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# Geographic latitude and sleep duration: A population-based survey from the Tropic of Capricorn to the Antarctic Circle

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**ABSTRACT**

The impact of latitude on sleep duration remains virtually unexplored, even though latitude exerts profound influences on daylight duration. Using Chile as a one-country model, we explored on the potential associations between sleep duration and latitude. Based on the 2nd Chilean Health Survey, we identified reported sleep data during spring of people living from north to south in Chilean cities, located between 18°29′S to 53°18′S (4329 km distance at same longitude).

A total of $n$ = 2493 participants were included (mean age 45.3 ± 18.4 years, 41.8% males). Mean sleep duration on workdays and weekends was 7.42 ± 1.71 h, and 7.91 ± 2.13 h, respectively, ranging from 7.91 ± 1.92 h in the north to 8.33 ± 1.89 h in the south, such that more northern latitudes (i.e., 18°29′S to 39°50′S) slept less compared to more southern latitudes (i.e., 51°43′S–53°18′), even after controlling for age, gender, and socioeconomic status. In the logistic regression models, men residing at northern latitudes exhibited an odds ratio of 3.348 [95% CI: 1.905–5.882; $p < 0.0001$] for having shorter sleep on weekends than their southern counterparts.

Latitude appears to strongly affect reported sleep patterns, leading to longer sleep duration with increasing latitude, particularly in men during weekends. Whether environmental factors such as photoperiod are causally involved in theses associations needs to be elucidated in future studies.

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## Introduction

Sleep strongly influences many aspects of human life including physical, cognitive, and emotional well-being. Sleep curtailment has been associated with several health consequences in adults, adolescents (Dewald et al., 2010; Redline et al., 2010; Young et al., 2009) and children (Bruni et al., 2010; Brockmann et al., 2012; Fernandez-Mendoza et al., 2012). In particular, short sleep duration has been associated with mental health problems (Beebe et al., 2004), obesity (Bixler et al., 2009; Gozal & Kheirandish-Gozal, 2009), cardiovascular diseases (Hall et al., 2008; Vgontzas et al., 2009; Redline et al., 2010), and impaired glucose metabolism (Drager et al., 2009; Drager et al., 2010).

Recently, a comprehensive review has recommended standard definitions for short and long sleep duration (Hirshkowitz et al., 2015). Short sleep was defined in adults as sleeping less than 7 hours (Hirshkowitz et al., 2015).

There is evidence that sleep length seems to be influenced by several individual factors that have been thoroughly explored (Allebrandt et al., 2014; Skeldon et al., 2014; Skeldon et al., 2015). However, in addition to individual factors, cultural (Adenekan et al., 2013) and social schedules (Geiger-Brown et al., 2011; Lo et al., 2014; Martin et al., 2015; Wolfson & Carskadon, 1998) also play a role in how long an individual sleeps.

In this context, the importance of geographic factors on sleep duration remains uncertain. In a recent study, populations living in various countries showed substantial differences in their sleep habits and duration (Walch et al., 2016). As the

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duration to light exposure is one of the most powerful factors that influence the circadian rhythm, latitude and longitude may impact the total sleep duration (Friborg et al., 2014). The influence of latitude on sleep duration may be explained by the different exposure to sunlight depending on the geographic zone (Friborg et al., 2012). The seasonal changes during the year are more marked in extreme Arctic and Antarctic latitudes than in Equatorial regions. Thus, people living at higher latitudes have a higher variability of sunlight duration, depending on the season. Even in pre-industrial societies, the specific photopic period related to latitude seems to markedly influence sleep duration (Yetish et al., 2015).

The impact of the sunlight exposure variability on sleep duration is still unexplored, as it may be difficult to obtain geographic models with a similar longitude but different latitudes. In a recent study by Walch and colleagues, later sunset times were associated with longer sleep duration among more than 20 different countries located around the globe (Walch et al., 2016). The unique geographic characteristics of Chile, a country that has a length of 4329 km from north to south, corresponding to a latitude from 18°29′S to 53°18′S served as an ideal setting to investigate the effect of latitude on sleep duration, using the Chilean National Health in its 2nd survey [23]. The mean width of 177 km from west to east of continental Chile further restricts its longitude to 71° W. Chile includes, therefore, the Tropic of Capricorn in the north and reaches almost as well as the Antarctic Circle in the South.

## Methods

### Survey data base

We used the Chilean National Health Survey database for this population-based analysis. Briefly, this survey was conducted by the Ministry of Health during 2009–2010 in Chile and consisted of a home visit by trained staff who conducted several interview-based questionnaires concerning demographic issues, life-style, health, and quality of life (Chilean National Health Survey, 2010). The sample was calculated such as to be representative of the entire Chilean population aged >15 years according to the last concomitant national census (Chilean National Health Survey, 2010). The response rate to the survey was 85% among the eligible population, with a rejection rate of 12% (Chilean National Health Survey, 2010). Upon completion of the survey, a total of $n$ = 5043 participants completed all aspects of the survey (Chilean National Health Survey, 2010). Questionnaires were carried out between October and December 2009 (i.e., spring in the southern hemisphere). More details on the methodology are given at the survey´s website (Chilean National Health Survey, 2010), as well as in a previous publication of our group (Brockmann et al., 2016). An informed consent was obtained from each participant. This study was approved by the IRB of the Pontificia Universidad Católica de Chile (protocol #:14–432). For the present study, records from participants living in five specific regions of Chile from north to south were included.

### Geography

For this study, we selected $n$ = 2493 people living in Chile in following five geopolitical geographic clusters: 1 (North 18°29′S–23°39′S): including the cities of Arica, Iquique, Antofagasta, and Calama; 2 (North-Central valley 27°22′S–33°27′S) Copiapó, La Serena-Coquimbo, Los Andes, and Santiago; 3 (Central valley/South 34°59′S–39°50′S) Curicó, Talca, Chillán, Temuco, and Valdivia; 4 (South/Patagonia 41°28′S–46°33′S) Puerto Montt, Coyhaique, and Chile Chico; and 5 (Patagonia/Strait of Magellan 51°43′S–53°18′S) Puerto Natales, Punta Arenas, and Porvenir. This five geopolitical regions of Chile include cities from north to south that are located at distances corresponding to at least 1–2° latitude between them due to historical reasons. If this was not possible, the next nearest inhabited zone was selected. Figure 1 gives the geographic details of Chile and the distribution of the inhabited conglomerations that were included in the present analysis.

### Sleep duration

Among the health items that were surveyed in the Chilean National Health Survey, there were several

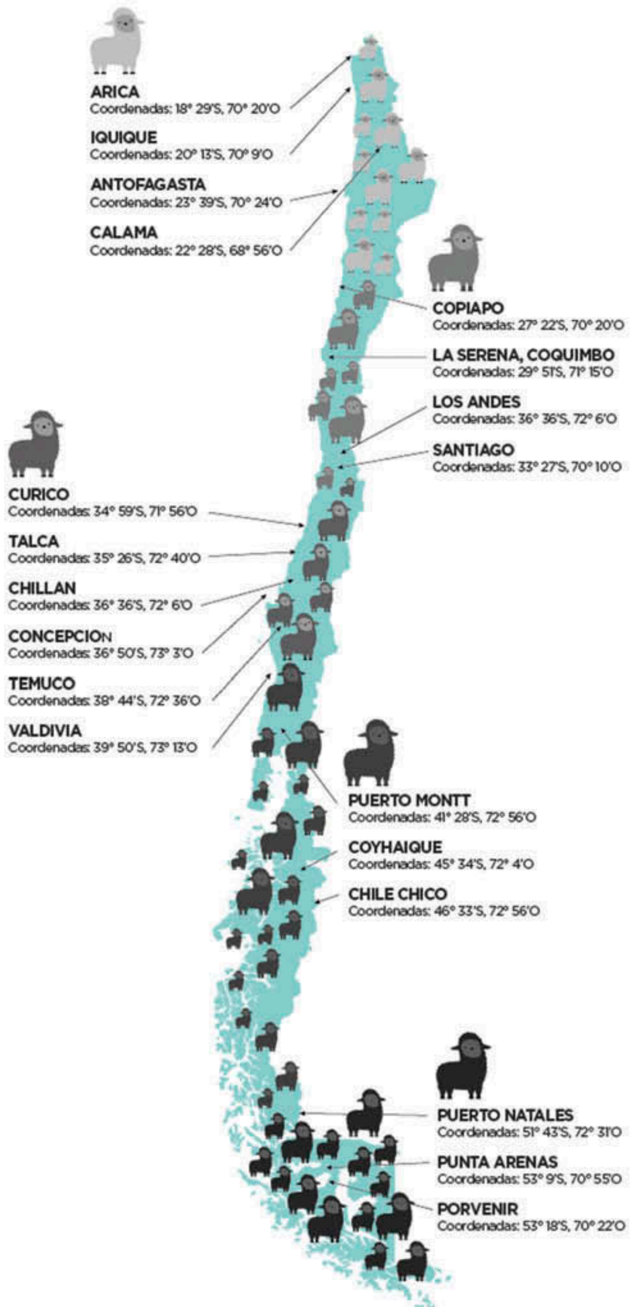


**Figure 1.** Map of Chile showing the included regions and cities; longer sleep duration is depicted darker.

questions on the length and quality of sleep. Questions on sleep duration on workdays and weekends were included and analyzed for workdays and weekends separately, as well as dichotomized according to current recommendations into short sleep (i.e., <7 h sleep/night), normal sleep (i.e., >7 h and <9 h sleep/night), and long sleep (i.e., >9 h sleep/night) (Hirshkowitz et al., 2015).

### *Statistics*

Descriptive statistics (mean, standard deviation [SD]) were used to outline sleep duration in each selected geographic cluster. Also, sleep hours, separated by workdays and weekends, were calculated separately. ANOVA was used to identify differences between the geographic clusters.

Multiple logistic regression analysis was used to examine the association of latitude with sleep duration. Short sleep was defined as sleeping <7 h according to current recommendations (Hirshkowitz et al., 2015). Two models were constructed, one for short sleep duration in workdays, and one for weekends. The extreme southern latitude was used as reference (i.e., Patagonia/Strait of Magellan region at 51° 43′S–53°18′S). Age, gender, body-mass index, and educational level were incorporated as co-factors into each model. In addition, temperature, altitude, mean sunlight hours, and number of inhabitants of each included city were analyzed as co-factors in the equation using generalized linear models (GLM), bivariate correlations, and binary logistic regressions. Findings are presented as odds ratios (ORs) and corresponding 95% confidence intervals (95% CI). A $p$ value <0.05 was considered statistically significant. Statistics were performed using SPSS Statistics 20.0 for MAC.

## Results

Of all $n$ = 5043 participants, $n$ = 2493 lived in the selected regions and were thus selected for further analysis. Mean (±SD) age was 45.3 ± 18.4 (± SD) years, and 1436 were males (59%). Latitude ranged from 18°29′S (i.e., the city of Arica in the north) to 53°18′S (i.e., the city of Porvenir on the Strait of Magellan in the south). Table 1 gives demographic details for responders of each selected region from north to south. Mean sleep duration on workdays and weekends were 7.42 ± 1.71 h and 7.91 ± 2.13 h, respectively.

Mean altitude, population, mean temperature, and the yearly sum of sunlight hours of each geographic cluster, as well as the percentage of people reporting short, normal, and long sleep duration, are given in Table 2. There were significantly more

**Table 1.** Demographic and geographic variables of the included subjects.

| Variable | Men | Women | Total |
|---|---|---|---|
| Gender, *n* = 2493 | 1057 (42.3) | 1436 (57.6) | 2493 (100) |
| Age (years), *n* = 2493, mean ± SD | 43.90 ± 18.37 | 46.35 ± 18.37 | 45.32 ± 18.41 |
| Body mass index, *n* = 2493, mean ± SD | 27.89 ± 5.27 | 27.64 ± 4.87 | 28.07 ± 5.53 |
| Nutritional status, *n* = 2253 | | | |
| Normal (≥18.5 and <25) | 258 (40.2) | 384 (59.8) | 642 (28.5) |
| Underweight (<18.5) | 11 (28.2) | 28 (71.8) | 39 (1.7) |
| Overweight (≥25 and <30) | 418 (44.6) | 479 (53.4) | 897 (39.8) |
| Obese (≥30) | 222 (36.0) | 395 (64.0) | 616 (27.3) |
| Severe Obesity (≥40) | 22 (37.3) | 37 (62.7) | 59 (2.6) |
| Educational level (years of study), *n* = 2455 | | | |
| Low (<8) | 180 (35.7) | 324 (64.3) | 504 (20.5) |
| Medium (8–12) | 606 (43.1) | 799 (56.9) | 1405 (57.2) |
| High (>12) | 239 (43.8) | 307 (56.2) | 546 (22.2) |
| Geographic region and latitude, *n* = 2493 | | | |
| North (18°29′S–23°39′S) | 330 (41.3) | 469 (58.7) | 799 (32.4) |
| North central-valley (27°22′S–33°27′S) | 258 (39.4) | 396 (60.6) | 654 (26.5) |
| Central valley & south (34°59′S–39°50′S) | 180 (48.5) | 191 (51.5) | 371 (14.9) |
| South & Patagonia (41°28′S–46°33′S) | 168 (47.2) | 188 (52.8) | 356 (17.9) |
| Patagonia/Strait of Magellan (51°43′S–53°18′S) | 165 (52.7) | 148 (47.3) | 313 (12.7) |

SD, standard deviation. If not otherwise stated data are given as *n* (%).

**Table 2.** Sleep duration category and geographic characteristics of each included cluster.

| | North (*n* = 799) | North central valley (*n* = 654) | Central valley & South (*n* = 371) | South & Patagonia (*n* = 356) | Patagonia/Strait of Magellan (*n* = 313) | *p* |
|---|---|---|---|---|---|---|
| Mean altitude (meters) | 148 | 450 | 148 | 18 | 9 | 0.001 |
| Population (*n*) | 231,063 | 1,646,953 | 208,487 | 289,611 | 48,762 | 0.001 |
| Yearly sum of sunlight hours (*n*) | 3070 | 2666 | 2319 | 1715 | 1886 | 0.001 |
| Mean Temperature (°C) | 19.8 | 12.4 | 11.5 | 10.4 | 6.3 | 0.001 |
| Short sleep workdays | 206 (26) | 209 (33) | 139 (31) | 73 (28) | 76 (24) | 0.023 |
| Normal Sleep workdays | 522 (65) | 392 (61) | 249 (56) | 157 (61) | 208 (67) | 0.008 |
| Long Sleep workdays | 67 (9) | 52 (8) | 51 (13) | 25 (11) | 29 (9) | 0.304 |
| Short sleep weekend | 182 (23) | 191 (29) | 104 (24) | 46 (18) | 46 (15) | 0.0001 |
| Normal Sleep weekend | 451 (56) | 344 (53) | 234 (53) | 141 (55) | 195 (62) | 0.048 |
| Long Sleep weekend | 162 (21) | 118 (18) | 101 (23) | 68 (26) | 72 (23) | 0.045 |

If not otherwise stated data is given as *n* (%).

short sleepers in northern than in southern latitudes ($p < 0.05$ throughout).

Table 3 gives the results for sleep duration categorized by region. Mean total sleep duration on workdays varied from 7.19 ± 1.65 h in the Central valley region to 7.50 ± 1.78 h in the South and Patagonia region. On weekends, the same figure was 7.51 ± 1.92 h in the North region to 8.33 ± 1.89 h in the Patagonia/Strait of Magellan region. ANOVA showed a significant difference between total sleep duration among the included regions ($p = 0.001$).

**Table 3.** Sleep duration categorized by each included geographic cluster/city.

| | Workdays | Weekends | Latitude |
|---|---|---|---|
| North (*n* = 799) | 7.41 ± 1.46 | 7.51 ± 1.92 | 18°29′S–23°39′S |
| North-central valley (*n* = 654) | 7.19 ± 1.65 | 7.61 ± 2.10 | 27°22′S–33°27′S |
| Central valley & South (*n* = 371) | 7.19 ± 1.82 | 7.82 ± 2.23 | 34°59′S–39°50′S |
| South & Patagonia (*n* = 356) | 7.50 ± 1.78 | 8.31 ± 2.11 | 41°28′S–46°33′S |
| Patagonia/Strait of Magellan (*n* = 313) | 7.47 ± 1.49 | 8.33 ± 1.89 | 51°43′S–53°18′S |

Logistic regression showed no significant associations between altitude (OR 1.005 [1.001–1.009]), population (OR 1.000 [1.000–1.001]), or mean temperature (OR 0.999 [0.998–1.001]), of each geographic cluster with sleep duration during workdays. The same model for sleep duration during weekends as dependent variable was: 1.005 [1.001–1.010], 1.000 [1.000–1.000], and 0.998 [0.998–1.001], respectively. Correlations between altitude, population and mean

**Table 4.** Risk factors for short sleep duration on workdays and weekends.

| | Workdays | | | Weekends | | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | *p* | OR | 95% CI | *p* |
| Age | 1.005 | 0.997–1.013 | 0.188 | 1.009 | 0.998–1.019 | 0.096 |
| Body mass index | 1.013 | 0.991–1.036 | 0.254 | 1.030 | 0.998–1.063 | 0.068 |
| Educational level | | | | | | |
| Low | 0.957 | 0.630–1.453 | 0.836 | 1.201 | 0.703–2.051 | 0.503 |
| Medium | 0.856 | 0.628–1.166 | 0.323 | 0.951 | 0.648–1.395 | 0.797 |
| High | ref | ref | ref | ref | ref | ref |
| Latitude | | | | | | |
| North 18°29′S–23°39′S | 1.058 | 0.681–1.644 | 0.802 | 3.045 | 1.759–5.271 | **<0.0001** |
| North-central valley 27°22′S–33°27′S | 1.366 | 0.876–2.129 | 0.168 | 3.348 | 1.905–5.882 | **<0.0001** |
| Central valley & South 34°59′S–39°50′S | 1.413 | 0.885–2.254 | 0.147 | 2.162 | 1.157–4.042 | **<0.0001** |
| South & Patagonia 41°28′S–46°33′S | 1.170 | 0.676–2.025 | 0.574 | 1.282 | 0.617–2.667 | 0.506 |
| Patagonia/Strait of Magellan 51°43′S–53°18′S | ref | ref | ref | ref | ref | ref |

CI, confidence interval; OR, odds ratio.

temperature with sleep duration on workdays were not significant: $r_s$ −0.059 ($p = 0.054$), −0.043 ($p = 0.40$), and −0.002 ($p = 0.927$). For sleep duration on weekends, the results were: $r_s$ −0.118 (0.065), −0.082 (0.533), and −0.65 (0.001), respectively. Correlation between sunlight hours and sleep hours was not significant on workdays (i.e., $r_s$ −0.033, $p = 0.888$) but was significant during weekends (i.e., −0.066, $p = 0.001$).

Table 4 shows the results of the regression model for the association between short sleep duration and latitude. On workdays, there was no significant association between sleep duration and latitude. However, on weekends, short sleep duration was significantly associated with latitude even after adjusting for age, gender, BMI, and socio-educational status: people living between 18°29′S to 39°50′S had a significantly shorter weekend sleep duration compared to those living in more southern latitudes (i.e., 51°43′S–53° 18′S), all $p < 0.0001$ throughout. A gender-based difference emerged in the association between short sleep and latitude (Table 5). On workdays, only men from more northern latitudes had significantly shorter sleep durations compared with the southern reference latitude: OR [95% CI] was 1.675 [1.053–2.663], and 1.733 [1.043–2.881] in the North central valley, and Central valley and South, respectively. On weekends, the same pattern emerged with odds being markedly higher in men 3.045 [1.759–5.271], 3.348 [1.905–5.882], and 2.162 [1.157–4.042] in the North, North - Central valley, and Central valley and South regions, respectively (Table 5). For women, only on weekends a similar effect was apparent in the North Central valley region: 1.961 [1.190–3.231].

## Discussion

Geographic latitude showed significant associations with reported sleep duration in this large population-based sample of people living between 18°29′S to 53°18′S in Chile. Those individuals who lived nearer to the Antarctic Circle had significantly longer sleep durations compared to their counterparts who resided closer to the equator; this association was stronger in men, and especially for sleep during weekends. People living in latitudes more proximal to the equator had greater than threefold odds of being short sleepers during weekends than those living near the Antarctic Circle.

Of particular interest was the finding on differences between workdays and weekends as a function of latitude. While during workdays there were no significant differences in the prevalence of short sleepers between northern and southern latitude, such similarities were not sustained during weekends, whereby significantly increased odds for shorter weekend sleep duration emerged among those living nearer the equator. This finding is concordant with previous studies reporting similar differences between workdays and weekends (Allebrandt et al., 2014; Randler, 2008). Thus, our data corroborate the fact that social modification of the light environment rather than latitude appear to exert a dominant effect on sleep duration during workdays, while more endogenous, and less modifiable timing mechanisms arise during weekends (Randler, 2008). On the other hand, the difference in the duration of sleep between workdays and weekends also increased along the north-south

**Table 5.** Risk factors for short sleep duration on workdays and weekends dichotomized by gender.

| | Workdays | | | | | |
|---|---|---|---|---|---|---|
| | Men | | | Women | | |
| | OR | 95% CI | *p* | OR | 95% CI | *p* |
| Age | 1.009 | 1.000–1.019 | **0.046** | 1.005 | 0.997–1.013 | 0.188 |
| Body mass index | 1.018 | 0.988–1.048 | 0.235 | 1.013 | 0.991–1.036 | 0.254 |
| Educational level | | | | | | |
| Low | 0.967 | 0.594–1.573 | 0.892 | 0.957 | 0.630–1.453 | 0.836 |
| Medium | 0.716 | 0.507–1.011 | 0.058 | 0.856 | 0.628–1.166 | 0.323 |
| High | ref | ref | ref | ref | ref | ref |
| Latitude | | | | | | |
| North 18°29′S–23°39′S | 1.327 | 0.846–2.080 | 0.218 | 1.058 | 0.681–1.644 | 0.802 |
| North-central valley 27°22′S–33°27′S | 1.675 | 1.053–2.663 | **0.029** | 1.366 | 0.876–2.129 | 0.168 |
| Central valley & South 34°59′S–39°50′S | 1.733 | 1.043–2.881 | **0.034** | 1.413 | 0.885–2.254 | 0.147 |
| South & Patagonia 41°28′S–46°33′S | 1.626 | 0.933–2.834 | 0.086 | 1.170 | 0.676–2.025 | 0.574 |
| Patagonia/Strait of Magellan 51°43′S– 53°18′S | ref | ref | ref | ref | ref | ref |
| | Weekends | | | | | |
| Age | 1.009 | 0.998–1.019 | 0.096 | 1.004 | 1.004–1.012 | 0.361 |
| Body mass index | 1.030 | 0.998–1.063 | 0.068 | 1.002 | 0.979–1.027 | 0.847 |
| Educational level | | | | | | |
| Low | 1.201 | 0.703–2.051 | 0.503 | 1.409 | 0.889–2.234 | 0.145 |
| Medium | 0.951 | 0.648–1.395 | 0.797 | 1.355 | 0.956–1.921 | 0.088 |
| High | ref | ref | ref | ref | ref | ref |
| Latitude | | | | | | |
| North 18°29′S–23°39′S | 3.045 | 1.759–5.271 | **<0.0001** | 1.243 | 0.752–2.055 | 0.124 |
| North-central valley 27°22′S–33°27′S | 3.348 | 1.905–5.882 | **<0.0001** | 1.961 | 1.190–3.231 | **0.008** |
| Central valley & South 34°59′S–39°50′S | 2.162 | 1.157–4.042 | **0.016** | 1.567 | 0.923–2.660 | 0.096 |
| South & Patagonia 41°28′S–46°33′S | 1.282 | 0.617–2.667 | 0.506 | 1.366 | 0.740–2.521 | 0.318 |
| Patagonia/Strait of Magellan 51°43′S– 53°18′S | ref | ref | ref | ref | ref | ref |

CI, confidence interval; OR, odds ratio.

axis, which could be indicative of increased misalignment of biological and social time on workdays in the zones more proximal to the Antarctic Circle.

In concordance with current findings, longer sleep durations in people living at higher latitudes are reported in the northern hemisphere (Friborg et al., 2012). Interestingly, Friborg et al. showed that sleep duration differed between two different latitudes: Norwegians in Tromsø (i.e., latitude 69° N) slept between 21 and 55 min longer compared with people living in Accra in Ghana (i.e., latitude 5°N) (Friborg et al., 2012). In that study, higher differences were more apparent in the summer with long days in Norway (Friborg et al., 2012). Although these two countries differ in many cultural and social aspects, in that study, several confounding factors were included in the analyses (Friborg et al., 2012). However, since only two countries with extremely different latitudes and sunlight-exposure patterns during the year were included by Friborg et al. [21], assessment of a potential dose–response relationship between latitude and sleep duration was not possible. In contrast, the nearly continuous range of latitudes along with a very homogeneous Latin-American cultural background enabled such estimates in the present study. In addition, the imposition of centrally determined work and study timetables throughout the country of Chile further reduce the potential impact of such factors on our findings. We should remark that the contiguous latitude spreads of the population in Chile derive from historical antecedents, whereby the foundation of cities during the Spanish colonial era was planned in a strategic way such as to allow for a maximum of one-day horse riding distance between each new city being established to populate the colonial possession. Therefore, this very unique geopolitical model enabled us to uncover the presence of a latitude-dependent trend to increase the risk for shorter sleep duration with increasing equatorial proximity, particularly during weekends.

There are several potential explanations that may account for the differences in sleep duration found in the present geographic model. First, the possibility exists that social self-regulation skills may have developed in response to the absence of sunlight during winter in more extreme latitudes. A previous study from Brazil compared two cities (i.e., Natal at 5°47′S and Sao Paulo at 23°32′S) and demonstrated longer sleep phase delays with the farther away people lived from the equatorial line (Miguel et al., 2014). Also, a trend towards a more eveningness chronotype was found in higher latitudes compared to the equatorial line (Miguel et al., 2014). In contrast to the present study where all participants lived within the 71°W longitude, the cities included in the Brazilian study were located in markedly different geographic longitudes: 46°38′W versus 35°12′W. (Miguel et al., 2014). However, in that study, sleep duration was not specifically compared (Miguel et al., 2014). Interestingly, differences in sleep duration may also be influenced by circadian preferences due to different exposures to daylight in specific geographic longitudes (Hense et al., 2011; Lo et al., 2014; Randler, 2008). This was proposed in a study that compared the circadian preference of students from West and East Germany (Randler, 2008). This study showed that students from West Germany woke up 20–30 min earlier than those living in the East. The difference in timing of sunrise was proposed as a possible explanation, as the sun rises around 20 min earlier in East Germany than in West Germany (Randler, 2008).

People living at different latitudes are exposed to different *scotopic* periods (i.e., the time interval between sunset and sunrise) and *photopic* periods (i.e., the time interval between sunrise and sunset), respectively. The exposure to bright sunlight may affect the phase position of the main sleep episode, leading to different sleep/wake patterns that may account for the geographic differences reported herein. We found a significant correlation between sunlight hours and sleep duration, particularly on weekends when the social determinants for the sleep period may be weaker. The effect of ambient temperature on sleep timing has been demonstrated previously in three pre-industrial original communities from South America and Africa, which live in similar tropical latitudes that ranged from 2°S to 20°S (Yetish et al., 2015).

One of the strengths of this study is the homogeneous and systematic data collection process that was conducted during the Chilean National Health Survey (Chilean National Health Survey, 2010). This survey allowed us to select representative populations throughout the Chilean territory and adjust for several cofounding factors such as socioeconomic status, BMI and gender. In addition, the Chilean population has a very similar genetic composition from north to south (Eyheramendy et al., 2015), which should reduce any genetic factors in sleep duration variance and certainly reduces cultural differences that may arise when comparing across different countries. However, the present study has some limitations that deserve mention. First, the study did not allow for measurements of any markers of circadian phase, such as melatonin or body temperature. Second, several other factors that are not included in the survey may have also influenced sleep duration. However, our analyses showed that population, altitude, and mean temperature of the geographic clusters did not seem to significantly associate with sleep duration. Indeed, mean temperature correlated modestly with sleep duration, but only on weekends. As anticipated, mean duration of sunlight hours constituted a plausible and possibly latitude-associated influencing factor, which was clearly apparent in a geographic setting such as Chile. Based on the significant association found between sunlight hours and sleep duration in the present study, the measurement of the *photopic* period may be an interesting parameter to explore in future studies, particularly when considering the relationship between sunlight hours and human sleep patterns (Yetish et al., 2015). How light environment is controlled at different latitudes may be also an interesting task to explore in future research. In addition to that, the extent to which temperature is independent of latitude could also be investigated using a complex geographic model with similar latitudes but different mean temperatures. A seasonal comparison (e.g., between winter and summer) of the effect of latitude on sleep duration and also the circadian phenotype (i.e., morningness and eveningness chronotype) are additional tasks to be addressed in the future.

## Conclusions

Taking advantage of a latitude-based geographic model, we here show that latitude is strongly associated with sleep patterns, indicating longer sleep durations in populations residing towards the more extreme Antarctic latitudes. This association seems to be more prominent in men and is especially apparent during weekends.

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## Declaration Of interest

The authors have no conflict of interest to declare.

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