Full Length Research Paper

Trends in body mass index values of Brazilian enlisted men, 1980 to 2005

César Marra1,2,*, Flávia dos Santos Barbosa1 and Rosely Sichieri1

1Department of Epidemiology, Institute of Social Medicine, State University of Rio de Janeiro, Rio de Janeiro, RJ, Brazil.
2Brazilian Army Physical Fitness Research Institute, Rio de Janeiro, RJ, Brazil.

Accepted 18 October, 2012

This study was to investigate the temporal evolution of body mass index (BMI) in young enlisted men of 18 years in Brazil between 1980 and 2005, to identify specific points of greatest variance in time series and compare specific points in time, and the temporal evolution of BMI with socioeconomic changes in Brazil. The present study explores a temporal series of twenty-six national surveys of Brazilian men enlisted between 1980 and 2005. Heteroscedasticity in BMI time series was tested using Engle's Lagrange-multiplier (LM) test, and analyses were performed using the autoregressive conditional heteroscedasticity (ARCH) model. As possible explanations for these increases in mean BMI, changes in economic indicators were considered. Particularly in 1985 to 1986 and 1994 to 1995, there was a sharp and significant increase in BMI. These two points occurred after two major economic policy changes that increased the purchasing power of the population related to economic factors such as: reducing the level of social inequality, increased family income, poverty reduction, inflation control, and increased consumption of foods. The present study showed a sharp increase of obesity in the population of young men in Brazil on two occasions during this series (years 1985 to 1986 and 1994 to 1995), when a possible reduction in caloric expenditure and increased food consumption population were observed.

Key words: Temporal trends, body mass index, obesity, Brazil.

INTRODUCTION

Trends of increasing overweight and obesity are now well documented in both developed countries for example, United States (Komlos and Brabec, 2010; Burkhauser et al., 2009), France (de Saint Pol, 2009), Japan (Yoshiike et al., 2002) and developing countries for example, Brazil (Wang et al., 2002) and Mexico (Rivera et al., 2004) but few studies have used time series with more frequent data collection points on weight change, which would allow testing, whether specific points in time are associated with more substantial increases in the rates of overweight and obesity.

Economic development, modernization, and urbanization have been associated to obesity (Staudigel, 2011; Peracchi and Arcaleni, 2011). Economic factors such as greater purchasing power of poor families (Lignani et al., 2011), low food prices (Christian and Rashad, 2009; Rashad, 2006), technological modernization (Lakdawalla and Philipson, 2009), increased family income (Fowler et al., 2005) are associated with dietary patterns of populations, particularly in developing countries, resulting in increased obesity (Mendez and Popkin, 2004; Ulijaszek and Koziel, 2007).

Recent data from the Brazilian Institute of Geography and Statistics (IBGE, 2010) reported that overweight has been increasing steadily in adults since the mid-1970s and it is currently found in approximately half of all Brazilians. Data from enlisted men have been used to describe the prevalence of overweight in Israel (Gross et al., 2009) and the United States (Hsu et al., 2007). These data are usually collected annually and therefore they are a
good resource for testing temporal changes, mainly when measured by professionals.

The objectives of this study are: (1) To evaluate the temporal change in BMI of enlisted men in Brazil from 1980 to 2005; (2) to test for specific points in time that display greater variance and; (3) to further compare specific points in time in the BMI temporal evolution with economic changes in Brazil.

METHODOLOGY

Study population

The present study explores a temporal series of twenty-six national surveys of Brazilian men who enlisted between 1980 and 2005. Each survey comprises a 35 to 40% of all Brazilian men aged 18 years at the time of examination. The article 143 in the Constitution of the Federative Republic of Brazil (1998) provides that a one year military service is compulsory. Women and clergymen are exempted from compulsory military service. Weight and height were measured to the nearest 0.1 kg and 0.5 cm, respectively using a scale with incorporated stadiometer (Filizola®). All measurements were performed by previously trained examiners. Participants were weighed and measured wearing light clothing and no shoes.

Body mass index data analysis

The Brazilian candidates for compulsory military service are representative of the male population in general thus allowing one to assess the increase in the prevalence of obesity during the period of analysis and identify periods of change. Prevalence of overweight and obese men was calculated with 95% confidence intervals, and the BMI values were plotted to make a descriptive analysis of the time series. This analysis showed that the variance of the error term was not equal over time that is, heteroscedasticity. The cutoff points of the World Health Organization (WHO, 2007) were used to classify overweight (BMI ≥ 25 kg/m² and < 30 kg/m²) and obese (BMI ≥ 30 kg/m²) men.

Heteroscedasticity in BMI time series was tested using Engle’s Lagrange-multiplier (LM) test, and analyses were performed using the autoregressive conditional heteroscedasticity (ARCH (1)) model (Engle, 1982; Bollerlev et al., 1994) with a level of significance set at p < 0.05. For those points in time with higher oscillations of the mean of BMI (1985, 1994 and 2000), dummy variables were included under the assumption that the growth rate of mean BMI was not the same throughout the period.

When heteroscedasticity is present, the regression coefficients for an ordinary least squares regression (OLS) are unbiased, but the variance and confidence intervals estimated by conventional procedures will be too narrow, giving a false sense of precision. In this context, an ARCH model, introduced by Engle (1982), is an appropriate framework for analyzing the data. All analyses were performed using the STATA.

Economic factors

As possible explanations for these increases in mean BMI, changes in economic indicators were considered (Brazilian Institute of Geography and Statistics and Institute of Applied Economic Research). The economics factors which have been analyzed were: annual inflation rate, food production, poverty (%), soft drinks consumption and average annual real income.

Annual inflation rate

The annual inflation rate was measured by the General Price Index, an index that attempts to reflect the monthly variations in prices (%). The index calculates the price variations of agricultural raw materials and wholesale industrial and final goods and services for consumption. Annual inflation was measured by the average of the 12 months of the year (IPEA, 2010).

Food production

Food production was measured by indicators for aggregated products that represent the sectors that provide supplies directly to livestock or delivering the first industrial processing of goods resulting from activities in the primary sector. The series consists of products and aggregates defined class-based agribusiness industry (year 1989 = 100) (ABIA, 2010).

Poverty

Poverty was measured by the percentage (%) of people in total population with per capita household income below poverty line. The poverty line is twice the extreme poverty line, an estimate of the value of a basic food basket with a minimum of calories needed to adequately sustain life, based on the recommendations of Food and Agriculture Organization and WHO (IPEA, 2009).

Soft drink consumption

The Soft drink consumption was measured by the annual wholesale value of soft drinks and juices in liters per year (l/y) (ABIR, 2009).

Average annual income

The series were calculated from all jobs of employed persons with employment income (IPEA, 2008). The annual income was measured by the average of the 12 months of the year and in national currency: Real (R$). The study was approved by the Research Ethics Committee of Rio de Janeiro State University, Institute of Social Medicine (protocol number 397523).

RESULTS

The study population of 11,090,230 males showed an increase in mean BMI from 21.4 kg/m² in 1980 to 22.2 kg/m² in 2005. The prevalence of overweight men changed from 4.5% in 1980 to 12.5% in 2005 (2.6 times larger). The prevalence of obesity increased from 0.5% in 1980 to 1.9% in 2005, an increase of almost 300% during the period; although these values are still at low level in international comparison. Table 1 shows increasing variance of mean BMI over time, indicating heteroscedasticity.

The LM test of heteroscedasticity on BMI showed a p-value
of 0.0002, rejecting the null hypothesis of no ARCH effects. The ARCH models were fitted including the dummy variables for the years 1985, 1994 and 2000 (the independent variables). Only 1985 and 1994 showed a statistically significant modification of the rate of change \( p < 0.05 \). The year 2000 was not statistically significant \( p = 0.54 \). Thus, the final model was ARCH (1) with two dummy variables (years 1985 and 1994). Data are shown in Figure 1 and the results of analysis are given in Table 2. From 1980 to 1985, there were no significant changes in mean BMI. From 1985 to 2005, BMI values increased.

In Table 2, the coefficients associated with the years 1985 and 1994 indicate the statistically significant changes. Thus, the constant represents the overall mean of 22.073 kg/m\(^2\) in years 1985 and 1994. The negative value -0.232 kg/m\(^2\) indicates a BMI smaller than mean BMI after 1985. The same apply for 1994 when BMI values after 1994 were 0.437 kg/m\(^2\) greater. The bottom portion of Table 2 is related to the fit of the model. The coefficient \( L1 = 0.49 \) indicates that the variance of the current period error depends on information that is revealed in the preceding period. The years of change in BMI were accompanied by the usual changes in Brazilian’s lifestyle (1985 to 1986 and 1994 to 1995) but by international comparison they are below average (Figure 1).

**DISCUSSION**

Non-genetic factors appear to have a major role in rapidly increasing rates of obesity (Ogden et al., 2007; Saarloos et al., 2009) but there is less consensus on the specific environmental factors that may contribute to such dramatic shifts (Jeffrey and Utter, 2003). Although young males are not the group with the greatest prevalence of overweight in Brazil, overweight changed from 4.5% in 1980 to 12.5% in 2005, the prevalence in the overall population according to nationwide surveys in Brazil has increased substantially. Overweight and obesity combined
among adults has increased from 18.5 to 50% in the last 30 years indicating that the obesity epidemic is happen
also in Brazil (IBGE, 2010).

The data of enlisted men provides a practical and large
convenience sample of the Brazilian young male popula-
tion and possibly reflects general population trends. We
identified turning points in the BMI curve in 1985 and
1994 and also identified changes in the Brazilian econo-
my of possible factors are corresponding in time with
increased BMI. Beginning in 1985, a marked change in
general consumption was noted with an increasing
amount of available calories (Silveira and Almeida, 2008)
and also the launching of many new food products
(Mendonça and Anjos, 2004). Beginning in 1994, a trend
was observed towards increased consumption of fast
foods (Mendonça and Anjos, 2004) and soft drinks (ABIR,
2009).

The decline in inflation rate and consequent reduction
in food prices, mainly for industrially-produced food pro-
ducts, was observed in both periods and many authors
have concluded that low food prices induce people to
consume more calories (Mitra, 2001; Cutler et al., 2003;
Chou et al., 2004). Glanz et al. (1998) found that cost is
one of the most important factors in food-purchasing
decisions and that these trends toward increased con-
sumption and reduced industrialized food prices (for ex-
ample, soft drinks and vegetable oils) have also been
observed in the past three decades in other developing
countries (Popkin, 1993).

An increase in wages mainly among the poor (Lavinias,
2001; IBGE, 2007) and the reduction of inequality
(Hoffman, 2002) were also a result of the 1994 real plan
in Brazil, a major economic intervention by the govern-
ment, which increased food consumption in res-
taurants and fast food establishments (Mendonça and Anjos,
2004). Eating outside the home has been associated with
obesity in studies conducted in the United States (Guthrie
et al., 2002) and Europe (Orfanos et al., 2007) and in
Brazil eating outside the home has been associated with
obesity among men (Bezerra and Sichieri, 2009).

In the United States, increased rates of obesity have
coincided with a large increase in average caloric intake
between 1985 and 2000 when more fats were added to
homemade foods and many processed foods (Chastenet,
2011) and in Brazil, an increase in processed foods and
sodas has been well documented (Levy-Costa et al.,
2005). Watching television has also received great
attention for its contribution to a sedentary lifestyle (Finkeltein
et al., 2005). Time spent on computers, video games and
other electronic resources have increased substantially
since the 1980’s in Brazil. Furthermore, an increase in TV
sales was observed in the period 1994 to 1995
(Mendonça and Anjos, 2004).

Conclusion

Finally, the results of this study show that between 1980

Figure 1. Log annual inflation (%), food production, poverty
(%), soft drink consumption (10^5 liters/year, body mass index
(kg/m^2)) and average annual income (R$) in Brazil, 1980 to
2005. The shaded zones illustrate that the periods of economic
growth (1985 to 1986 and 1994 to 1995) and are

1980
1985
1990
1995
2000
2005
21.0
21.5
22.0
22.5
300
400
500
600
700
800
Year
BMI (kg/m^2)
Average ... 105/y)
0
20
40
60
Poverty (%)
0
50
100
150
200Food Production
1
10
100
1000
10000Log Annual Inflation (%)
and 2005, we identified that two points of rate of change in BMI are corresponding in time with economic changes that altered Brazilians’ lifestyles. Much has yet to be investigated on the influence of economic factors on the development of obesity and although time series studies are not considered the best framework for causal analysis, this methodology clearly allows the identification of major changes over time, as shown in our analyses. Because of their public health importance, trends in overweight and obesity need to be monitored continuously and factors associated with these trends studied, in order to develop sound health-policy strategies to improve health and prevent obesity.

ACKNOWLEDGEMENTS
The authors would like to thank the Brazilian Army for making the data available.

REFERENCES


<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>P &gt;</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1985</td>
<td>-0.323</td>
<td>0.001</td>
<td>-0.321 - -0.144</td>
</tr>
<tr>
<td>Year 1994</td>
<td>-0.437</td>
<td>0.001</td>
<td>-0.555 - -0.319</td>
</tr>
<tr>
<td>constant</td>
<td>22.073</td>
<td>0.001</td>
<td>22.025 - 22.122</td>
</tr>
<tr>
<td>ARCH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L1</td>
<td>0.497</td>
<td>0.043</td>
<td>0.015 - 0.979</td>
</tr>
<tr>
<td>constant</td>
<td>0.003</td>
<td>0.020</td>
<td>0.000 - 0.005</td>
</tr>
</tbody>
</table>