parsons et al. 2015; Wong et al. 2015).

Besides that, despite SJL and travel-induced jetlag are both circadian misalignments, the desynchronization in both cases may be different. According to Vetter (2018), in travel-induced jetlag, the environmental signal, the light/dark cycle, is misaligned with the endogenous clock (phase). In this case, the circadian system will gradually entrain to the local light-dark cycle and this process could last on average 1 day per hour of time change (Vetter 2018). In SJL, the light/dark cycle is aligned, but there is a behavioral misalignment, where the feeding/fasting cycle, or sleep and wake, are misaligned with the endogenous clock (Vetter 2018). These differences could be the evidence to support that SJL and jetlag are different phenomena.

There is a great heterogeneity in the cutoff points reported in the literature, and the threshold value between "having" or "not having" SJL (Beauvalet et al. 2017) is not defined in any study. Thus, associations with negative health outcomes in the literature should be better explored and mechanisms underlying these associations better investigated. In addition, we should point out that many of these studies present some methodological limitations, such as small sample sizes, unclear SJL measurements and

lack of adjustment by confounders (Beauvalet et al. 2017; Parsons et al. 2015; Polugrudov et al. 2016). Thus, studies that overcome these limitations are necessary in order to understand if SJL could be a contributing factor for health conditions.

As a limitation of our study, the use of subjective (self-reported) sleep measures may have influenced the validation parameters. Self-referenced measures were used for logistical and cost reasons, because the use of objective tools to measure sleep (such as the actigraphy) would require a larger research team and a greater amount of financial resources, thus impairing the conduction of the study. However, a study that evaluated SJL by means of the MCTQ and the actigraphy, pointed out that both instruments presented similar results (Roenneberg et al. 2015), indicating a small impact of this limitation in our study.

In conclusion, the concept of SJL showed to be ineffective for describing the travel-induced jetlag symptoms. Therefore, future studies with samples not restricted to university students or those with classes on Monday's morning and using objective sleep measurements should be performed to better explore the SJL concept. Furthermore, we cannot discard that SJL is a phenomenon that is associated with negative outcomes, a subject that still needs attention in further researches.

Disclosure statement

All authors declare that they have no conflicts of interest.

Funding

This research was funded by the Postgraduate Program in Epidemiology, with the support of the Coordenação de Aperfeiçoamento Pessoal de Nível Superior (CAPES) – Financing Code 001;Conselho Nacional de Desenvolvimento Científico e Tecnológico.

ORCID

Luciana Tovo-Rodrigues http://orcid.org/0000-0002-8732-6059

References

Associação Brasileira de Empresas de Pesquisa. 2008. Critério de classificação econômica Brasil. São Paulo (Brasil): Associação Brasileira de Empresas de Pesquisa.

Babor TF, Higgins-Biddle JC, Saunders JB, Monteiro MG. 2001. The alcohol use disorders identification test: guidelines for use in primary care. Geneva (Switzerland): World Health Organization.

Baron KG, Reid KJ. 2014. Circadian misalignment and health. International Review of Psychiatry. 26:139–154.

Beauvalet JC, Quiles CL, de Oliveira MAB, Ilgenfritz CA, Hidalgo MP, Tonon AC. 2017. Social jetlag in health and behavioral research: a systematic review. Chrono Physiol Ther. 7:19–31.

Fiebach NH, Barker LR, Burton JR, Zieve PD. 2007. Principles of ambulatory medicine. Philadelphia (USA): Lippincott Williams & Wilkins.

Haraszti R, Ella K, Gyöngyösi N, Roenneberg T, Káldi K. 2014. Social jetlag negatively correlates with academic performance in undergraduates. Chronobiol Int. 31:603–612.

Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde J. 2009. Research electronic data capture (REDCap) – a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 42:377–381.

Johnsen MT, Wynn R, Bratlid T, Vinciguerra M. 2013. Optimal sleep duration in the subarctic with respect to obesity risk is 8–9 hours. PLoS One. 8:e56756.

Koopman ADM, Rauh SP, van 't Riet E, Groeneveld L, van der Heijden AA, Elders PJ, Dekker JM, Nijpels G, Beulens JW, Rutters F. 2017. The association between social jetlag, the metabolic syndrome, and type 2 diabetes mellitus in the general population: the new hoorn study. Journal of Biological Rhythms. 32:359–368.

Lang CJ, Reynolds AC, Appleton SL, Taylor AW, Gill TK, McEvoy RD, Ferguson SA, Adams RA. 2018. Sociodemographic and behavioural correlates of social jetlag in Australian adults: results from the 2016 National Sleep Health Study. Sleep Med. 51:133–139.

Lazar AS, Santhi N, Hasan SLo JCY, Johnston JD, Von Schantz M, Archer SN, Dijk DJ. 2013. Circadian period and the timing of melatonin onset in men and women: predictors of sleep during the weekend and in the laboratory. Journal of sleep research. 22: 155–159

Lee S, Park C, Kim B, Lee C, Cha B, Lee YJ, Soh M, Park JA, Young PS, Song EH. 2016. Association between morningness and resilience in Korean college students. Chronobiol Int. 33:1391–1399.

Levandovski R, Dantas G, Fernandes LC, Caumo W, Torres I, Roenneberg T, Hidalgo MP, Allebrandt KV. 2011. Depression scores associate with chronotype and social jetlag in a rural population. Chronobiol Int. 28:771–778.

Matsudo S, Araújo T, Marsudo V, Andrade D, Andrade E, Braggion G. 2001. Questinário internacional de ativAge f1sica (IPAQ): estudo de validade e reprodutibilidade no

Brasil. Rev Bras Ativ Fís Saúde. 05–18. doi:10.12820/rbafs.v.6n2p5-18

Parsons MJ, Moffitt TE, Gregory AM, Goldman-Mellor S, Nolan PM, Poulton R, Caspi A. 2015. Social jetlag, obesity and metabolic disorder: investigation in a cohort study. Int J Obes. 39:842.

Polugrudov AS, Panev AS, Smirnov VV, Paderin NM, Borisenkov MF, Popov SV. 2016. Wrist temperature and cortisol awakening response in humans with social jetlag in the North. Chronobiol Int. 33:802–809.

Randler C, Vollmer C. 2013. Aggression in young adults—a matter of short sleep and social jetlag? Psychol Rep. 113:754–765.

Roenneberg T, Allebrandt K, Merrow M, Vetter C. 2012. Social jetlag and obesity. Curr Biol. 22:939–943.

Roenneberg T, Keller LK, Fischer D, Matera JL, Vetter C, Winnebeck EC. 2015. Human activity and rest in situ. Methods Enzymol. 552:257–283.

Roenneberg T, Kuehnle T, Juda M, Kantermann T, Allebrandt K, Gordijn MMerrow M. 2007. Epidemiology of the human circadian clock. Sleep Medicine Reviews. 11:429–438.

Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, Merrow M. 2004. A marker for the end of adolescence. Curr Biol. 14(24):R1038–R1039.

Roenneberg T, Pilz LK, Zerbini G, Winnebeck EC. 2019. Chronotype and social jetlag: a (self-) critical review. Biology. 8:54.

Rutters F, Lemmens SG, Adam TC, Bremmer MA, Elders PJ, Nijpels G, Dekker JM. 2010. Is social jetlag associated with an adverse endocrine, behavioral, and cardiovascular risk profile? J Biol Rhythms. 29:377–383.

Rutters F, Lemmens SG, Adam TC, Bremmer MA, Elders PJ, Nijpels G, Dekker JM. 2014. Is social jetlag associated with an adverse endocrine, behavioral, and cardiovascular risk profile?. Journal of Biological Rhythms. 29:377–383.

Ryu H, Joo EY, Choi SJ, Suh S. 2018. Validation of the munich chronotype questionnaire in korean older adults. Psychiatry Investigation. 15:775–782.

Santisteban JA, Brown TG, Gruber R. 2018. Association between the munich chronotype questionnaire and wrist actigraphy. Sleep Disorders. 2018:1–7.

Silva DAS, Petroski EL. 2011. Factors associated with the degree of participation in physical activities among students of a public university in the south of Brazil. Cien Saude Colet. 16:4087–4094.

Vetter C. 2018. Circadian disruption: what do we actually mean? Eur J Neurosci. 1–20. doi:10.1111/ejn.14255

Wittmann M, Dinich J, Merrow M, Roenneberg T. 2006. Social jetlag: misalignment of biological and social time. Chronobiol Int. 23:497–509.

Wittmann M, Paulus M, Roenneberg T. 2009. Decreased psychological well-being in late 'chronotypes' is mediated by smoking and alcohol consumption. Subst Use Misuse. 45:15–30.

Wong PM, Hasler BP, Kamarck T, Muldoon MF, Manuck SB. 2015. Social jetlag, chronotype, and cardiometabolic risk. J Clin Endocrinol Metab. 100:4612–4620.