DOI: 10.1590/1413-81232022273.03132021

Is sleep time associated with handgrip strength in adolescents from the 1997/1998 São Luís Birth Cohort?

O tempo de sono está associado à força de preensão manual em adolescentes da Coorte de São Luís de 1997/1998?

Susana Cararo Confortin (https://orcid.org/0000-0001-5159-4062) [1]
Rosângela Fernandes Lucena Batista (https://orcid.org/0000-0002-1529-0165) [1]
Aline Rodrigues Barbosa (https://orcid.org/0000-0003-0929-7659) [2]
Andrea Wendt (https://orcid.org/0000-0002-4640-2254) [3]
Inácio Crochemore-Silva (https://orcid.org/0000-0001-5390-8360) [3]
Maria Teresa Seabra Soares de Britto e Alves (https://orcid.org/0000-0002-4806-7752) [1]
Vanda Maria Ferreira Simões (https://orcid.org/0000-0001-8351-1348) [1]
Antônio Augusto Moura da Silva (https://orcid.org/0000-0003-4968-5138) [1]

Abstract *This article aims to analyze the association between sleep time and handgrip strength in adolescents belonging to the 1997/1998 São Luís Birth Cohort. This was a cross-sectional study nested in a birth cohort study. One thousand two hundred sixty-nine individuals (18 and 19 years) wore an Actigraph® GTX3+ accelerometer on their wrist 24 hr/day for 7 consecutive days. Handgrip strength was measured using a digital hand dynamometer. We used directed acyclic graphs (DAG) to identify confounding variables. This sample of adolescents was mostly composed of men, with brown skin color, economic class C, which did not work, did not consume alcohol, did not smoke, and never used drugs. The mean value of handgrip strength was 28.2 (±9.3) kgf, and the mean of sleep time was 6 (±1.0) hours per day. The crude analysis showed an association between sleep time and muscle strength. An increase of one hour of sleep reduced the handgrip strength by 1.95 kgf (95%CI:-2.51;-1.39). However, after adjustment for confounders, the association was not maintained (β:-0.07; 95%CI:-0.48;0.36). Sleep time is not associated with handgrip strength in adolescents in São Luís.*

Key words *Muscle strength, Sleep, Adolescents*

Resumo *O objetivo deste artigo é analisar a associação entre tempo de sono e força de preensão manual em adolescentes da Coorte de Nascimentos de São Luís 1997/1998. Estudo transversal aninhado a um estudo de coorte de nascimentos. Mil duzentos e sessenta e nove indivíduos (18 e 19 anos) usaram um acelerômetro Actigraph® GTX3 + em seu pulso 24 horas/dia por sete dias consecutivos. A força de preensão manual foi medida por meio de um dinamômetro digital de mão. Usou-se gráficos acíclicos direcionados (DAG) para identificar variáveis de confusão. A amostra de adolescentes foi composta em sua maioria por homens, de cor da pele parda, classe econômica C, que não trabalhava, não consumiam álcool, não fumavam e nunca usaram drogas. O valor médio da força de preensão manual foi de 28,2 (±9,3) kgf, e a média do tempo de sono foi de seis (±1,0) horas por dia. A análise bruta mostrou associação entre tempo de sono e força muscular. O aumento de uma hora de sono reduziu a força de preensão manual em 1,95 kgf (IC95%:-2,51;-1,39). No entanto, após o ajuste para fatores de confusão, a associação não foi mantida (β:-0,07; IC95%:-0,48;0,36). O tempo de sono não foi associado à força de preensão manual em adolescentes de São Luís.*

Palavras-chave *Força muscular, Sono, Adolescentes*

[1] Programa de Pós-Graduação em Saúde Coletiva, Universidade Federal do Maranhão. Rua Barão de Itapary 155 Centro 65020-070 São Luís MA Brasil. susanaconfortin@gmail.com
[2] Escola de Esportes, Universidade Federal de Santa Catarina. Florianópolis SC Brasil.
[3] Programa de Pós-Graduação em Epidemiologia, Universidade Federal de Pelotas. Pelotas RS Brasil.

Introduction

Muscle strength is an essential fitness component that enables the execution of various daily activities and sport participation throughout the life span[1]. Handgrip strength (HGS) is an indicator of general health[2], which tends to reflect overall muscle strength[1]. This indicator has clinical value, is associated with muscle mass, nutritional status, health/morbidity, and physical function[1,2]. HGS can also predict future outcomes, such as reduced functional capacity and mortality[2], even in adolescents[3].

Several factors can interfere with muscle strength, such as age, sex, economic status, smoking, physical activity, and sleep[4]. Sleep plays a determinant role in the process of growth and development. Particularly, adolescents not getting enough sleep show changes in the sleep/wake cycle, including a delay in the sleep phase[5].

Adverse sleep patterns can affect the function of trophic factors, such as reduction of insulin-like growth factor-1 (IGF-1). IGF-1 is thought to mediate the development of muscle mass and muscle function[6] and promotes the synthesis of muscle proteins[7]. In this sense, there may be biological plausibility that sleep affects muscle strength.

Studies that analyzed the association between sleep and HGS showed that prolonged sleep latency, insomnia[8], poor sleep quality, and short sleep duration[9] were associated with lower HGS in adults[8] and university students[9].

Researches that studied the relationship between sleep and muscle strength usually evaluated young adults and used self-reported questionnaires on sleep quality[9] and duration and hours of sleep per day[4]. In Brazil, only Lima *et al.*[4] assessed this relationship in young adults (average age: 45.5 years) from Florianópolis and found no association. However, according to our knowledge, the literature on the association between sleep and handgrip strength in adolescents is scarce, especially with sleep assessed using accelerometry. Recently, Al-Rasheed and Ibrahim[10] showed that poor sleep did not affect isometric muscle strength of adolescents. However, the study involved only 62 adolescents, suggesting the need for further studies.

The identification of the relationship between sleep time and handgrip strength can provide useful information on the global health of adolescents, enabling health promotion strategies, so that adolescents maintain strength and muscle mass across the life span. Thus, this study aimed to analyze the association between sleep time, measured by accelerometry, and handgrip strength in adolescents in São Luís, Northeast of Brazil.

Methods

A cross-sectional study nested in a birth cohort study was carried out in São Luís, Maranhão State. Baseline data were collected in 1997/1998, with follow-up in 2005 (7 to 9 years) and 2016 (18 and 19 years). The current study used data referring to individuals in the epidemiological research entitled "Determinants throughout the life cycle of obesity, precursors to chronic diseases, human capital, and mental health" (*Determinantes ao longo do ciclo vital da obesidade, precursores de doenças crônicas, capital humano e saúde mental*), called the *RPS Consortium* of the Ribeirão Preto, Pelotas, and São Luís birth cohorts.

At the baseline, a systematic stratified sample, according to the number of births in each of the ten maternity hospitals, was carried out in the city of São Luís (March 1997 to February 1998). Non-hospital births and those occurring in hospitals with less than 100 births per year were excluded. Two thousand five hundred forty-one births were considered eligible, and 48 stillbirths and 50 twin births were excluded. The final sample consisted of 2,443 births. More detailed information on location, population, and sampling have been previously published[11].

In 2016, from January to December, the third phase of the cohort was carried out. All participants included in the initial phase of the study were sought through telephone contact, enrollment records at schools and universities, as well as through military enlistment, the latter only for male adolescents. We identified six hundred eighty seven adolescents, and they agreed to participate in the study[11]. Because of the difficulty in locating participants in the stages after the baseline and to expand the size and power of the sample, it was decided to include, to be part of the birth cohort, non-randomized adolescents born in the municipality in 1997. A search for adolescents was carried out using the database of the Live Birth Information System (SINASC) as the first stage, being considered as an inclusion criterion having been born, in a maternity hospital located in São Luís – MA in 1997. From this list, a random draw was carried out, making a total of 4,593 births in 1997. Of these, 1,133 adolescents were contacted by phone or in per-

Ciência & Saúde Coletiva, 27(3):1147-1155, 2022

son. Subsequently, 695 volunteers were identified through schools, universities and social media. In this stage, 1,828 individuals were included, totaling 2,515 participants. Data collection was carried out through structured questionnaires using a face-to-face interview[11]. All those involved in data collection participated in training conducted by the research coordinators, including the use of accelerometers.

Handgrip strength (dependent variable)

Handgrip strength was measured using a digital hydraulic dynamometer Jamar Plus + (by Sammons Preston) adjusted, for each individual, according to the size of the hands. During the execution of the test[12], the interviewee remained seated, with his feet resting on the floor, keeping the elbow of the tested arm, in 90-degree flexion, forearm in the neutral position, and palm facing upwards, exercising as much grasp as possible. Two measurements were taken for each arm, with 1-minute interval between measurements. The average strength of the dominant hand was used, in kilogram strength (Kgf), since the dominant hand is stronger than non-dominant hand[13].

Sleep Time (independent variable)

Sleep measurements were assessed using an accelerometer (model GTX3 +, Actigraph®), previously calibrated. This instrument is valid and reliable, providing information on useful measures of the sleep-wake cycle, by detecting limb movements for 24 hours[14].

We invited the participants to use the accelerometer for seven consecutive days, 24 hours a day, on the non-dominant wrist, except during bath and water activities.

Data were collected in epochs of 5 seconds with a frequency of 60 Hz. We used the ActiLife software (version 6.12) to extract the raw data from the accelerometer. The data were processed in the R statistical package (GGIR package version 1.11-0), using the filtering of non-human movements, as well as the validation of time of use, and a recalibration process for each data. The processing also generated data quality graphs for each participant.

Data from 1,363 participants were processed. However, we excluded data from those who had any error or defect: n = 35, due to a calibration error greater than 0.02, patterns not compatible with human movement, incomplete 24-hour cycle and for presenting quality problems after visual inspection of the plots; n = 84, incomplete data (less than 4 days).

The Spearman-Brown formula was applied to test reliability. The minimum days of the accelerometer used to measure sleep parameters[15] were defined as at least 4 nights, with a value of 0.52, being the best result of reliability so as not to lose a large number of individuals in the sample. The algorithm proposed by Van Hess et al.[16] was used as a basis to identify sleep parameters by automatic detection[17]. We defined sleep episodes as periods of inactivity sustained in the sleep period window, and the algorithm detects the bases of sleep in changes in the angle related to the horizontal plane (z-axis)[17]. We used a 5-minute time window and a 3-degree wrist angle change to detect sleep parameters. For this study, the variable total sleep time in hours was used, which resulted from the total number of minutes classified by the algorithm as sleep.

Complementary variables

Complementary variables included age (in continuous years), sex (male and female), skin color (white, black and brown), education (elementary, middle, technical or vocational, college) and socioeconomic class according to the ABEP - Brazil Economic Classification 2016: A, B (B1 + B2), C (C1 + C2), D / E, with class A being the richest and most educated and classes D / E is the poorest and least educated[18]. Current work (yes / no), marital status (no partner - single, divorced, widowed / consensual union - married, stable union), current smoking (yes / no) and alcohol consumption [low risk: <8 / high risk: ≥8, using the instrument Alcohol Use Disorder Identification Test (AUDIT)][19]. Carbohydrate (g / day) and protein (g / day) intake were collected using a food frequency questionnaire (FFQ) validated for the Brazilian population[20]. We used the accelerometer (minutes/day) to assess moderate and vigorous physical activity using a validated cut-off point[21]. We used the Self-Administered Physical Activity Checklist (SAPAC)[22] to assessed leisure physical activity (insufficiently active, physically active). Illegal drug use was categorized as never used / has used or currently uses. The M.I.N.I (Mini International Neuropsychiatric Interview - Brazilian version 5.0.0 - DSM IV)[23] assessed major depressive episodes or depression (yes/no).

Data analysis

Descriptive analyzes were performed for all variables, estimating absolute and relative frequencies. To compare the mean handgrip strength between groups, we used Student's t-test and ANOVA One-Way. To verify the correlation between the outcome and the continuous variables, Pearson's correlation was used. The associations between sleep time and handgrip strength were estimated using crude and adjusted linear regression models, with an estimate of the regression coefficient and 95% confidence interval (95% CI). The Linear Regression model did not show an interaction between sleep time and sex on muscle strength; therefore, we did not stratify the sample by sex. Despite this, there was a difference in mean muscle strength and sleep between genders.

The minimum adjustment set for confounding was identified in a directed acyclic graph (DAG), using the DAGitty program (Figure 1)[24]. The interrelationships between variables were built on a theoretical basis according to the current literature on the subject. The back-door criterion selected the following variables: sex, skin color, socioeconomic class, work, protein intake, carbohydrate intake, smoking, alcohol consumption, physical activity, drug use.

All statistical analyses were performed using the statistical program Stata 13.0 (Stata Corp., College Station, USA).

Ethical aspects

The 1997/98 São Luís birth cohort followed the criteria and ethical resolutions of the National Health Council and its complementary clauses. Everyone who agreed to participate in the studies signed the Free and Informed Consent Form. The Research Ethics Committee of the University Hospital of the Federal University of Maranhão (Consubstantiated Opinion number 1,302,489 of 10/29/2015) approved the project. The investigators declare that they have no conflicts of interest.

Results

Table 1 shows the distribution of the participants, according to wearing or not an accelerometer. There were differences between the categories of age ($p \leq 0.001$), sex ($p = 0.003$), education ($p \leq 0.001$), economic class ($p = 0.018$), leisure

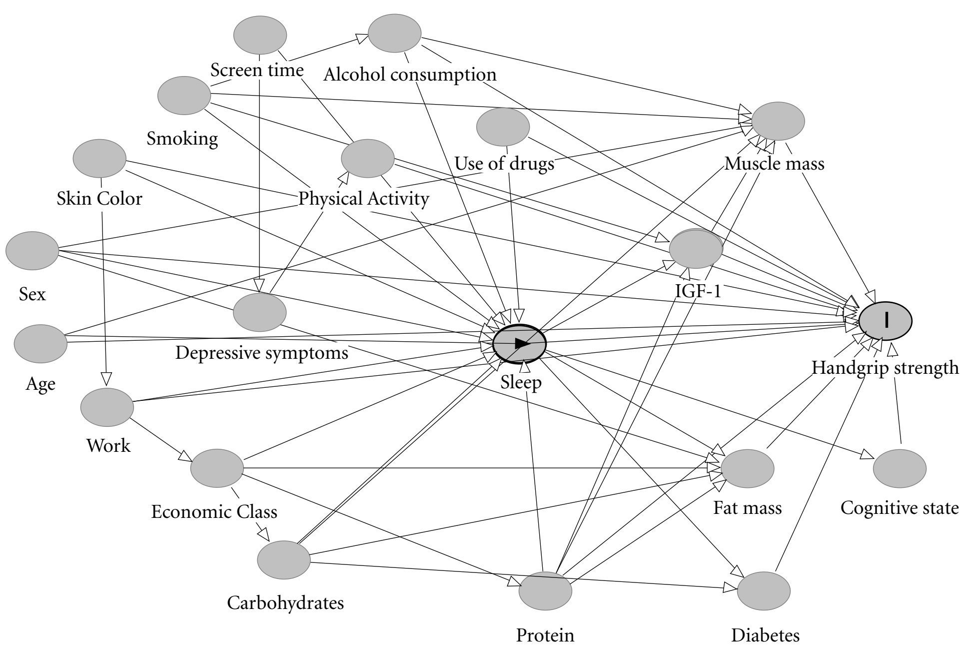

Figure 1. Directed Acyclic graph for the association between sleep and handgrip strength.

Source: Authors.

Ciência & Saúde Coletiva, 27(3):1147-1155, 2022

physical activity (p ≤0.001) and drug use (p = 0.031). Most participants who used the accelerometer were aged 18, had less education, were males, poorer, more physically active, and not drug users.

We evaluated 1,269 individuals, and the proportion of men was 50.3%. The mean value of handgrip strength was 28.2 (± 9.3) kgf, and the mean sleep time was 6 (± 1.0) hours per day. There was a higher percentage of brown-skinned

Table 1. Distribution of the adolescents (n = 2,515), according to wearing or not an accelerometer. São Luís, Maranhão, Brazil, 2016-2017.

Variable	Accelerometer				p-value
	No		Yes		
	n	%	n	%	
Age					<0.001
18	600	50.0	1142	86.8	
19	600	50.0	173	13.2	
Sex					0.003
Male	533	44.4	663	50.4	
Feminine	667	55.6	652	49.6	
Education					<0.001
Fundamental	12	1.0	15	1.1	
Medium	742	61.9	941	71.6	
Technical or vocational course	63	5.2	68	5.2	
College	382	31.9	290	22.1	
Skin Color					0.099
White	252	21.1	243	18.6	
Black	208	17.5	208	15.9	
Brown	732	61.4	857	65.5	
Economic Class					<0.018
A/B	336	31.4	324	28.1	
C	545	50.8	571	49.5	
D/E	191	17.8	259	22.4	
Marital Status					0.234
No companion	1.150	95.8	1.272	96.7	
Consensual union	50	4.2	43	3.3	
Currently working					0.232
No	1152	96.0	1274	96.9	
Yes	48	4.0	41	3.1	
Physical Activity in Leisure					<0.001
Insufficiently active	781	65.1	751	57.1	
Physically active	419	34.9	564	42.9	
Alcohol consumption					0.456
No	687	57.7	772	59.2	
Yes	503	42.3	532	40.8	
Smoking					0.232
No	1152	96.0	1274	96.9	
Yes	48	4.0	41	3.1	
Major depressive episode					0.373
No	274	83.0	838	85.1	
Yes	56	17.0	147	14.9	
Use of drugs					0.031
Never used	856	72.3	989	76.1	
Have used or currently use	328	27.7	311	23.9	

Source: Authors.

individuals (65.3%) belonging to socioeconomic class C (49.6%), who did not work (84.1%) did not consume alcohol (59.1%), did not smoke (96,9%) or have used or are currently using drugs (76.4%). The mean daily carbohydrate consumption was 482.9 (± 262.5) grams, and the average daily protein intake was 106.9 (± 62.4) grams. The mean time of physical activity (moderate and vigorous) was 31.2 minutes/day. Women, those belonging to the socioeconomic class D/E, those who did not work, those who did not smoke, and those who have not used or are using drugs had lower mean values of handgrip strength. There was a positive correlation between handgrip strength and carbohydrate intake, protein intake, and physical activity. The handgrip strength showed a negative correlation with total sleep time (Table 2).

The results of the crude analysis showed an association between sleep time and handgrip strength (Table 3). The increase of one hour of sleep reduced handgrip strength by 1.89 kgf (95% CI: - 2.45; -1.32). However, after adjusting, the association was not maintained (β: -0.07; 95% CI: - 0.50; 0.35).

Discussion

This study is the first population-based Brazilian survey, carried out with a sample of adolescents, to analyze the association between sleep time and

Table 2. Characterization of the sample and mean values (standard deviation) of handgrip strength according to demographic and socioeconomic characteristics. São Luís, Maranhão, Brazil, 2016-2017.

	n	%	Handgrip strength Mean(SD)	p-value
Sex (n=1,269)				<0.001*
Male	638	50.3	35.0(7.6)	
Feminine	631	49.7	21.2(4.7)	
Skin Color (n=1,262)				0.491**
White	236	18.7	27.8(9.1)	
Black	202	16.0	28.9(9.1)	
Brown	824	65.3	28.1(9.5)	
Economic Class (n=1,111)				0.009**
A/B	309	27.8	28.4(9.0)	
C	551	49.6	28.5(9.2)	
D/E	251	22.6	26.6(9.4)	
Currently working (n=1,269)				0.014*
No	1,069	84.1	27.9(9.3)	
Yes	202	15.9	29.7(9.7)	
Alcohol consumption (n=1,258)				0.287*
No	744	59.1	28.0(9.3)	
Yes	514	40.9	28.4(9.0)	
Smoking (n=1,269)				0.017*
No	1,229	96.9	28.1(9.3)	
Yes	40	3.1	32.0(9.5)	
Use of drugs (n=1,254)				<0.001*
Never used	957	76.4	27.7(9.3)	
Have used or currently use	297	23.6	29.8(9.2)	
	n	**Mean(±SD)**	**r (r^2)**	**p-value**
Carbohydrate intake (g / day)	1,269	482.9±262.5	0.12(1.4)	<0.001***
Protein intake (g / day)	1,244	106.9±62.4	0.13(1.7)	<0.001***
Physical activity (minutes per day)	1,268	31.2±26.1	0.20(4.0)	<0.001***
Total sleep time (hours)	1,269	6.0±1.0	-0.20(4.0)	<0.001***

*Student's t-test; **ANOVA One-Way; *** Pearson's correlation.

Source: Authors.

Ciência & Saúde Coletiva, 27(3):1147-1155, 2022

Table 3. Crude and adjusted* analysis of the association between sleep time and handgrip strength in adolescents. São Luís, Maranhão, Brazil, 2016-2017.

Variable	Crude analysis		Adjusted analysis*	
	β (95%CI)	p	β (95%CI)	p
Sleep time (hours)	-1,95(-2,51;-1,39)	≤0,001	-0,07(-0,48;0,36)	0,760

*sex, skin color, socioeconomic class, work, protein consumption, carbohydrate consumption, smoking, alcohol consumption, physical activity, drug use. β = regression coefficient.

Source: Authors.

handgrip strength. The association did not remain statistically significant after adjustment for confounding.

The non-association between sleep time and handgrip strength values in adolescents, found in the present study, is consistent with data from adolescents from Saudi Arabia[10], and other studies carried out with young[4,7,9] and older adults[8]. Al-Rasheed e Ibrahim[10] evaluated 63 adolescents (convenience sample), aged 12 to 15 years, and reported that there was no difference in handgrip strength parameters, between groups of adolescents with poor and regular sleep, analyzed by the *Pittsburgh* sleep quality index[10].

According to the search in databases, the study by Al-Rasheed e Ibrahim[10] is the only one that evaluated this relationship in adolescents. However, unlike the present study, the authors assessed poor sleep quality using a questionnaire. Also, an important point to be highlighted is the difference in the age of the participants in the two studies, which can have implications in the sexual maturation stages. It is well-known that sexual maturation interferes with body composition and that this has repercussions on both muscle strength [25] and sleep duration[26].

In studies with other age groups, the results were conflicting. Lima *et al.*[4], in a survey with 705 adults (25 to 65 years), showed no association between sleep duration (questionnaire) and the handgrip strength[4]. The study by Chen *et al.*[9], conducted with 10,125 university students (16 to 30 years old) from the city of Dalian (China), showed an association between poor sleep quality and lower muscle strength in both sexes, and between short sleep duration and reduced handgrip strength in men.

Another study carried out in China with 19,434 adults[7] found an association between self-reported excessive daytime sleepiness accompanied by snoring or apnea and lower handgrip strength, regardless of confounding factors. Also, in China, Auyeung et al.[8] performed a study with 1,274 individuals (65 years or older), and the results showed that prolonged sleep latency, as well as insomnia, were associated with lower handgrip strength.

It is important to note that, unlike our study, Chen *et al.*[9], Cao *et al.*[7], and Auyeung *et al.*[8] investigated different sleep parameters (duration, insomnia, latency, poor sleep quality, excessive daytime sleepiness, etc.) using questionnaires, which can limit the comparison between studies. Likewise, the studies[7-9] used different instruments to assess muscle strength. Thus, the divergent results may be due to sampling differences, adjustment characteristics, and age groups analyzed.

The present study, however, has limitations. One of the limitations refers to the use of self-reported information of confounding variables, which may incur the interviewee's misinterpretation and omission of legitimate responses, resulting in information bias. The second limitation was losses related to participants who used an accelerometer, which may lead to selection bias. Those losses may lead to selection bias since it is the adolescents in better health who may have attended to assess the muscle strength, which may underestimate the handgrip strength values. Another limitation is in relation to the use of illicit drugs, which may have measurement bias. Adolescents may be embarrassed to answer this question, and thus underestimate the consumption of these drugs. The questionnaire on the subject was self-administered to alleviate the problem.

A relevant aspect to highlight is the difference between sleep duration measured by accelerometry and other sleep outcomes evaluated in different studies. Sleep duration based on accelerometry may be briefly defined as a total of minutes without a movement in the wrist for a determined period. This definition and others used in studies with accelerometry are based only on a lack of body movement. Although the lack of body movement is a marked feature of non-sleep, it is not the only one[14,16]. In long-term sleep monitoring and population studies, accelerometry seems to be better than polysomnography (PSG), an expensive method that requires a laboratory setting[16]. Still, the accelerometry is limited to the results of sleep architecture, not allowing the analysis of subjective aspects of sleep, such as sleep quality or satisfaction with sleep[14,27]. Based on these questions highlighted, our finding regarding no association between muscle strength and sleep duration should be interpreted with caution. This lack of association may be right for our type of measure, but sleep ascertained with subjective measures may be associated with handgrip strength. Studies exploring other sleep aspects remain necessary.

The strengths of our study include the evaluation of handgrip strength, using and instrument and procedures adopted in studies involving different populations, including adolescents. Another strength was the construction of a conceptual, theoretical model to identify confounding factors with the implementation of the Directed Acyclic Diagram (DAG).

It is important to note that the study cannot have the results extrapolated to the population because the sample was not probabilistic.

Conclusion

In the present study, there was no statistically significant association between sleep time and handgrip strength in a sample of adolescents of São Luis, Northeast of Brazil.

Collaborations

SC Confortin, RFL Batista, MTSSB Alves, VMF Simões, and AAM Silva designed research. SC Confortin, RFL Batista, MTSSB Alves, VMF Simões, and AAM Silva conducted research. SC Confortin, RFL Batista, MTSSB Alves, VMF Simões, and AAM Silva provided essential materials. SC Confortin, AR Barbosa, A Wendt, I Crochemore-Silva, and AAM Silva analyzed data or performed statistical analysis. SC Confortin, RFL Batista, AR Barbosa, A Wendt, I Crochemore-Silva, MTSSB Alves, VMF Simões, and AAM Silva wrote paper. SC Confortin had primary responsibility for final content. All authors have read and approved the final manuscript. For single-authored research papers and reviews, please state: The sole author had responsibility for all parts of the manuscript.

Ciência & Saúde Coletiva, 27(3):1147-1155, 2022

References

1. Bohannon RW. Muscle strength: Clinical and prognostic value of hand-grip dynamometry. *Curr Opin Clin Nutr Metab Care* 2015; 18(5):465-470.
2. McGrath R, Johnson N, Klawitter L, Mahoney S, Trautman K, Carlson C, Rockstad E, Hackney K. What are the association patterns between handgrip strength and adverse health conditions? A topical review. *SAGE Open Med* 2020; 8:205031212091035.
3. Ortega FB, Silventoinen K, Tynelius P, Rasmussen F. Muscular strength in male adolescents and premature death: Cohort study of one million participants. *BMJ* 2012; 345(7884):1-12.
4. Lima TR, Silva DAS, Kovaleski DF, González-Chica DA. The association between muscle strength and sociodemographic and lifestyle factors in adults and the younger segment of the older population in a city in the south of Brazil. *Cien Saude Colet* 2018; 23(11):3811-3820.
5. Pereira ÉF, Teixeira CS, Louzada FM. Sonolência diurna excessiva em adolescentes: Prevalência e fatores associados. *Rev Paul Pediatr* 2010; 28(1):98-103.
6. Borst SE, Lowenthal DT. Role of IGF-I in Muscular Atrophy of Aging. *Endocrine* 1997; 7(1):61-63.
7. Cao X, Gu Y, Fu J, Vu TQC, Zhang Q, Liu L, Meng G, Yao Z, Wu H, Bao X, Zhang S, Wang X, Sun S, Zhou M, Jia Q, Song K, Wu Y, Niu K. Excessive daytime sleepiness with snoring or witnessed apnea is associated with handgrip strength: a population-based study. *QJM An Int J Med* 2019;112(11):847-853.
8. Auyeung TW, Kwok T, Leung J, Lee JSW, Ohlsson C, Vandenput L, Wing YK, Woo J. Sleep Duration and Disturbances Were Associated With Testosterone Level, Muscle Mass, and Muscle Strength-A Cross-Sectional Study in 1274 Older Men. *J Am Med Dir Assoc* 2015;16(7):630.e1-630.e6.
9. Chen Y, Cui Y, Chen S, Wu Z. Relationship between sleep and muscle strength among Chinese university students: A cross-sectional study. *J Musculoskelet Neuronal Interact* 2017; 17(4):327-333.
10. Al-Rasheed AS, Ibrahim AI. Does the poor sleep quality affect the physical activity level, postural stability, and isometric muscle strength in Saudi adolescents? A comparative study. *Saudi Med J* 2020; 41(1):94-97.
11. Simões VMF, Batista RFL, Alves MTSSB, Ribeiro CCC, Thomaz EBF, Carvalho CA, Silva AAM. Saúde dos adolescentes da coorte de nascimentos de São Luís, Maranhão, Brasil, 1997/1998. *Cad Saude Publica* 2020; 36(7).
12. Fess EE. Grip strength. In: JS C, editor. *American Society of Hand Therapists*. 2ª ed. Chicago; 1992. p. 41-45.
13. Ferreira ACC, Shimano AC, Mazzer N, Barbieri CH, Elui VMC, Fonseca MCR. Grip and pinch strength in healthy children and adolescents. *Acta Ortopédica Bras* 2011; 19(2):92-97.
14. Martin JL, Hakim AD. Wrist Actigraphy. *Chest* 2011; 139(6):1514-1527.
15. Eisinga R, Grotenhuis M Te, Pelzer B. The reliability of a two-item scale: Pearson, Cronbach, or Spearman-Brown? *Int J Public Health* 2013; 58(4):637-642.
16. Van Hees VT, Sabia S, Anderson KN, Denton SJ, Oliver J, Catt M, Abell JG, Kivimäki M, Trenell MI, Singh Manoux A. A novel, open access method to assess sleep duration using a wrist-worn accelerometer. *PLoS One* 2015; 10(11):1-13.
17. van Hees VT, Sabia S, Jones SE, Wood AR, Anderson KN, Kivimäki M, Frayling TM, Pack AI, Bucan M, Trenell MI, Mazzotti DR, Gehrman PR, Singh-Manoux BA, Weedon MN. Estimating sleep parameters using an accelerometer without sleep diary. *Sci Rep* 2018; 8(1):1-11.
18. Associação Brasileira de Empresas de Pesquisa (ABEP). *Critério Brasil e Alterações na aplicação do Critério Brasil, válidas a partir de 16/04/2018*. São Paulo: ABEP; 2018. p. 1-6. [acessado 2020 Ago 20]. Disponível em: http://www.abep.org/criterio-brasil
19. Moretti-Pires RO, Corradi-Webster CM. Adaptation and validation of the Alcohol Use Disorders Identification Test (AUDIT) for a river population in the Brazilian Amazon. *Cad Saude Publica*. 2011; 27(3):497-509.
20. Ribeiro AB, Cardoso MA. Development of a food frequency questionnaire as a tool for programs of chronic diseases prevention. *Rev Nutr* 2002; 15(2):239-245.
21. Hildebrand M, Hansen BH, van Hees VT, Ekelund U. Evaluation of raw acceleration sedentary thresholds in children and adults. *Scand J Med Sci Sport* 2017; 27(12):1814-1823.
22. Farias Júnior JC, Lopes AS, Mota J, Santos MP, Ribeiro JC, Hallal PC. Validity and reproducibility of a physical activity questionnaire for adolescents: adapting the Self- Administered Physical Activity Checklist. *Rev Bras Epidemiol* 2012; 15(1):198-210.
23. Amorim P. Mini International Neuropsychiatric Interview (MINI): validation of a short structured diagnostic psychiatric interview. *Rev Bras Psiquiatr* 2000; 22(3):106-115.
24. Textor J, Hardt J. DAGitty: A graphical tool for analyzing causal diagrams. *Epidemiology* 2011; 22(5):745.
25. Matsudo VKR, Matsudo SM, Rezende LFM, Raso V. Handgrip strength as a predictor of physical fitness in children and adolescents. *Rev Bras Cineantropometria e Desempenho Hum* 2014; 17(1):1-10.
26. Felden ÉPG, Filipin D, Barbosa DG, Andrade RD, Meyer C, Louzada FM. Fatores associados à baixa duração do sono em adolescentes. *Rev Paul Pediatr* 2016; 34(1):64-70.
27. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric pratic and research. *Psychiatry Research* 1989; 28(2):193-213.

Article submitted 27/08/2020
Approved 17/02/2021
Final version submitted 19/02/2021