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HEART RATE VARIABILITY IN OBESE CHILDREN

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ABSTRACT:

Introduction: in recent years, several studies have performed the behavior of ANS on obesity by the heart rate variability (HRV). The literature describes that obese adults have dysfunctions on ANS, nevertheless there is a few information with childhood obesity and the findings are still inconclusive. **Objective:** gathering studies that approach the analysis of the ANS by HRV in obese children to understand better the influence of obesity on this system and in this population and provide an update of the findings published in the last eleven years. **Methods:** the search of articles was conducted on Pubmed, Ibesc, Medline, Scielo, Cochrane and Lilacs databases using the keywords: heart rate, autonomic nervous system, obesity, child and sympathetic nervous system of health subject headings (MeSH). **Results:** the electronic search resulted in 11 articles and, in general, showed a decrease in activity of the parasympathetic branch of obese children and inconclusive results by the sympathetic branch. Moreover, interventions as diet and physical activity "could increase the ANS function in these children. **Conclusion:** obese children have changes on ANS function and this presents the necessity of precocious attention aims at avoiding future complications.

Key words: child; obesity; autonomic nervous system; parasympathetic autonomic nervous system; heart rate; review.

INTRODUCTION

Among the nutritional disorders in childhood, the obesity - defined as the excessive deposition and storage of fat in the body, usually caused by the interaction of several factors, including poor eating habits, genetics, emotional factors, gender, age, level of physical activity and cultural aspects[1-3] is considered an important public health problem[4].

Epidemiological data showed that obesity has increased significantly in recent years and according to the World Health Organization affected actually 35% of world population. In Brazil, about 24% of population was in overweight and obesity, already among young people, in recent years, the obesity increased from 3.7% to 12.6%[5,6]. In relation to Brazilian children, a preliminary data showed that 7% was in a situation of excess weight, ranging from 6% in the North to 9% in the South, indicating moderate exposure to obesity in all regions of the country[7].

The consequences of obesity included, metabolic, endocrine and cardiovascular diseases such as hypertension, arteriosclerosis and severe arrhythmias[8-10]. When it was present in childhood or adolescence, the obesity is associated with higher incidence of cardiovascular and metabolic disorders in adulthood [11]. Furthermore, studies have shown that obesity causes changes in the function of the autonomic nervous system (ANS)[9,12-15], which is an important condition, because this system controls part of the internal functions of the body.

In recent years, several studies have analyzed the behavior of ANS on obesity[16-19] using the heart rate variability (HRV) analysis, that is a noninvasive measure of autonomic impulses and indicates the heart's ability to answer a physiological stimulus,

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which can be used in several conditions, including in diseases[20-22].

Although described in the literature that obese adults have ANS disorders[1,23,24], missing information for obese children and the findings are still inconclusive[8,25,26].

In this context and considering the importance of early identification the changes in ANS induced by the obesity, this study aimed at gathering information about the ANS analysis by HRV in obese children to the better comprehension the influence of obesity on this system in this population and provide an update of the findings published in the last eleven years on this subject. Studies involving these questions could contribute to perform early actions that aimed improve the conditions of this system in this population.

The objective was to verify the effects of obesity on the behavior of the autonomic nervous system in children.

METHODS

The articles used in this study were selected on Pubmed, IBECS, Medline, SciELO, Lilacs and Cochrane databases at February 2011. For this search, were used the keywords junctions: heart rate, autonomic nervous system, obesity, child and sympathetic nervous system, which were defined on Medical Subject Headings (MeSH).

The studies were initially selected based on their titles and were analyzed by a single researcher, who selected them according to established inclusion criteria for this review. Therefore, the title should express as focus of the study: heart rate variability in obese children, the influence of obesity on the ANS, the consequences of obesity on the children's health and those related to obesity or any information pertaining to this condition, as body fat, the words parasympathetic/or sympathetic nervous system and hemodynamic and metabolic changes. After that, we made a filtering of the results to identify repetitions, since the search was conducted in various databases.

After this triage, all chosen titles had their abstracts studied in detail in order to select the articles that addressed the HRV in obese children. Sequentially, the abstracts that addressed in this thematic had their full texts read.

Furthermore, all selected studies had their references analyzed independently to identify relevant studies that were not found in the electronic search. All steps were followed by a senior reviewer who conducted the final judgment of articles.

The included studies were published between the 2000 to 2011 period in Portuguese, Spanish and English, with obese children up to 12 years to examine the ANS through HRV. All types of study design were included.

Data were qualitatively described and tabulated according to the authors, year of study, clinical and physical characteristics of the population, the study aimed, indices evaluated and findings observed.

RESULTS

Search strategy and selection

The electronic search, with the descriptors in databases, provided a total of 3128 titles. The first selection resulted in 2829 titles eliminated, and the remaining studies passed to the next stage of selection, which analyzed the content of their abstracts and 170 abstracts were eliminated, which did not meet the established criteria. The 129 remaining texts had their study read in full and after the last elimination stage, which excluded a total of 118 studies, resulted in 11 articles.

Characteristics of selected studies

Table 01 are organized by authors and publication year, characteristics of population, aim, evaluated indices and conclusions and contains 11 articles resulting from the systematic search.

Table 01: Studies description according to authors and publication year, characteristics of population, aim, evaluated indices and conclusions

Author and publication year	Characteristics of population	Aim	Evaluated indices	Conclusions
Nagai et al., 2003.	Obese group (N = 42): Mean age 9,0 ± 0,3 years and BMI 23,4 ± 0,5 Kg/m². Non-obese group (N = 42): Mean age 9,0 ± 0,3 years and BMI 17,9 ± 0,6 Kg/m².	To investigate if the components sympathetic and / or parasympathetic are altered in obese children and the correlation of duration of the obesity with the degree of dysfunction of the ANS.	LF(ms²)*, HF(ms²)* and TP(ms²)*.	Both components of the ANS are influenced by obesity, with lower activity of this system. Moreover, it was possible to observe a negative correlation with the duration of obesity values of LF, HF and TP, indicating that the duration of obesity influences the SNA dysfunction.
Nagai et al., 2004.	Obese active group (N = 24): Mean age 9,5 ± 1,4 years and BMI 23,0 ± 2,5 Kg/m². Obese inactive group (N = 24): Mean age 9,3 ± 1,7 years and BMI 24,3 ± 3,4 Kg/m². Non-obese active group (N = 24): Mean age 9,6 ± 1,3 years and BMI 17,0 ± 1,4 Kg/m². Non-obese inactive group (N = 24): Mean age 9,4 ± 1,8 years and BMI 17,0 ± 1,5 Kg/m².	To evaluate the ANS through HRV in obese and non-obese children, which were divided into active and inactive, to verify that the compo-nents sympathetic and parasym-pathetic are altered due to obesity and physical inactivity.	LF(ms²)*, HF(ms²)* and TP(ms²)*.	Obese children have lower values of LF, HF and TP compared to non-obese children, which have similar levels of physical activity. So the both components of the ANS of obese children have disorders.

Author and publication year	Characteristics of population	Aim	Evaluated indices	Conclusions
Kaufman et al., 2007.	Obese group (N = 10): Mean age 11,5 ± 0,8 years and BMI 32,4 ± 5,5 Kg/m². Overweight group (N = 10): Mean age 11,3 ± 0,5 years and BMI 24,8 ± 1,5 Kg/m². Non-obese group (N = 10): Mean age 11,5 ± 1,1 years and BMI 18,1 ± 3,1 Kg/m².	To examine the cardiovascular autonomic function and their potential relationship with leptin resistance, insulin resistance, oxidative stress and inflammation in a sample of children with different levels of obesity.	Mean of intervals RR, SDRR, RMSSD, LFun*, HFun*, LF/HF*, TP(ms²) and Sample entropy.	Lower values of HF and higher values of LF and LF / HF ratio were observed in obese children to be compared to non-obese children. These data reflect a dysfunction in this ANS population.
Kaufman et al., 2008.	Obese children (N = 15): Mean age 11,4 ± 0,5 years and classified as obese according to the BMI corresponding to the 85th percentile.	To evaluate the effects of 5 months of eating habits on the ANS and the endothelial system of obese children.	SDNN, RMSSD**, LFun, HFun e LF/HF**.	The results reflect an increase in component parasympathetic. Therefore one can conclude that diet contributes to the control of weight and ANS dysfunction.
Ancona et al., 2009.	Obese group (N = 15): Mean age 9,6 ± 0,7 years and BMI 23,2 ± 0,8 Kg/m². Non-obese group (N = 15): Mean age 9,4 ± 0,6 years and BMI 16,3 ± 2,2 Kg/m².	To analyze possible changes in the component parasympathetic and sympathetic in obese and eutrophic children in the supine and standing.	Mean of intervals RR, Standard deviation of the intervals RR, RMSSD, pNN50, HF(ms²), LH(ms²)and LF/HF.	Both supine and in the standing position, there were no significant differences in cardiac autonomic modulation between groups, suggesting that the cardiac autonomic modulation does not suffer this degree of influence childhood obesity.
Paschoal et al., 2009.	Obese group (N = 15): Mean age 10,2 ± 0,7 years and BMI 23,9 ± 1 Kg/m². Non-obese group (N = 15): Mean age 9,8 ± 0,7 years and BMI 17,7 ± 1,6 kg/m².	To add the most relevant and recurring paradigms of early influence of obesity on future cardiovascular and metabolic diseases.	Mean of intervals RR, SDNN, RMSSD, pNN50, LFun*, HFun, LF(ms²), HF(ms²), LF/HF*.	The obese group showed higher activity of the component sympathetic due to higher index values LFun and LF / HF relative the non-obese group.
Dipla et al., 2010.	Obese group (N = 14): Mean age 11,7 ± 0,23 years and BMI 29,2 ± 0,9 Kg/m². Non-obese group (N = 13): Mean age 11,8 ± 0,22 years and BMI 18,9 ± 0,3 Kg/m².	To test the hypothesis that obese children have hemodynamic responses and baroreflex control different to non-obese children compared to isometric exercise and recovery.	RMSSD*, SD1*, SD2 and SD1/SD2.	During isometric exercise, obese children have lower performance of component parasympathetic compared with non-obese children. But the recovery period there was no difference between groups.
Vanderlei et al., 2010.	Obese group (N = 51): Mean age 10,06 ± 1,27 years and BMI 28,45 ± 3,54 Kg/m². Non-obese group (N = 61): Mean age 10,49 ± 1,39 years and BMI 17,42 ± 1,76 Kg/ m².	To investigate the dynamics of the heart rate of obese children through long-and short-term fractal exponent by DFA, along HRV analysis in the frequency domain.	LFun, HFun, LF(ms²)*, HF(ms²)*, LF/HF, Alfa1*, Alfa2 and Alfa1/Alfa2 ratio.	The obese group presented autonomic dysfunction, characterized by decreased activity of component parasympathetic and sympathetic and loss of short-term fractal correlation of HR.
Vanderlei et al., 2010.	Obese group (N = 61): Mean age 10,20 ± 1,47 years and BMI 29,30 ± 4,74 Kg/m². Non-obese group (N = 72): Mean age 10,57 ± 1,51 years and BMI 17,37 ± 1,82 Kg/m².	To investigate the modulation of autonomic eutrophic and obese children by HRV indices obtained by geometric methods.	RRtri*, TINN*, SD1*, SD2*, SD1/SD2 e visual analysis of the Poincaré plot.	In obese children were analyzed reductions in geometric indexes, suggesting that in these children, the overall HRV is reduced and parasympathetic activity.
Vanderlei et al., 2010.	Obese group (N = 56): Mean age 9,96 ± 1,31 years and BMI 28,58 ± 3,66 Kg/m². Non-obese group (N = 65): Mean age 10,39 ± 1,42 years and BMI 17,33 ± 1,77 kg/m².	To compare autonomic function in obese and eutrophic children by HRV analysis.	RMSSD*, SDNN*, pNN50*, SD1*, SD2*, SD1/SD2, LFun, HFun, LF(ms²)*, HF(ms²)*, LF/HF.	The results suggest a decrease in the activity of component parasympathetic and sympathetic of obese children due to the findings of the indices when compared to normal children.
Sekine et al., 2011.	Obese group (N = 7): Mean age 9,21 ± 0,33 years and BMI 21,6 ± 0,75 Kg/m². Non-obese group (N = 9): Mean age 9,11 ± 0,29 years and BMI 16,2 ± 1,32 Kg/m².	To determine the relationship between obesity and ANS activity in healthy children.	SD, CV, RMSSD, TP(ms²)*, VLF(ms²)*, LF(ms²), HF(ms²), LFun*, HFun* e LF/HF*.	According to the values of the indices and comparison between groups obese children have higher activity in the sympathetic while parasympathetic activity is decreased.

* Static difference between obese and non-obese group; ** Statistical difference between before and after intervention; Abbreviations: N, number of children analyzed; BMI, body mass index; ANS, autonomic nervous system; HRV, heart rate variability; DFA, fluctuation detrended analysis; RMSSD, square root the average of the squared differences between adjacent normal RR intervals; SD1, standard deviation of the variability instantaneous beat-to-beat; SD2, standard deviation of long-term continuous RR intervals; SD1/SD2, the ratio between short and long variations RR intervals; SDNN, standard deviation of all normal RR intervals; LFun, low frequency component in normalized unit; HF, high frequency component in normalized unit; LF / HF ratio between the components of low and high frequency; TP, total frequency in ms ²; LF, low frequency component in ms²; HF, high frequency component in ms²; Alpha1, short term fractal exponent; Alpha2, long-term fractal exponent; Alfa1/alfa2, fractal exponents ratio of short and long term; pNN50, percentage of adjacent RR intervals with a difference of duration greater than 50ms; RRtri, triangular index; TINN , triangular interpolation of RR intervals; SDRR, standard deviation of normal RR intervals; SD, standard deviation of normal RR intervals; CV, coefficient of variation; VLF, very low frequency component.

DISCUSSION

The analysis of the selected texts showed that obesity in children under 12 years causes changes in ANS that can be characterized as: 1) in general, obese children had a reduction on parasympathetic activity of ANS when compared to non-obese children, 2) the results of sympathetic component of ANS are divergent, some studies pointing a reduction of sympathetic activity, and others studies showing an increment in the sympathetic activity, and also, some studies found no changes in this system in obese children compared to non-obese, 3) interventions, such as weight reduction per diet and physical activity, promoted improvements on ANS in this population.

Changes on ANS activity of both components, sympathetic and parasympathetic, in obese children were described by several authors. Nagai et al [26] investigated the ANS changes through LF, HF and TP indexes in obese children and correlated the duration of obesity with the dysfunction degree of ANS. The authors found that obese children had sympathetic and parasympathetic dysfunctions, characterized by the reduction of all HRV indexes analyzed when compared to non-obese children, and they argue that the reduction of the activity of parasympathetic component could be associated with future autonomic neuropathy, metabolic disorders and high blood pressure levels, while the reduction of the sympathetic component activity, could be associated with a less energy expenditure and consequently with an energy imbalance, causing obesity. The negative correlation between the duration of obesity with the degree of ANS dysfunction was observed, indicating the longer duration of obesity the lower ANS activity.

This same pattern of ANS behavior was describe on Vanderlei et al [30] stugy, which evaluated in obese children the HRV indexes by the time domain (RMSSD, pNN50 and SDNN), frequency domain (LF and HF in normalized units (NU) and ms ², and LF / HF ratio) and by the Poincaré plot (SD1 , SD2 and SD1/SD2 ratio). The reduction in all these indexes in obese children was observed, indicating a reduction of global variability and a reduction on activity of both systems.

Reductions on parasympathetic activity and on global variability were also observed in obese children by Vanderlei et al [28] through geometric analysis of HRV indexes. Using RRtri, TINN, SD1, SD2, SD1/SD2 ratio indexes and visual analysis of Poincaré plot, the authors showed that obese children had a decrease of parasympathetic activity, characterized by decreased on SD1 index associated with the reduction of global ANS, observed through the analysis of RRtri, TINN, SD2 indexes and visual analysis of the Poincaré plot.

Analyzing the autonomic activity by RMSSD, SD1, SD2 and the SD1/SD2 ratio indexes in response to the isometric exercise of elbow flexion and during recovery, Dipla et al [27] observed no significant changes in ANS between obese and non-obese children during recovery, however, during the course of the exercise, obese children had lower values of RMSSD and SD1, indicating a lower performance of the parasympathetic system in these children. According to the authors, the answer to this changes appear only during exercise could be related to an early stage of obesity, showing exercise performance highlights changes that are not observed at rest.

A study by Pascoal et al [2] showed a different behavior of sympathetic ANS studies exhibited. They evaluated different HRV indexes in obese and non-obese children on standing position and observed that only LFun and LF / HF ratio indexes shown significant differences, with higher values for obese children, indicating a sympathetic hyperactivity. The authors also reported the children of their study exhibit an age range different of groups when compared with other clinical trials, which could be one of the factors responsible for the divergent results.

Other authors confirm this pattern of sympathetic behavior. Sekine et al [31] observed higher values to LFun and LF / HF ratio indexes in obese children compared to non-obese group, suggesting larger sympathetic activity in these children. Moreover, indices reflecting the performance of the parasympathetic system (TP (ms ²) and HFun), showed lower values for obese, suggesting that these children had a decrease of parasympathetic activity.

Even, the ANS behavior pattern was reported by Kaufman et al [32] clinical trial, which examined the cardiovascular autonomic function and their potential relationship with leptin resistance, insulin resistance, oxidative stress and inflammation in children with different levels of obesity. The authors found lower HFun values and higher LFun and LF / HF ratio values in obese children compared to non-obese. In this study, no changes were observed between the group of overweight children to obese children, indicating that the ANS activity does not change until obesity be substantially increased.

Contradicting the above studies, Ancona et al [34] found no significant differences between obese and non-obese children, in the supine and standing position, by SDNN, RMSSD, pNN50, HF (ms ²), LH (ms ²), the LF / HF ratio indexes and the mean of RR intervals, suggesting the degree of obesity presented by obese children analyzed in this study was not able to promote changes in ANS.

The only study that assessed HRV in obese children using nonlinear methods was published by Vanderlei et al [8]. By using the Detrended Fluctuation Analysis – DFA index, and the authors reported that obese children have loss of fractal correlation properties of short-term heart rate dynamics, tending the randomness, associated with a reduction of both components activity (sympathetic and parasympathetic). According to the authors, the early loss of fractal heart rate dynamics was associated with an increment of the risk to developing cardiovascular disease.

The described studies indicated some divergence regarding the behavior of sympathetic and parasympathetic components of the ANS in obese children. One of the possible causes for these differences is the difficulty to control the variables present in the studies groups such as age, sex, history of obesity, diet and eating habits, levels of physical activity and emotional stress [8, 26, 29, 31 35]. Moreover, methodological limitations for assessment of sympathetic activity depending on the LF and LF / HF ratio indexes but they were not pure indexes of activity this system [26, 31], and this is another factor could contributed to these conflicting results.

The literature also showed that the reduction in body weight and physical activity could promote improvements in ANS in obese children. Evaluating the effects of five months of nutrition education on the ANS and the endothelial system of obese children, Kaufman et al [33] reported lower levels of body fat, weight, body mass index and body fat percentage; a decrease in the LF / HF ratio and RMSSD increased, indicating that the nutritional education program promoted an increase of parasympathetic activity. The authors noted the reduction in the free radical formation increase the receptor leptin activity and decrease the leptin levels resulting in weight loss could be related to the increment on parasympathetic system activity in obese children.

Regarding physical activity, Nagai et al [29] evaluated HRV indexes (LF, HF and TP ms²) of obese or non-obese children characterized as active or inactive and verified if ANS was altered due to obesity and physical inactivity. The comparison between obese or non-obese children with similar levels of physical activity had shown that obese children, regardless of activity level, showed lower values of evaluated indexes. Moreover, the comparison between obese children showed the more active had TP index values greater than sedentary ones, indicating that physical activity could reduce changes in ANS of obese children obesity-induced.

Within this context, it should be noted that interventions with diet and exercise to reduce the degree of obesity, could be able to decrease the changes in ANS in obese children and they should be early encouraged to minimize or eliminate risks produced by obesity.

This review showed the obesity produces changes on ANS behavior in obese children and in general, there is a reduction of a parasympathetic system activity, nevertheless the results about the sympathetic activity are inconclusive.

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