Resting pulse rate among adolescents: the 11-year follow-up of the 1993 Pelotas (Brazil) birth cohort study

Frequência do pulso de repouso em adolescentes: a visita de 11 anos da coorte de nascimentos de Pelotas, Rio Grande do Sul, Brasil, 1993

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Abstract

The aim of this study was to describe resting pulse rate and associated factors among adolescents. This was a cross-sectional analysis nested in a prospective cohort study, including 4,452 adolescents born in Pelotas, Rio Grande do Sul State, Brazil in 1993, representing 87.5% of the original cohort. Pulse rate was measured with an electronic device at the beginning and end of the interview, and the mean value was used in the analyses. Mean pulse rate was 78.4bpm (SD = 11.0) in the total sample, 76.5bpm (SD = 10.7) in boys, and 80.2bpm (SD = 10.9; p < 0.001) in girls. Black adolescents showed lower mean pulse rates. There was a direct association between pulse rate and blood pressure. Physical activity was inversely associated with pulse rate in the crude analysis only. Elevated pulse rate is strongly associated with high blood pressure, and both variables are predictors of risk of chronic disease in adulthood.

Heart Rate; Adolescent; Cohort Studies

Introduction

The epidemiological transition, characterized by a progressive decrease in morbidity and mortality from infectious diseases and a proportional increase in the burden of non-communicable diseases and injuries [1], demands a reorientation of public health research. One of the field's main current challenges is to elucidate the risk and protective factors for non-communicable diseases and injuries, including the investigation of biological and social exposures that increase the disease risk at the population level. Evidence shows that resting pulse rate is a strong predictor of risk for coronary diseases [2,3,4,5].

Until recent years there was a clear tendency to evaluate risk factors for non-communicable diseases and injuries mainly in adults. However, it is now known that the future risk of chronic diseases is influenced by factors that begin during intrauterine life [6] and extend into adulthood, with adolescence as a particularly important period when life habits are established [7]. The literature on factors associated with resting pulse rate is scarce, especially in relation to risk factors for pulse rate levels. Most articles on resting pulse rate evaluate its consequences [2,3,4,5], especially for risk of coronary diseases. Studies on adolescents are even more scarce [8].

This study aimed to fill part of the gap in this knowledge by describing the resting pulse rate

and associated factors in adolescents followed from birth to 11 years of age.

Methods

All the hospital births in the city of Pelotas, Rio Grande do Sul State, Brazil, in 1993 were monitored. The mothers answered a questionnaire, and the newborns were weighed and measured. Subsamples were visited at 1, 3, and 6 months and 1, 4, 6, and 9 years of age. In 2004-2005, all the cohort participants were searched for a new follow-up, the methodological details of which are described elsewhere [9].

Resting pulse rate in beats per minute (bpm) was monitored with a digital monitor, Omron brand, model 711-AC (Beijing, China), placed on the adolescent's wrist. The instrument's accuracy is ±5% according to the manufacturer. The measurements were taken at the beginning and end of the interview (approximately 60 minutes apart), with the adolescents in sitting position. The mean of the two measurements was used in the following analyses.

The household assets index was constructed with a list of household assets and was divided into quintiles for purposes of analysis. Self-reported skin color was used in the analyses. We chose to evaluate the category "black" separately from "brown or mulatto", since the literature suggests the specific influence of black race on pulse rate [10]. The mother's body mass index (BMI) was analyzed, as was the adolescent's own BMI, and both were calculated using two weight and height measurements, taking the mean value for the analyses. Weight was measured with a digital scale, SECA brand, accurate to 100g (Birmingham, UK), while height was measured with an aluminum stadiometer, accurate to 1mm. The physical activity score was based on a questionnaire that included the mode of commuting to school and participation in sports or structured and unstructured physical activities in and out of school [11]. Blood pressure was measured with the same instrument as for pulse rate. Smoking prevalence in the adolescents was also recorded, based on a confidential questionnaire. In the crude analysis, the association was also tested between pulse rate and diastolic blood pressure, but since the association was in the same direction but with a lower magnitude than for systolic pressure, the latter was chosen for the analyses.

The initial analysis shows the mean values and respective standard deviations (SD) for resting pulse rate in the total sample and in boys and girls separately. A histogram describes the distribution of the dependent variable. The mean pulse rate values were calculated for the subgroups of independent variables, and the statistical significance was evaluated with the t test (exposures with two categories) or analysis of variance (exposures with three or more categories). Simple and multiple linear regression analyses were performed to evaluate the effect of various predictors on pulse rate.

The project was approved by the Research Ethics Committee of the School of Medicine, Federal University in Pelotas. The parents or guardians signed a free and informed consent form, authorizing the children to participate in the study.

Results

Of the 5,249 cohort participants, 4,452 were located in the 11-year follow-up, which, after computing the 141 who had died by this age, represented 87.5% of the original cohort.

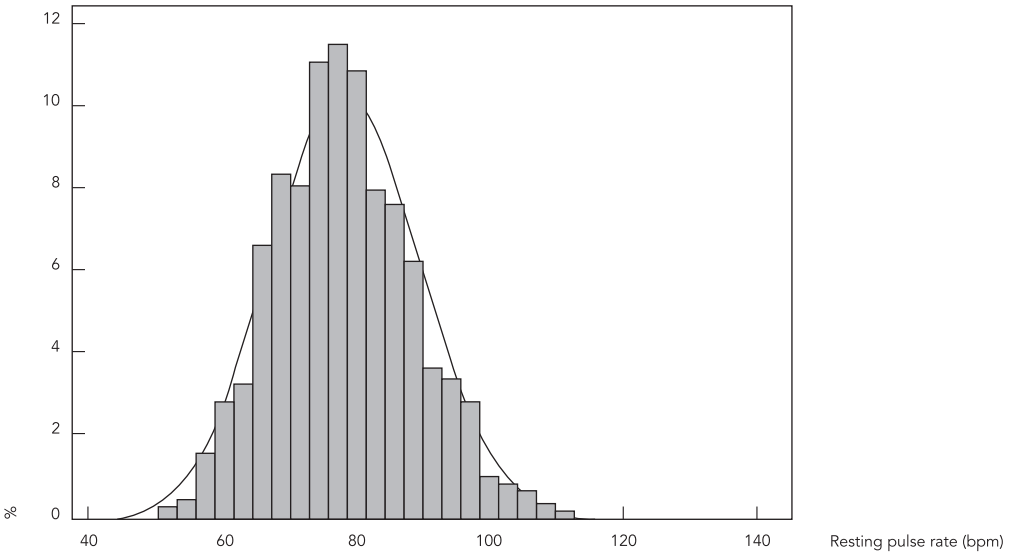
Mean resting pulse rate was 78.9bpm (SD = 12.6) at the first measurement and 77.9bpm (SD = 12.1) at the second, with a mean of 78.4bpm (SD = 11.0). Mean pulse rate in boys was 76.5bpm (SD = 10.7), as compared to 80.2bpm in girls (SD = 10.9; $p < 0.001$). Figure 1 shows the histogram with the pulse rate distribution in the total sample, confirming this variable's normal distribution.

Table 1 shows the mean pulse rates for the total sample and for boys and girls separately. In the total sample, there was no association between pulse rate and the variables household assets index, maternal BMI, or adolescent's smoking. Black and brown youngsters showed significantly lower mean pulse rates than whites. Pulse rate was positively associated with the adolescent's BMI and blood pressure, while there was an inverse association with physical activity score. The results in the total sample were very similar to those observed in boys, although the association between physical activity score and pulse was not statistically significant in boys. In girls, there was no relationship between pulse rate and the adolescent's BMI or physical activity score.

Table 2 shows the crude and adjusted linear regression coefficients for resting pulse rate according to the independent variables in the total sample. The results of the adjusted analysis were very similar to those observed in the crude analysis, except for the variable adolescent's BMI, which lost the association with pulse rate after adjusting for confounding factors. A specific analysis showed that the principal variable that eliminates the effect of adolescent's BMI after adjustment is blood pressure. Girls showed

Figure 1

Distribution of resting pulse rate values in adolescents.



a mean pulse rate 3.8bpm higher than boys, while brown/mulatto youngsters showed a pulse rate 2.2bpm lower than whites. Adolescents in the upper quartile of the physical activity score displayed a mean pulse rate 1.6bpm lower than those in the lower quartile of physical activity. The strongest association was observed with blood pressure: adolescents in the upper quartile showed a mean rate 4.12bpm higher than those in the lower quartile.

Table 3 shows the crude and adjusted coefficients for boys. After adjusting, the effect of adolescent's BMI and physical activity score on resting pulse rate did not remain statistically significant, and only black skin color and elevated systolic blood pressure were associated with pulse rate. Brown-skinned youngsters had a pulse rate 3.3bpm lower than whites, while the highest quartile of systolic pressure showed a mean rate 4.5bpm higher than the lowest quartile.

In girls (Table 4), there was an inverse phenomenon in the association between adolescent's BMI and pulse rate. The crude analysis showed no relationship between the variables, whereas after adjustment the p-value was 0.09, and the upper BMI quartile showed a mean pulse rate 1.6bpm lower than the lower quartile. Again, after adjusting for confounding factors, only skin color (black and brown) and blood pressure (quartiles 3 and 4) remained significantly associated with pulse rate.

Discussion

Although resting pulse rate is strongly associated with blood pressure, there is evidence that resting pulse rate is an independent risk factor for coronary disease [2,3]. Thus, knowing the factors associated with resting pulse rate is relevant in public health terms. However, the literature in this area is extremely limited, and most of the studies approach the consequences rather than the factors associated with elevated resting pulse rate. In this sample of Brazilian adolescents 11 years of age, we showed that resting pulse rate is lower in boys and in youngsters with black or brown skin. Pulse showed an inverse association with physical activity and a direct association with blood pressure.

The association between resting pulse rate and gender has proven inconsistent in the scientific literature. A study in Niterói, Rio de Janeiro State, Brazil, showed that resting pulse rates were higher in boys than in girls [8], contrary to the current study's findings. Studies in adults have also shown higher pulse rates in men [10]. In the current study's sample [12], there was no significant asso-

Table 1

Mean resting pulse rate and standard deviation (SD) for the overall sample and stratified by gender according to independent variables.

Variable	Overall sample		Boys		Girls	
	Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Assets index (quintiles)		0.39 *		0.24 *		0.88 *
1st (poorest)	78.7 (10.9)		77.2 (11.2)		80.3 (10.4)	
2nd	77.8 (10.6)		75.5 (10.0)		79.9 (10.8)	
3rd	78.4 (10.6)		76.6 (10.9)		79.9 (10.2)	
4th	78.7 (11.3)		76.8 (10.5)		80.4 (11.6)	
5th (wealthiest)	78.5 (11.4)		76.6 (11.4)		80.5 (11.4)	
Maternal BMI (kg/m2)		0.23 *		0.64 *		0.28 *
< 18.5	78.0 (12.8)		75.5 (10.2)		80.7 (14.9)	
18.5-24.9	78.1 (10.7)		76.5 (10.4)		79.7 (10.8)	
25.0-29.9	78.9 (11.0)		77.0 (10.5)		80.6 (11.1)	
≥ 30.0	78.5 (11.2)		76.4 (11.9)		80.7 (10.1)	
Skin color		< 0.001 *		< 0.001 *		0.02 *
White	78.8 (11.3)		77.1 (10.9)		80.6 (11.3)	
Black	77.7 (10.2)		76.3 (10.3)		79.1 (9.8)	
Brown	76.8 (10.2)		73.8 (10.1)		79.3 (9.5)	
Adolescent's BMI (quartiles)		0.02 *		< 0.001 *		0.86 *
1st (lower)	78.0 (10.9)		75.7 (10.7)		80.2 (10.7)	
2nd	78.0 (10.8)		75.5 (10.5)		80.6 (10.5)	
3rd	78.4 (10.8)		76.6 (10.2)		80.1 (11.2)	
4th (upper)	79.2 (11.2)		78.3 (11.3)		80.1 (11.0)	
Physical activity score (quartiles)		< 0.001 *		0.09 *		0.46 *
1st (lower)	79.4 (11.2)		77.2 (11.3)		80.6 (10.9)	
2nd	79.0 (11.3)		77.0 (11.0)		80.6 (10.3)	
3rd	78.2 (10.7)		76.6 (11.0)		80.0 (10.1)	
4th (upper)	77.1 (10.4)		75.7 (10.0)		79.7 (10.6)	
Smoking		0.56 **		0.69 **		0.36 **
No	78.4 (10.9)		76.5 (10.8)		80.1 (10.7)	
Yes	78.9 (11.6)		77.0 (9.8)		81.3 (13.3)	
Systolic blood pressure (quartiles)		< 0.001 *		< 0.001 *		< 0.001 *
1st (lower)	76.4 (10.5)		74.1 (9.8)		78.5 (10.6)	
2nd	78.2 (10.5)		76.2 (10.3)		80.1 (10.3)	
3rd	78.6 (10.5)		76.7 (10.5)		80.6 (10.1)	
4th (upper)	80.4 (12.0)		79.1 (11.7)		81.8 (12.2)	

BMI: body mass index.

* Analysis of variance;

** t test.

ciation between blood pressure and gender, indicating that the differences in resting pulse rate are not explained by blood pressure. A possible explanation would be the higher level of physical activity in boys than in girls [13]. However, the association remained significant even after adjusting for this variable.

In this same sample of adolescents, the blood pressure levels were higher in black individuals compared to whites and browns [12]. Meanwhile, resting pulse rates showed exactly the opposite association. The literature is contradictory on this association in young people. Meanwhile, in North American adults, there is a trend towards higher pulse rates in ethnic minorities [10]. There is evidence that black individuals have greater difficulty excreting sodium and some fluids, leading to a greater tendency to concentrate the urine,

Table 2

Crude and adjusted linear regression coefficients for resting pulse rate (bpm) in the total sample.

Variable	Crude analysis		Adjusted analysis *	
	Coefficient (95%CI)	p-value **	Coefficient (95%CI)	p-value
Gender		< 0.001		< 0.001
Male	0.00		0.00	
Female	3.71 (3.08; 4.35)		3.86 (3.50; 4.22)	
Assets index (quintiles)		0.39		0.42
1st (poorest)	0.00		0.00	
2nd	-0.93 (-1.97; 0.12)		-1.02 (-2.11; 0.09)	
3rd	-0.30 (-1.34; 0.74)		-0.59 (-1.69; 0.51)	
4th	-0.01 (-1.05; 1.03)		-0.55 (-1.66; 0.56)	
5th (wealthiest)	-0.14 (-1.18; 0.90)		-0.91 (-2.05; 0.22)	
Maternal BMI (kg/m2)		0.23		0.29
< 18.5	0.09 (-2.55; 2.72)		0.48 (-2.27; 3.24)	
18.5-24.9	0.00		0.00	
25.0-29.9	0.89 (-1.76; 3.54)		0.80 (-0.01; 1.60)	
≥ 30.0	0.53 (-2.15; 3.21)		0.43 (-0.50; 1.36)	
Skin color		< 0.001		< 0.001
White	0.00		0.00	
Black	-1.12 (-2.11. -0.12)		-1.17 (-2.14; -0.19)	
Brown	-2.02 (-2.02; -1.12)		-2.21 (-3.10; -1.33)	
Adolescent's BMI (quartiles)		0.02		0.98
1st (lower)	0.00		0.00	
2nd	0.00 (-0.91; 0.91)		0.07 (-0.84; 0.99)	
3rd	0.43 (-0.48; 1.35)		-0.12 (-1.05; 0.80)	
4th (upper)	1.24 (0.33; 2.15)		-0.01 (-0.96; 0.95)	
Physical activity score (quartiles)		< 0.001		0.21
1st (lower)	0.00		0.00	
2nd	-0.34 (-1.27; 0.58)		-0.07 (-1.05; 0.91)	
3rd	-1.15 (-2.07; -0.24)		-0.84 (-1.81; 0.14)	
4th (upper)	-2.28 (-3.20; -1.35)		-0.85 (-1.79; 0.07)	
Smoking		0.56		0.40
No	0.00		0.00	
Yes	0.51 (-1.20; 2.23)		0.84 (-1.11; 2.79)	
Systolic blood pressure (quartiles)		< 0.001		< 0.001
1st (lower)	0.00		0.00	
2nd	1.77 (0.87; 2.66)		2.09 (1.13; 3.06)	
3rd	2.21 (1.31; 3.11)		2.15 (1.17; 3.13)	
4th (upper)	4.00 (3.10; 4.91)		4.12 (3.09; 5.14)	

95%CI: 95% confidence interval; BMI: body mass index.

* Analysis adjusted for all the independent variables presented in the table;

** Wald test.

which can lead in turn to greater susceptibility to hypertension [14]. However, the current study's results related to color and pulse rate require confirmation by further research.

The inverse association observed in the crude analysis between resting pulse rate and physical activity is consistent with the findings in the scientific literature [15]. Interventions to promote physical activity may help decrease pulse rates in adolescents [16]. After adjustment, there was no significant association between pulse rate and BMI, perhaps because of the strong association between BMI and blood pressure [12].

Table 3

Crude and adjusted linear regression coefficients for resting pulse rate (bpm) in boys.

Variable	Crude analysis		Adjusted analysis *	
	Coefficient (95%CI)	p-value **	Coefficient (95%CI)	p-value
Assets index (quintiles)		0.24		0.14
1st (poorest)	0.00		0.00	
2nd	-1.65 (-3.10; -0.21)		-1.55 (-3.08; -0.02)	
3rd	-0.59 (-2.04; 0.87)		-1.17 (-2.72; 0.38)	
4th	-0.40 (-1.84; 1.05)		-1.36 (-2.91; 0.20)	
5th (wealthiest)	-0.53 (-1.95; 0.90)		-1.98 (-3.56; -0.40)	
Maternal BMI (kg/m2)		0.64		0.71
< 18.5	0.99 (-2.60; 4.59)		-1.15 (-4.88; 2.58)	
18.5-24.9	0.00		0.00	
25.0-29.9	1.55 (-2.06; 5.17)		0.42 (-0.72; 1.55)	
≥ 30.0	0.94 (-2.72; 4.60)		-0.21 (-1.50; 1.08)	
Skin color		< 0.001		0.001
White	0.00		0.00	
Black	-0.78 (-2.16; 0.61)		-0.78 (-2.16; 0.61)	
Brown	-3.31 (-4.61; -2.01)		-3.31 (-4.61; -2.01)	
Adolescent's BMI (quartiles)		< 0.001		0.08
1st (lower)	0.00		0.00	
2nd	-0.20 (-1.46; 1.06)		-0.37 (-1.74; 1.00)	
3rd	0.92 (-0.36; 2.19)		0.36 (-1.04; 1.76)	
4th (upper)	2.61 (1.34; 2.88)		1.49 (0.01; 2.98)	
Physical activity score (quartiles)		0.09		0.60
1st (lower)	0.00		0.00	
2nd	-0.28 (-1.73; 1.17)		0.11 (-1.43; 1.66)	
3rd	-0.62 (-2.01; 0.76)		-0.17 (-1.65; 1.30)	
4th (upper)	-1.54 (-2.87; -0.20)		-0.72 (-2.15; 0.70)	
Smoking		0.69		0.85
No	0.00		0.00	
Yes	0.46 (-1.80; 2.72)		0.25 (-2.27; 2.77)	
Systolic blood pressure (quartiles)		< 0.001		< 0.001
1st (lower)	0.00		0.00	
2nd	2.08 (0.81; 3.34)		2.34 (0.98; 3.71)	
3rd	2.65 (1.39; 3.90)		2.54 (1.16; 3.92)	
4th (upper)	4.98 (3.72; 6.25)		4.57 (3.13; 6.01)	

95%CI: 95% confidence interval; BMI: body mass index.

* Analysis adjusted for all the independent variables presented in the table;

** Wald test.

The strongest predictor of resting pulse rate was blood pressure. The literature is consistent in showing a strong correlation between these two variables. However, some risk factors for elevated pulse rate differed from those for blood pressure in the same sample [12], indicating that the two variables have similarities but also differences in their epidemiology.

Some limitations of the current study should be considered. Initially, although the study is part of a birth cohort, the analyses presented here are cross-sectional, which prevents establishing a cause-effect relationship between the independent variables and resting pulse rate. In addition, we chose to use the subjects' self-reported skin color, which can lead to some degree of classification error. However, this decision was based on the method currently used by the Brazilian Institute of Geography and Statistics (National Census Bureau) to evaluate this variable.

Table 4

Crude and adjusted linear regression coefficients for resting pulse rate (bpm) in girls.

Variable	Crude analysis		Adjusted analysis *	
	Coefficient (95%CI)	p-value **	Coefficient (95%CI)	p-value
Assets index (quintiles)		0.88		0.91
1st (poorest)	0.00		0.00	
2nd	-0.40 (-1.87; 1.06)		-0.57 (-2.12; 0.98)	
3rd	-0.32 (-1.77; 1.12)		-0.44 (-1.98; 1.10)	
4th	0.16 (-1.30; 1.62)		-0.01 (-1.57; 1.55)	
5th (wealthiest)	0.25 (-1.23; 1.72)		-0.05 (-1.66; 1.55)	
Maternal BMI (kg/m2)		0.28		0.17
< 18.5	1.08 (-2.69; 4.85)		2.31 (-1.68; 6.30)	
18.5-24.9	0.00		0.00	
25.0-29.9	0.90 (-0.16; 1.96)		1.04 (-0.08; 2.16)	
≥ 30.0	1.00 (-0.23; 2.22)		1.11 (-0.20; 2.42)	
Skin color		0.02		0.005
White	0.00		0.00	
Black	-1.39 (-2.38; -0.40)		-1.83 (-2.95; -0.71)	
Brown	-1.29 (-2.51; -0.08)		-1.63 (-2.90; -0.36)	
Adolescent's BMI (quartiles)		0.86		0.09
1st (lower)	0.00		0.00	
2nd	0.38 (-0.90; 1.66)		0.02 (-1.37; 1.41)	
3rd	-0.12 (-1.38; 1.14)		-0.82 (-2.23; 0.58)	
4th (upper)	-0.09 (-1.35; 1.18)		-1.64 (-3.10; -0.17)	
Physical activity score (quartiles)		0.46		0.76
1st (lower)	0.00		0.00	
2nd	0.03 (-1.15; 1.22)		0.36 (-0.89; 1.62)	
3rd	-0.58 (-1.81; 0.66)		-0.26 (-1.57; 1.05)	
4th (upper)	-0.90 (-2.26; 0.47)		-0.33 (-1.78; 1.12)	
Smoking		0.36		0.11
No	0.00		0.00	
Yes	1.20 (-1.36; 3.76)		2.42 (-0.57; 5.40)	
Systolic blood pressure (quartiles)		< 0.001		< 0.001
1st (lower)	0.00		0.00	
2nd	1.59 (0.35; 2.82)		2.11 (0.78; 3.44)	
3rd	2.06 (0.82; 3.31)		2.11 (0.74; 3.48)	
4th (upper)	3.30 (2.04; 4.56)		4.13 (2.69; 5.57)	

95%CI: 95% confidence interval; BMI: body mass index.

* Analysis adjusted for all the independent variables presented in the table;

** Wald test.

New studies are needed on factors associated with resting pulse rate. Our literature review indicated a scarcity of data on risk factors for elevated pulse rate. A better understanding of the determination of resting pulse rate could help prevent chronic diseases. Health promotion strategies, including encouragement for physical activity, could help reduce resting pulse rates in adolescents.

Resumo

O objetivo do estudo foi descrever a freqüência do pulso de repouso em adolescentes e avaliar variáveis associadas. Trata-se de análise transversal aninhada a um estudo de coorte prospectivo, incluindo 4.452 adolescentes nascidos em Pelotas, Rio Grande do Sul, Brasil, em 1993, os quais representam 87,5% da coorte original. A freqüência do pulso foi mensurada no início e ao final da entrevista com aparelho digital, sendo o valor médio utilizado nas análises. O valor médio da freqüência do pulso foi de 78,4bpm (DP = 11,0), sendo de 76,5bpm (DP = 10,7) nos meninos e 80,2bpm (DP = 10,9; p < 0,001) nas meninas. Os adolescentes com pele preta apresentaram valores mais baixos da freqüência do pulso. Houve uma forte associação positiva entre pressão arterial e freqüência do pulso. O escore de atividade física associou-se inversamente com a freqüência do pulso somente na análise bruta. Valores elevados de freqüência do pulso estão fortemente relacionados com valores elevados de pressão arterial, sendo ambas variáveis preditoras do risco de doenças crônicas na vida adulta.

Frequencia Cardíaca; Adolescente; Estudos de Coorte

Contributors

P. C. Hallal coordinates the 1993 birth cohort, participated in the data collection, elaboration of the research instruments, and data analysis, headed the writing of the manuscript, and approved the final version submitted for publication. A. M. B. Menezes and C. L. Araújo coordinate the 1993 Pelotas birth cohort and approved the final version of the manuscript. A. D. Bertoldi and S. C. Dumith assisted in the data analysis, literature review, and writing of the article and approved the final version of the manuscript.

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