The influence of school time on sleep patterns of children and adolescents

The influence of school-time on sleep pattern of children and adolescents

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ABSTRACT

Objective: In this epidemiological study, we evaluate the impact of school-time in sleep parameters in children and adolescents.

Methods: This cross-sectional study involved 639 elementary and high-school students (mean age 13.03 years [range: 8-18]; 58.5% female) from the south of Brazil. Participants answered the Morningness-Eveningness Questionnaire (MEQ), and asked as to their sleeping habits on weekdays and the weekend. *Sleep deficit* was defined as the difference between sleep duration on weekdays and weekend.

Results: The morning school-time students presented the significantly highest age, bedtime and wake up differences, sleep deficit and social jet lag. The sleep deficit presented by girls was greater than that observed in boys of the same age. The difference between weekdays and weekend waking times was also significantly greater in girls than boys aged 13 to 18 years. Sleep deficit was significant positively correlated with age and difference in wake up times; and significant negatively correlated with MEQ scores, social jet lag, difference between weekdays and weekend bedtimes, midpoint of sleep on free days and midpoint of sleep on free days corrected for sleep deficit. A step-by-step multivariate logistic regression identified social jetlag, the difference between weekdays and weekend waking times, and the midpoint of sleep on free days as significant predictors of sleep deficit (Adjusted $R^2 = 0.95$; $F = 1606.87$; $p < 0.001$).

Conclusion: Our results showed that school-time influences the sleep parameters. The association of school schedules and physiological factors influence the sleep/wake cycle.

Keywords: circadian rhythm; sleep deficit; school schedules; chronotype; child; adolescent.

Abbreviations

MEQ: Morningness-Eveningness Questionnaire

BMI: Body mass Index

MSW: Midpoint of sleep on workdays

MSF: Midpoint of sleep on free days

MSFsc: Midpoint of sleep on free days corrected for sleep deficit

1. Introduction

Human sleep patterns have changed significantly in the last century as a consequence of social organization and the advent of electrical light [1]. Our extended presence in human-controlled environments has had an impact on our physiology. As more time is spent under electrical light exposure in work places, daily exposure to darkness and total sleep durations have decreased [1]. As a result, the production of hormones such as melatonin is disturbed [2]. The impact of this metabolic alteration depends on the age, sex, and activity schedule (work, school, social interaction) of each individual. As a result, individual behavior patterns may vary as a function of the interaction between rhythmic psychobiological activities and the circadian timing system [3]. Social schedules may also affect circadian rhythmicity, although the extent of this impact depends on individual characteristics [4]. Variability in sleep patterns and activity schedules, combined with circadian preferences and adaptability, related to a shift in circadian preference from morning type to evening type, may result in sleep deprivation or sleep deficit in children and adolescents. Such disturbances have severe health repercussions, including changes in appetite regulating hormones [5], obesity [6,7], increased cardiovascular risk [8], hypertension [9], behavioral problems in school-aged children [10], and depression [11].

The social demands may interfere mainly in children and adolescents who had the sleep preference as evening chronotype, defined as the preference for sleep late and the difficulty to waking in the morning. Evening-types showed the largest differences in sleep timing between weekdays and weekend, leading to a sleep debt on weekdays, which tends to be compensated on weekend [12]. This misalignment of social and biological time refers not only to the duration of sleep time but also to the difference between the midpoint of sleep on weekdays and on weekend, defined as social jetlag [12]. Social jetlag has been identified as a risk factor for psychological disorders [13] and obesity [14,15]. The influence of age-related sleep delays is particular important in adolescents, when the restricted school-night sleep had an increase impact being recognized as a public health issue [16,17]. In adulthood, a similar phenomenon may occur during attempts to recover weekdays sleep debts (working days) by oversleeping on the weekend (days off).

Beyond the early school-time, other factors have contributed to an insufficient sleep, as electronic media use and caffeine consumption [18]. These factors, in

particular school time, could influences in sleep duration, circadian rhythm disruption, metabolic alterations, measures of alertness, mood, and health of children and adolescents [19,20,21]. In Brazil, most schools start at 7:30 AM, but this requirement does not take into account the recommendations for delaying school start times to opportunity an optimal level of sleep at this developmental stage [13,14]. The factors that may affect early school-time included economic background of the students, number of bus tiers, and school size [22].

In children and adolescents, weekend and weekdays sleep schedules differ due to school attendance [23]. Thus, the time at which classes begins may contribute to sleep deprivation in this population [24]. In this epidemiological study, we evaluated the impact of school-time in sleep parameters in Brazilian children and adolescents.

2. Methods

2.1. Subject Selection

This cross-sectional study was conducted in the cities of Lajeado and Progresso, located in the Vale do Taquari region, Rio Grande do Sul, Brazil (Fig. 1), Caucasian descendants. In spite of both cities been in the same region, 60 km of distance, Lajeado is more urbanized than Progresso. The most of students living in Progresso came from farmers families, and in Lajeado, the most of the students came from industrial workers. The sample was composed of 639 elementary (n= 283) and high school students (n= 356) (mean age 13.03 years [range: 8-18]; 58.5% female), (Fig. 2) 538 morning shift students (7:30 to 12:00) and 101 afternoon shift students (13:30 to 17:30). The school at Lajeado has only the morning shift option for this age. Participation was based on written parental consent, and the following exclusion criteria were applied: age >18 years, no school enrollment, and in night school-time. This study was performed according to international ethical guidelines (ethics committee approval number: 12–0386 GPPG/HCPA) [25].

2.2. Measures and Procedure

Over the course of the school year, students were invited to answer a set of questionnaires regarding meal times, sleep habits, and physical activity levels. Trained interviewers administered the questionnaires during school hours, in the presence of teachers, in a procedure lasting approximately 30 minutes. To ensure data consistency, parents were also administered questionnaires regarding their child’s schedule. A

collegial team proposed these two transcultural instruments.[26] During that occasion, all researchers were present and approved the final version of instruments. We used the same proposal transcultural instrument, translated to Portuguese by Brazilian team and approved by the all authors. The parent's questions were used to confirm the children answers. To this study, the following questions about sleep habits for weekdays and weekend were analyzed: "What time do you usually sleep?" and "What time do you usually wake up?". Therefore, it was possible to calculate the sleep duration of sleep and the midpoint of sleep for weekdays and weekend.

The main outcome evaluated was sleep deficit, defined as a difference in sleep duration from weekend to weekdays, using self-reported schedules (sleep deficit = Sleep duration of weekend – sleep duration of weekdays). Sleep deficit was considered as a continuous variable for all analyzes.

Age, sex, Body mass Index (BMI), school-time, chronotype and sleep parameters were evaluated as potential predictors of sleep deficit. Demographic variables were assessed using a questionnaire.

Chronotype was measured using the Morningness-Eveningness Questionnaire (MEQ), developed by Horne and Östberg [27]. The MEQ consists of 19 questions regarding subjective circadian preferences, yielding a total score ranging from 16 to 86 points. The highest scores indicate morningness preferences.

The *sleep-wake difference* using self-reported schedules was defined as the discrepancy between sleeping and waking times on the weekends and weekdays (sleep difference = sleep time at weekend – sleep time at weekdays; wake up difference = wake up time at weekend – wake up time at weekdays).

Midpoint of sleep was calculated using self-reported bedtimes and it is defined as an individual's sleeping period in the weekend and in the weekdays (MSW = Sleep onset on workdays added sleep duration on workdays divided by two: SO + SD/2; MSF = Sleep onset on free days added sleep duration on free days divided by two: SO + SD/2;) [28].

Midpoint of sleep on free days corrected for sleep deficit (MSFsc) was calculated as follows: MSF - 0.5*(SDF - (5*SDW + 2*SDF)/7) [28].

Social jetlag, using self-reported schedules, was defined as the discrepancy between social and biological time, and calculated as the difference between the midpoint of sleep on free days and on workdays (social jetlag = midpoint of sleep on free days – midpoint of sleep on workdays) [12,14].

BMI was calculated as the ratio of weight in Kg to height in m² [29]. Weight and height were measured using a digital portable scale with a maximum load of 150 kg with a resolution of 100g (brand Plenna®, Brazil) for determination of body weight and a stadiometer (Wiso®, Brazil) fitted to a flat wall and no footer for determining height.

2.3. Statistical Analysis

The distribution of sleep variables by school-time (morning or afternoon) was investigated using Student's t-test. The effect sizes were calculated by Hedges' g measure. To distribution of sleep variables and BMI was compared between genders and age groups (child and adolescent) using Student's t-test for independent samples. A chi-square test was performed to analyze the distribution of categorical variables.

Pearson's correlation coefficients were used to analyze the relationship between sleep deficit, age, BMI, MEQ score, sleep/wake differences, MSW, MSF, MSFsc and social jetlag. Variables, which showed a univariate association with sleep deficit, were included in a stepwise hierarchical regression model step-by-step controlling for confounding factors and potential collinearity. Age, sex, school-time, and Educational Institution were included in the first step of the equation; MEQ scores were entered in the second; while sleep/wake differences, MSF and social jetlag were inserted in the third step of the model. In all analyzes, the sleep deficit was used as a continuous variable. SPSS v.18 was used for all statistical analyses (SPSS Chicago, IL). Statistical significance was set at $p < 0.05$.

3. Results

Descriptive data comparing morning and afternoon shift students are displayed in Table 1. Sleep duration, MSW and MSFsc were significantly higher in the afternoon school-time students comparing to morning school-time students. However, the morning shift students presented the significantly highest age, bedtime and wake up difference, sleep deficit and social jet lag. Most students of the afternoon school-time do not take a nap during weekdays (15.3%) and weekends (13.8%). In the weekdays, morning shift students take a nap significantly more time than afternoon shift students.

Descriptive statistics for the sample are presented in Table 2. The sleep deficit presented by girls aged 12 years or younger and 13 to 18 years (1.19±1.37; 1.52±1.31, respectively) was greater than that observed in boys of the same age (0.40±1.48; 1.28±1.35, respectively). The difference between weekdays and weekend waking times

was also significantly greater in girls (3.41±1.43) than boys (3.13±1.57) aged 13 to 18 years. The MSFsc was significantly lower in girls (3.57±1.88) compared to boys (4.17±2.19) aged 12 years or younger.

The Pearson correlation was made to test the reliability of the answers about sleep in the questionnaires administered to schoolchildren and their parents. All sleep variables presented a significantly correlation comparing schoolchildren with parents' answers: wake up time ($r = 0.83$; $p < 0.001$), bedtime ($r = 0.52$; $p < 0.001$), and sleep duration at weekdays ($r = 0.38$; $p < 0.001$); wake up time ($r = 0.73$; $p < 0.001$), bedtime ($r = 0.65$; $p < 0.001$), and sleep duration at weekend ($r = 0.45$; $p < 0.001$).

The results of Pearson correlations between sleep deficit and age, BMI, MEQ score and sleep variables are shown in Table 3. Sleep deficit was negatively correlated with MEQ scores ($r = -0.16$; $p < 0.001$), social jetlag ($r = -0.34$; $p < 0.001$), difference between weekdays and weekend bedtimes ($r = -0.34$; $p < 0.001$), MSF ($r= -0.30$; $p < 0.001$) and MSFsc ($r = -0.56$; $p < 0.001$). Age and difference in wake up times were positively correlated with sleep deficit ($r= 0.20$; $p < 0.001$; $r= 0.56$; $p < 0.001$), which, in turn, showed no correlation with BMI ($r= 0.01$; $p = 0.89$) and MSW ($r = 0.03$; $p = 0.41$).

The regression model step-by-step identified social jetlag, the difference between weekdays and weekend waking times, and MSF as significant predictors of sleep deficit (Table 4; Adjusted $R^2 = 0.95$; $F = 1606.865$; $p < 0.001$). The difference between bedtime on weekdays and the weekend was the only variable excluded from the model due to collinearity.

Fig. 3 shows the schedules of sleeping, waking, and sleep deficit to the morning and afternoon shift students during weekdays and the weekend. Afternoon students slept ($p < 0.001$, 95% CI [-1.01, -0.57], Hedges's gs = -0.79) and woke up ($p < 0.001$, 95% CI [-3.90, -3.32], Hedges's gs = -3.61) significantly later than morning students on the weekdays. In the weekend, morning students slept significantly later than afternoon students ($p = 0.020$, 95% CI [0.23, 0.65], Hedges's gs = 0.44), although the difference in waking times did not distinguish the two groups ($p = 0.13$, 95% CI [-0.75, -0.32], Hedges's gs = -0.54). The highest sleep deficits in the sample were observed among morning shift students ($p < 0.001$, 95% CI [0.61, 1.04], Hedges's gs = 0.83).

4. Discussion

The present study assessed the influence of school-time on the sleeping pattern (waking, bedtime, chronotype, and sleep deficit) of children and adolescents. Our results also showed the influence of waking times, social jetlag and MSF on sleep deficit.

Our data showed that school-time is an important determinant of sleeping and waking patterns during weekdays. Afternoon shift students slept and awoke significantly later than morning shift students, showing that school schedule plays an important role in the difference between sleep duration from weekend to weekdays. Morning classes may cause sleep deficit during weekdays in comparison to afternoon classes, which probably is partly compensated on weekends, thus bedtime and wake up time are delayed. In a previous study, adolescents were found to show sleep disturbances during the weekend [30]. Insufficient sleep in adolescents can be considered a major public health concern [20]. Sleep disturbances and sleep-related health problems have been found to be more prevalent in adolescents who start school earlier in the morning [31]. In Brazilian children from the city of São Paulo, school-time has been found to influence sleep habits. The morning shift students showed a reduced total in the sleep duration, sleep earlier, and nap more often than afternoon students [32]. In addition to disturbing circadian rhythmicity, earlier school-times have been found to be significant contributors to insufficient sleep [20,24]. In the present study, morning students also slept earlier than afternoon students on weekdays.

Circadian preference starts to shift toward eveningness at the age of 13 years. Although individual differences in chronotype tend to persist throughout life, biological and social synchronizers lead to more morningness in early development, a shift toward eveningness in adolescence, and a return to the morningness with aging [33]. School schedules can be considered one of these synchronizers [34]. Wittmann et al. (2006) [12] demonstrated that the correlation between late chronotype, wellbeing, and stimulant use may be a consequence of social jetlag, attributable to the discrepancy between social and biological time in workdays *vs.* the weekend. In adults, a social jetlag greater than two hours has been found to be associated with depression [13]. In children without psychiatric disorders, no correlations have been identified between a social jetlag of two hours or more and depression levels [11]. In this study, we showed that social jetlag, weekend/weekdays differences in waking times and MSF are significant predictors of sleep deficit. These results suggest that social jetlag may have a

chronic influence on sleep deficit, which, in turn, contributes to the development of depression in adulthood.

Social jetlag can be transient [16], and cause temporary symptoms such as changes in mood, sleep, and appetite, as part of the physiological adaptation to a sudden change of schedules. However, the chronic nature of the sleep disturbances experienced by children and adolescents is a cause for concern. Problems such as depression [13] and obesity [14,15] may both occur as a consequence of this chronic desynchronization. Sleep education programs at schools have been found to increase weekend sleep duration in adolescents in the short term [35]. Sleep recommendations [36] may therefore be an important tool to improve sleep quality and prevent the consequences of sleep deficits in children and adolescents.

In the present study, sleep deficit was assessed using a self-report questionnaire, which may be vulnerable to response bias. However, the questionnaires administered to children and adolescents were also answered by parents, increasing the reliability of current findings. Furthermore, it will be important replicate our results in future research using multiple informants relating to the symptoms of sleep disorders, and lifestyle habits, such as academic performance, electronic media use, substance use and mental impairments, which were not considered and they may affect sleep pattern. Future studies may overcome this limitation by using objective measures of sleep and waking times and may be investigated all areas of interest.

Our findings reinforce the evidence that school-time showed to influence the sleep deficit experienced by children and adolescents. Also, school-time showed to be a confounding variable, since not all students were adapted according the circadian preference. Sleep deficit was, in turn, associated with eveningness and age. In the regression model, we observed the influence of waking times, social jetlag and free days sleep midpoint on sleep deficit. In conclusion, the combination of school-time and physiological factors was found to influence the sleep/wake cycle and contribute to the sleep disturbances observed in this population.

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Table 1.
Descriptive statistics for school-time, sex, age, weight status, and sleep.

	Morning (n= 538)	Afternoon (n= 101)	p value
Sex, n (%)[#]			0.08
Male	215 (33.6%)	50 (7.8%)	
Female	323 (50.5%)	51 (8%)	
Age	13.35±2.60	11.35±1.98	< 0.001*
Body mass index (SD)	20.25±3.58	19.66±4.12	0.60
Sleep duration (h)			
Weekdays	8.06±0.59	9.35±1.36	< 0.001*
Weekend	9.43±1.33	9.56±1.50	0.20
MEQ total (SD)	49.08±8.52	51.28±10.84	0.06
Bedtime difference (h)	1.54±1.39	0.36±1.28	< 0.001*
Wake up difference (h)	3.31±1.43	0.56±1.26	< 0.001*
Sleep deficit (h)	1.37±1.36	0.22±1.37	< 0.001*
MSW (h)	2.20±0.39	3.53±1.17	< 0.001*
MSF (h)	4.14±1.47	4.29±1.41	0.18
MSFsc (h)	3.67±2.03	4.36±1.98	0.002*
Social Jet Lag (h)	1.54±1.37	0.36±1.28	< 0.001*
Nap, n (%)[#]			
Weekdays			< 0.001*
Yes	199 (31.1%)	3 (0.5%)	
No	339 (53.1%)	98 (15.3%)	
Weekend			0.01*
Yes	129 (20.2%)	13 (2.0%)	
No	408 (63.9%)	88 (13.8%)	
Nap, yes (h)			
Weekdays	1.43±1.20	0.30±0.00	< 0.001*
Weekend	1.44±0.56	1.28±0.43	0.31

Abbreviations: MEQ, Morningness-Eveningness Questionnaire; Weekend/weekdays difference in bedtime and waking time; Sleep deficit, weekend/weekdays difference in sleep duration; MSW, Midpoint of sleep on workdays; MSF, Midpoint of sleep on free days; MSFsc, Midpoint of sleep on free days corrected for sleep deficit; Student's t-test; [#]Chi-square test; *Statistically significant differences ($p < 0.05$).

Table 2.

Descriptive statistics for age, weight status, school-time and sleep.

	Children (age 12 or younger)			**Adolescents (13 to 18 years)**		
	Boys (n= 122)	Girls (n= 161)	p value	Boys (n= 143)	Girls (n= 213)	p value
Age	10.50±1.21	10.53±1.31	0.85	15.06±1.53	15.02±1.32	0.81
Body mass index (SD)	19.28±3.55	18.71±3.24	0.16	20.84±3.82	21.31±3.47	0.23
MEQ total (SD)	50.63±9.39	49.92±8.75	0.51	49.42±8.77	48.38±8.91	0.28
Bedtime difference (h)	1.50±1.53	1.26±1.39	0.06	1.42±1.41	1.47±1.35	0.61
Wake up difference (h)	2.25±2.05	2.45±1.49	0.15	3.13±1.57	3.41±1.43	0.026*
Sleep deficit (h)	0.40±1.48	1.19±1.37	0.002*	1.28±1.35	1.52±1.31	0.017*
Social Jet Lag (h)	1.50±1.53	1.26±1.39	0.07	1.42±1.41	1.47±1.31	0.59
MSW (h)	2.34±1.01	2.59±1.01	0.82	2.44±1.04	2.30±0.49	0.24
MSF (h)	4.23±1.50	4.02±1.33	0.079	4.23±1.51	4.17±1.50	0.091
MSFsc (h)	4.17±2.19	3.57±1.88	0.015*	3.91±2.01	3.62±2.05	0.20
School-time, n (%)[#]			0.59			0.042*
Morning	88 (31%)	121 (43%)		127 (36%)	202 (57%)	
Afternoon	34 (12%)	40 (14%)		16 (5%)	11 (3%)	

Abbreviations: MEQ, Morningness-Eveningness Questionnaire; Weekend/weekdays difference in bedtime and waking time; Sleep deficit, weekend/weekdays difference in sleep duration; MSF, Midpoint of sleep on free days; MSW, Midpoint of sleep on workdays; MSFsc, Midpoint of sleep on free days corrected for sleep deficit; Student's t-test; [#]Chi-square test; *Statistically significant differences ($p < 0.05$)

Table 3.

Results of univariate Pearson correlations between sleep deficit and age, body mass index, sleep parameters, and chronotype.

	Sleep deficit	
Variable	Pearson correlation (r)	p value
Age	0.197	<0.001
Body mass index	0.005	0.89
MEQ	-0.161	<0.001
Bedtime difference	-0.342	<0.001
Wake up difference	0.561	<0.001
MSW	-0.033	0.41
MSF	-0.304	<0.001
MSFsc	-0.557	<0.001
Social Jet Lag	-0.342	<0.001

MEQ, Morningness-Eveningness Questionnaire; Weekend/weekdays difference in bedtime and waking time; MSW, Midpoint of sleep on workdays; MSF, Midpoint of sleep on free days; MSFsc, Midpoint of sleep on free days corrected for sleep deficit; Sleep deficit, weekend/weekdays difference in sleep duration.

Table 4.

Stepwise univariate linear regression model of sleep deficit.

Variables	Multivariate B (Std Error)	Beta	Multivariate t
Step 1 Adjusted R^2= 0.12			
Age	0.087 (0.03)*	0.137	3.477
Sex	0.476 (0.13)**	0.141	3.725
School-time	-0.791 (0.21)**	-0.174	-3.861
Educational Institution	0.368 (0.15)*	0.110	2.533
Step 2 Adjusted R^2= 0.12			
Age	0.079 (0.03)*	0.124	3.135
Sex	0.462 (0.13)**	0.137	3.635
School-time	-0.840 (0.21)**	-0.185	-4.103
Educational Institution	0.255 (0.15)	0.076	1.690
MEQ	-0.019 (0.07)*	-0.101	-2.551
Step 3 Adjusted R^2= 0.95			
Age	0.004 (0.01)	0.006	0.602
Sex	0.003 (0.03)	0.001	0.099
School-time	0.099 (0.07)	0.022	-1.513
Educational Institution	0.017 (0.02)	0.009	0.811
MEQ	-0.003 (0.00)	-0.017	-1.533
Wake up difference	0.968 (0.01)**	1.106	83.164
Social Jetlag	-0.915 (0.02)**	-0.916	-40.523
MSF	-0.061 (0.02)*	-0.065	-2.642

MEQ, Morningness-Eveningness Questionnaire; Weekend/weekdays difference in waking time; MSF, Midpoint of sleep on free days; Weekend/weekdays difference in bedtime was excluded from the model due to collinearity; Significant at $p < 0.05$*, $p < 0.001$**.

Figure legends

Fig. 1. Geographic coordinates and sample size surveyed in the Vale do Taquari, in southern Brazil.

Fig. 2. Flowchart of the study.

Fig. 3. Bedtime, waking time, and sleep deficit of morning and afternoon shift students on weekdays and on weekend. Level of significance: $p < 0.05$*.

REFERENCES

[1] Eisenstein M. Chronobiology: stepping out of time. Nature 2013;497(7450):S10-2.

[2] Czeisler CA. Perspective: casting light on sleep deficiency. Nature 2013;497(7450):S13.

[3] Hidalgo MP, Camozzato A, Cardoso L, Preussler C, Nunes CE, Tavares R, Posser MS, Chaves ML. Evaluation of behavioral states among morning and evening active healthy individuals. Braz J Med Biol Res 2002;35(7):837-42.

[4] Korczak AL, Martynhak BJ, Pedrazzoli M, Brito AF, Louzada FM. Influence of chronotype and social zeitgebers on sleep/wake patterns. Braz J Med Biol Res 2008;41(10):914-9.

[5] Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. PLoS Med 2004;1(3):e62.

[6] Van Cauter E, Spiegel K, Tasali E, Leproult R. Metabolic consequences of sleep and sleep loss. Sleep Med 2008;9 Suppl 1:S23-8.

[7] Van Cauter E, Knutson KL. Sleep and the epidemic of obesity in children and adults. Eur J Endocrinol 2008;159 Suppl 1:S59-66.

[8] Narang I, Manlhiot C, Davies-Shaw J, Gibson D, Chahal N, Stearne K, Fisher A, Dobbin S, McCrindle BW. Sleep disturbance and cardiovascular risk in adolescents. CMAJ 2012;184(17):E913-20.

[9] Peach H, Gaultney JF, Reeve CL. Sleep characteristics, body mass index, and risk for hypertension in young adolescents. J Youth Adolesc. 2015;44(2):271-84.

[10] Astill RG, Van der Heijden KB, Van Ijzendoorn MH, Van Someren EJ. Sleep, cognition, and behavioral problems in school-age children: a century of research meta-analyzed. Psychol Bull 2012;138(6):1109-38.

[11] de Souza CM, Hidalgo MP. Midpoint of sleep on school days is associated with depression among adolescents. Chronobiol Int 2014;31(2):199-205.

[12] Wittmann M, Dinich J, Merrow M, Roenneberg T. Social jetlag: misalignment of biological and social time. Chronobiol Int 2006;23(1-2):497-509.

[13] Levandovski R, Dantas G, Fernandes LC, Caumo W, Torres I, Roenneberg T, Hidalgo MP, Allebrandt KV. Depression scores associate with chronotype and social jetlag in a rural population. Chronobiol Int 2011;28(9):771-8.

[14] Roenneberg T, Allebrandt KV, Merrow M, Vetter C. Social jetlag and obesity. Curr Biol 2012;22(10):939-43.

[15] Challet E. Circadian clocks, food intake, and metabolism. Prog Mol Biol Transl Sci 2013;119:105-35.

[16] Gradisar M, Gardner G, Dohnt H. Recent worldwide sleep patterns and problems during adolescence: a review and meta-analysis of age, region, and sleep. Sleep Med 2011;12(2):110-8.

[17] Touitou Y. Adolescent sleep misalignment: a chronic jet lag and a matter of public health. J Physiol Paris 2013;107(4):323-6.

[18] Owens J; Adolescent Sleep Working Group; Committee on Adolescence. Insufficient sleep in adolescents and young adults: an update on causes and consequences. Pediatrics 2014;134(3):e921-32.

[19] Paksarian D, Rudolph KE, He JP, Merikangas KR. School Start Time and Adolescent Sleep Patterns: Results From the US National Comorbidity Survey-Adolescent Supplement. Am J Public Health 2015;105(7):1351-7.

[20] Adolescent Sleep Working Group; Committee on Adolescence; Council on School Health. School start times for adolescents. Pediatrics 2014;134(3):642-9.

[21] Owens JA, Belon K, Moss P. Impact of delaying school start time on adolescent sleep, mood, and behavior. Arch Pediatr Adolesc Med 2010;164(7):608-14.

[22] Wolfson AR, Carskadon MA. A Survey of Factors Influencing High School Start Times. NASSP Bulletin 2005;89: 47-66.

[23] Carskadon MA, Acebo C, Jenni OG. Regulation of adolescent sleep: implications for behavior. Ann N Y Acad Sci 2004;1021:276-91.

[24] Hansen M, Janssen I, Schiff A, Zee PC, Dubocovich ML. The impact of school daily schedule on adolescent sleep. Pediatrics 2005;115(6):1555-61.

[25] Portaluppi F, Smolensky MH, Touitou Y. Ethics and methods for biological rhythm research on animals and human beings. Chronobiol Int 2010, 27:1911–1929.

[26] Martoni M, Fabbri M, Erbacci A, Tonetti L, Spinelli A, Natale V. Sleep and body mass index in Italian children and adolescents: a self-report study. In Special Issue: Abstracts of the 21st Congress of the European Sleep Research Society, 4-8 September 2012, Paris, France. Journal of Sleep Research, vol. 21 (Suppl. 1), p. 304.

[27] Horne JA, Ostberg O. A self-assessment questionnaire to determine Morningness-eveningness in human circadian rhythms. Intl J Chronobiol 1976;4:97-110.

[28] Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, Merrow M. A marker for the end of adolescence. Curr Biol. 2004;14(24):R1038-9.

[29] WHO Multicentre Growth Reference Study Group: WHO Child Growth Standards: Length/height-for-age, weight-forage, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva, World Health Organization, 2006. Available at: http://www.who.int/childgrowth/standards/technical_report/en/index.html

[30] Salcedo Aguilar F, Rodríguez Almonacid FM, Monterde Aznar ML, García Jiménez MA, Redondo Martínez P, Marcos Navarro AI. Sleeping habits and sleep disorders during adolescence: relation to school performance. Aten Primaria 2005;35(8):408-14.

[31] Ming X, Koransky R, Kang V, Buchman S, Sarris CE, Wagner GC. Sleep insufficiency, sleep health problems and performance in high school students. Clin Med Insights Circ Respir Pulm Med 2011;5:71-9.

[32] Silva TA, Carvalho LB, Silva L, Medeiros M, Natale VB, Carvalho JE, Prado LB, Prado GF. [Sleep habits and starting time to school in Brazilian children]. Arq Neuropsiquiatr 2005;63(2B):402-6.

[33] Tonetti L, Fabbri M, Natale V. Sex difference in sleep-time preference and sleep need: a cross-sectional survey among Italian pre-adolescents, adolescents, and adults. Chronobiol Int 2008;25(5):745-59.

[34] Wolfson AR, Carskadon MA. Understanding adolescents' sleep patterns and school performance: a critical appraisal. Sleep Med Rev 2003;7(6):491-506.

[35] Kira G, Maddison R, Hull M, Blunden S, Olds T. Sleep education improves the sleep duration of adolescents: a randomized controlled pilot study. J Clin Sleep Med 2014;10(7):787-92.

[36] Matricciani L, Blunden S, Rigney G, Williams MT, Olds TS. Children's sleep needs: is there sufficient evidence to recommend optimal sleep for children? Sleep 2013;36(4):527-34.

Figure 1

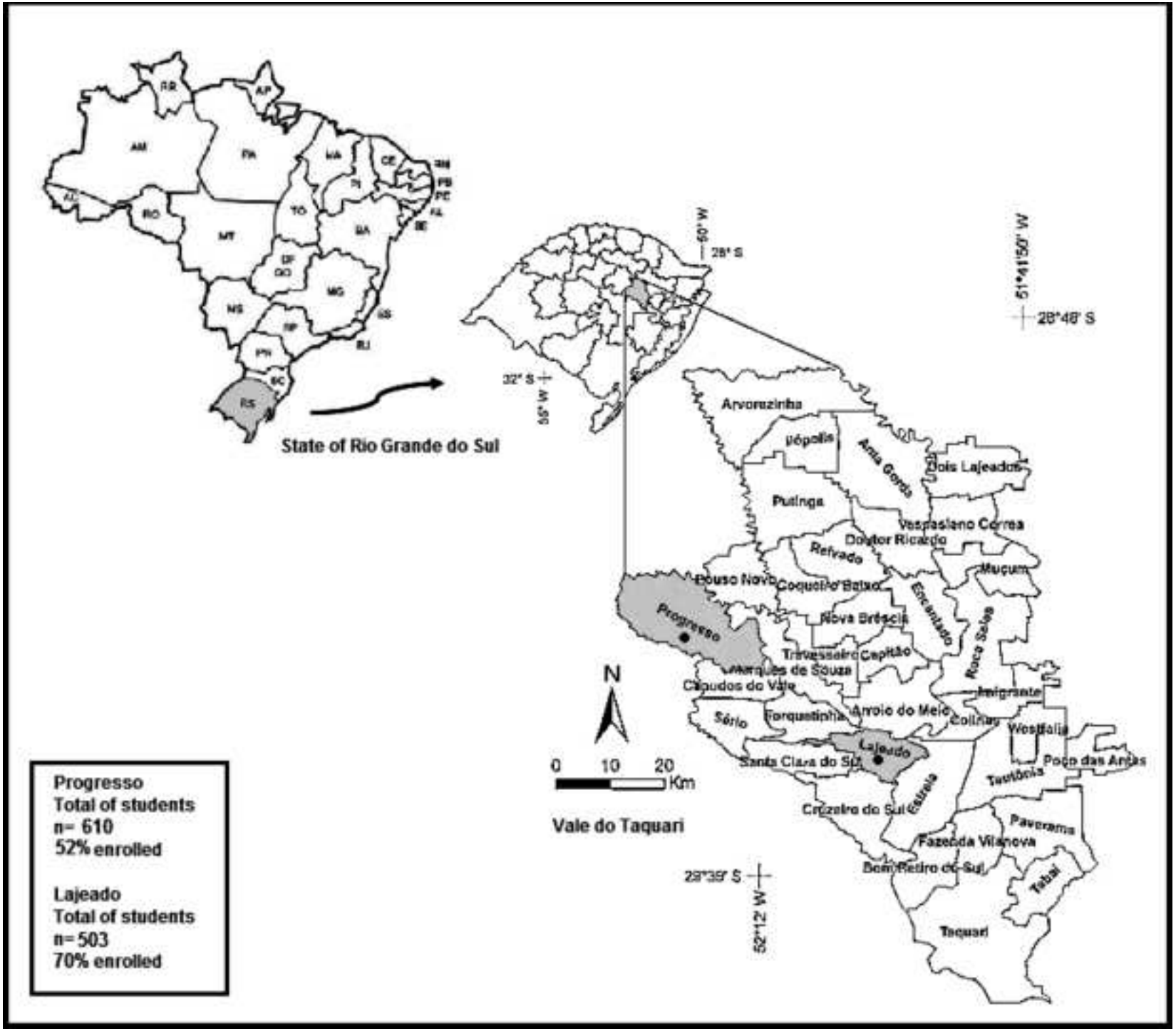

State of Rio Grande do Sul
Progresso
Total of students
n= 610
52% enrolled
Lajeado
Total of students
n= 503
70% enrolled
Vale do Taquari
N
0 10 20
Km
Arvorezinha
Ilópolis
Anta Gorda
Dois Lajeados
Putinga
Vespasiano Corrêa
Doutor Ricardo
Relvado
Muçum
Bouso Novo
Coqueiro Baixo
Encantado
Nova Brescia
Roca Sales
Progresso
Travessão
Capitão
Marques de Souza
Capitão do Vale
Imigrante
Sério
Forquetinha
Arroio do Meio
Colinas
Westfália
Lajeado
Santa Clara do Sul
Poço das Antas
Teutônia
Cruzeiro do Sul
Estrela
Paverama
Fazenda Vilanova
Bom Retiro do Sul
Tabaí
Taquari
28° S
50° W
32° S
55° W
51°41'50" W
28°48' S
29°39' S
52°12' W

Figure 2

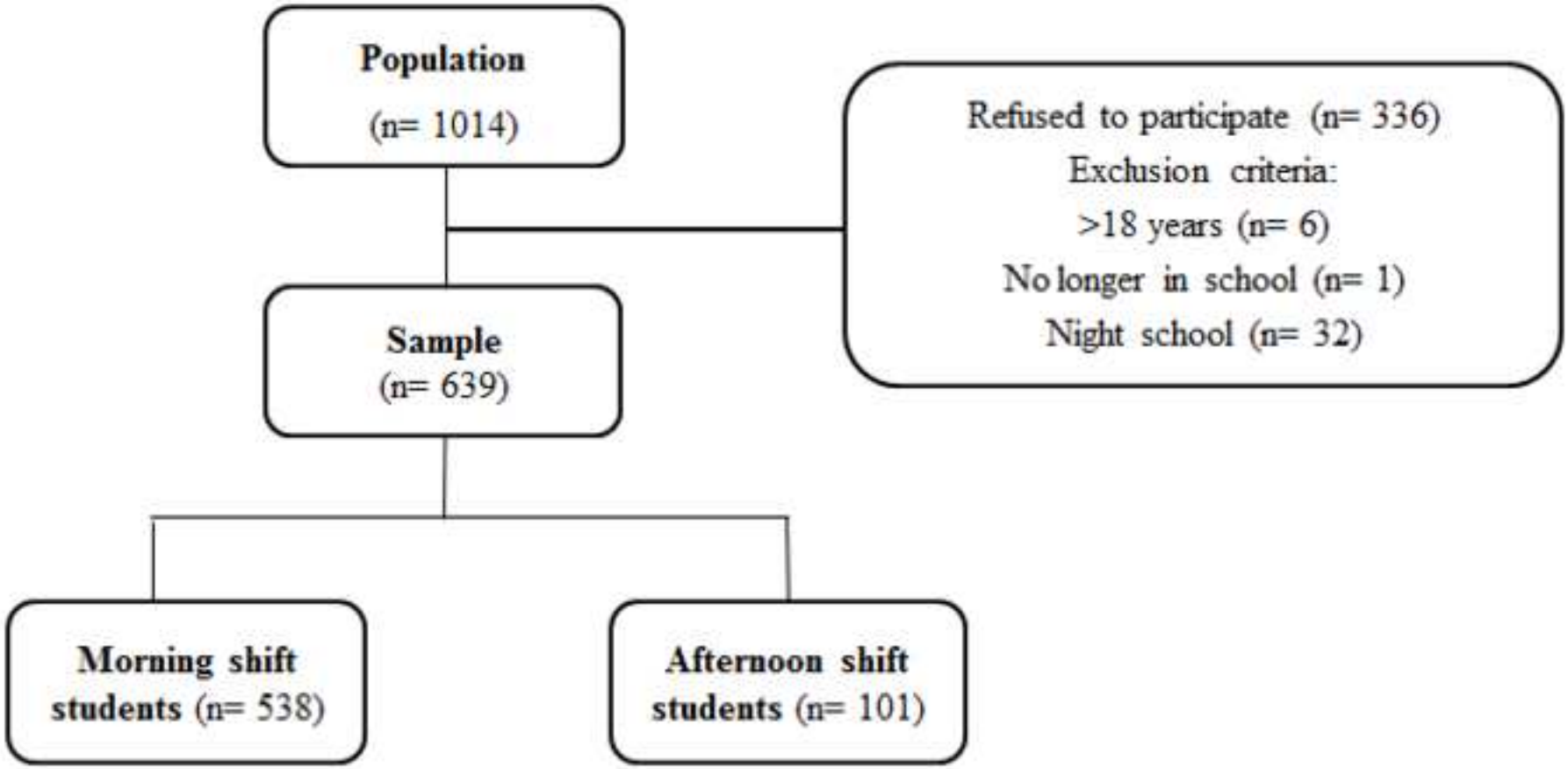
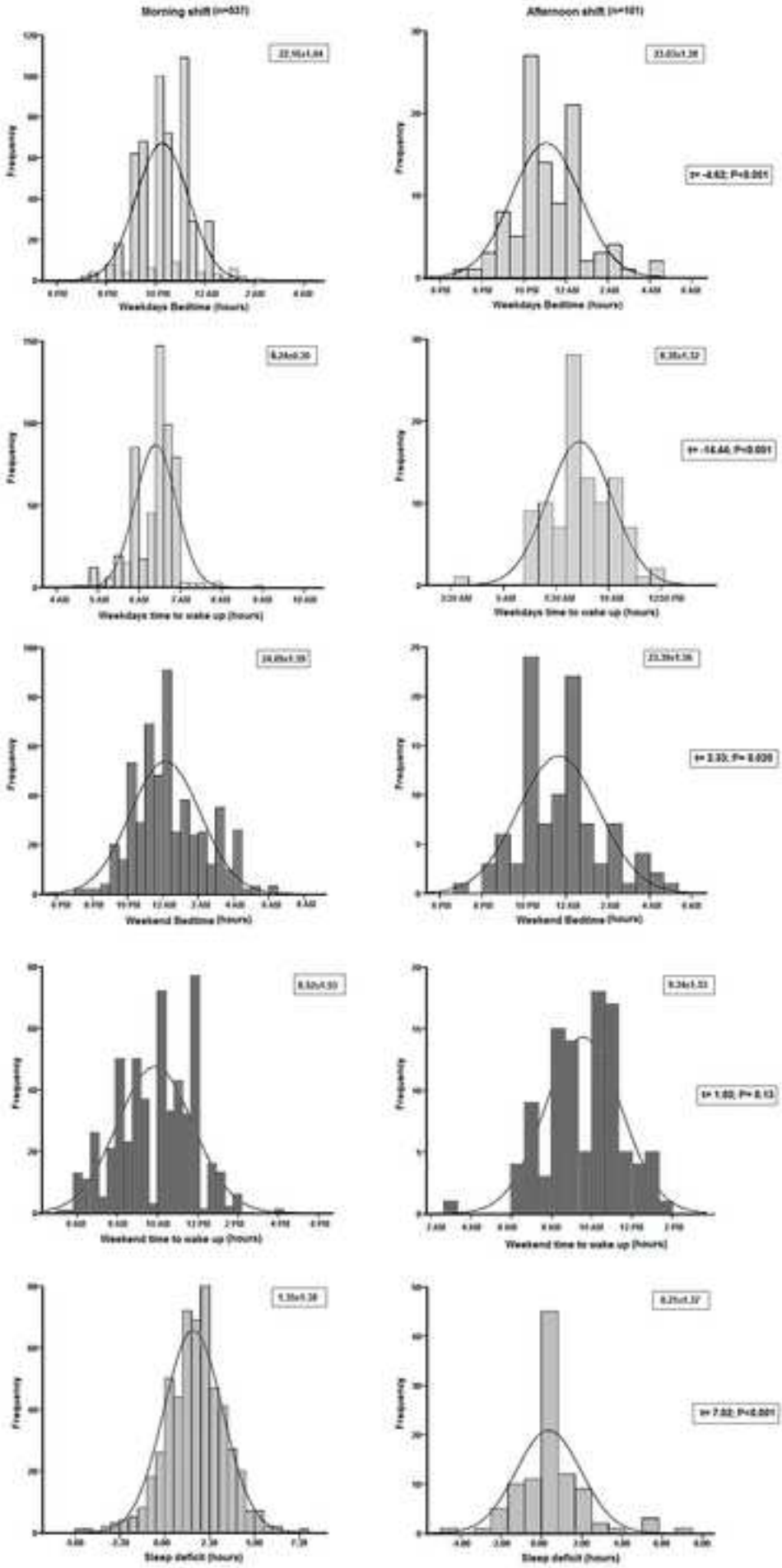

Population
(n= 1014)
Refused to participate (n= 336)
Exclusion criteria:
>18 years (n= 6)
No longer in school (n= 1)
Night school (n= 32)
Sample
(n= 639)
Morning shift students (n= 538)
Afternoon shift students (n= 101)

Figure 3


Morning shift
Afternoon shift
Frequency
Weekdays Bedtime (hours)
Weekdays time to wake up (hours)
Weekend Bedtime (hours)
Weekend time to wake up (hours)
Sleep deficit (hours)