Study About Pediatric Hypertension in *Lisboa and Vale do Tejo*

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Abstract. The pediatric high blood pressure has severe risk factors and it's prevention is mandatory. To evaluate the pediatric arterial hypertension caregivers Knowledge, in [1,2] was done a preliminary study of an experimental and simple questionnaire with 5 questions previously introduced in [3]. The analysis of an improved questionnaire applied to children caregivers and filled online was completed in [4,5]. In [6], was performed an analysis of variance as a preliminary approach where the authors obtain estimates about the childhood hypertension prevalence in several regions of Portugal, using a sample collected during the hypertension day activities. The same study [6] evidences significant differences on high blood pressure prevalence between girls and boys; also the children's age is a significant issue to take into consideration. Actually, in present work we obtain similar results using ANOVA techniques and more complex methods, for example general linear models and mixed models between others, considering a sample from metropolitan zone of *Lisboa and Vale do Tejo* (LVT).

Keywords: Pediatric hypertension · Caregiver · Questionnaire · Statistical approach · Analysis of variance · General linear models

1 Introduction

The high arterial blood pressure is a condition which, although traditionally considered a disease of adults, may increase during the pediatric age and in most cases, silently. The diagnostic criteria for Pediatric Hypertension (PH) have as their main reference the normal distribution of blood pressure (BP) in healthy children [7] and based on the concept that the pediatric BP increases with age and with body mass [8]. Thus, taking into account that there is a

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strong correlation between body mass index (BMI) and BP levels [8], the PH has become highly prevalent among children and teens [9] due to a parallel growth with the epidemic of childhood obesity [10], the which suggests that obesity is a major risk factor in the development of pediatric hypertension [9,11].

Under the aim of a preliminary study about PH caregivers (parents or their legal representatives) acquaintance, a simpler questionnaire composed by five questions was introduced in [3]. To complete such work, different statistical techniques were performed in [1,2,12], namely logit modeling, exploratory factorial analysis and MANOVA, following e.g. [13,14]. In [15], a redesign of such questionnaire was built (including fifteen questions) and applied to a different target population. This work was continued in [4,5] using statistical multivariate techniques. In addition, in both questionnaires was included a question to check if the regular measurement of the BP, according to current European recommendations, was usually fulfilled.

A study about prevalence of pediatric hypertension at national level promoted by the Portuguese Society of Pediatrics (SPP) and Pediatric Hypertension Group (PHG) is ongoing. The medical individual characteristics of children and adolescents are observed by a medical team and a questionnaire was designed to be answered by caregivers of children and Portuguese teenagers where sociodemographic and familiar health history details are inquired. The data collection is still ongoing over several regions of Portugal (main land and islands). In present work we have considered a subset of such data set relatively to *Lisboa e Vale do Tejo* region.

In this article the objectives are to characterize the BP profile of a pediatric population with scholar age and to evaluate the prevalence of PH and normal-high BP and analyze the relation between PH/normal-high BP and age, sex, race and geographical origin. It was performed a preliminary approach in [6] using a sample non representative of Portuguese population evidences significant differences of high blood pressure prevalence between girls and boys; also the children's age is a significant issue. The work [6] is used as reference in the present work. We have obtained similar and confirmatory results in this manuscript.

This article is comprised of an introduction and results and final remarks Sections, Sect. 2 containing the description of data and methodology. The empirical application can be found in Sect. 3.

2 Data and Methodology

In [6] the authors have performed and observational, prospective, transverse pilot study (Tracking) in May 2017, in public and private schools from Northern to South of Portugal (Aveiro, Braga, Lisboa).

A sample, almost 5 hundred of observations, was collected by the PHG during the Hypertension Day activities, during an action of disclosure and tracking of PH. The target population was the set of students from first year until 12th year of schooling in three different groups of schools in Lisbon, Aveiro and Braga. These groups of schools have a population of students, aged between

5 of and 18 years old. The data collection occurred in May 2017, 25th, after adequate approval from Ministry of Education, General Direction of Health, Data Protection Committee and school Executive Committee. It was measured the blood pressure by oscillometric method (up to 3 measurements) and annotated some medical and socio-demographic characteristics for each student. The age was classified in three intervals: I (5–10 years); II (11–15 years); III (16–18 years). To characterize of the tensional profile was used the criteria defined SEH 2016. The classification of pediatric hypertension is presented in Table 1 (adapted from [10]).

Table 1. Classification of pediatric hypertension (adapted from [10]).

Class	SBP and/or DBP Percentile
Normal	<90
Normal-high	≥90 until <95 mmHg
	Teenagers: AP > 120/80 mmHg, including percentile <90
HBP - class 1	95 ≤ Class 1 ≤ 99 + 5 mmHg
HBP - class 2	>99 + 5 mmHg

The blood pressure measurements and remaining information are analyzed statistically following [14]. This sample is not representative of the Portuguese population, but was considered to get some preliminary results that can be used as an alert to the PBP problem and also as an incitement to complete the sample collection stage of ongoing pediatric BP study. In the present work, we consider a partial data set which is still being collected in all regions of Portugal: *Madeira* (M), *Açores* (A), *Lisboa e Vale do Tejo* (LVT), *Norte* (N), *Centro* (C), *Sul* (S). It is still necessary to complete the data collection, in particular it is still missing the data from region *Sul*, so the prevalence of pediatric HTA in Portugal can be estimated correctly. The sample considers 962 individuals aged between 5 years and 18 years, and covers partially the region of *Lisboa e Vale do Tejo*.

3 Empirical Application

Matlab, R and SPSS software were used to organize and model the data. The first step organizes the data and get some simple measures by descriptive statistic techniques. There are the approximately the same number of girls and boys. In Fig. 1 we can find the characterization of students per race. The non-Caucasian students are few (11%) when compared with the number of remaining students, but race still was tested to be considered as explanatory variable. In a preliminary data analysis and taking into account the non-quantitative nature of some involved variables, were calculated some measures of association, nonparametric Spearman correlation coefficient, and performed several tests, namely nonparametric test of Friedman, median test, rank test, signal test so we could identify potential explanatory variables or compare distinct groups (age, gender).

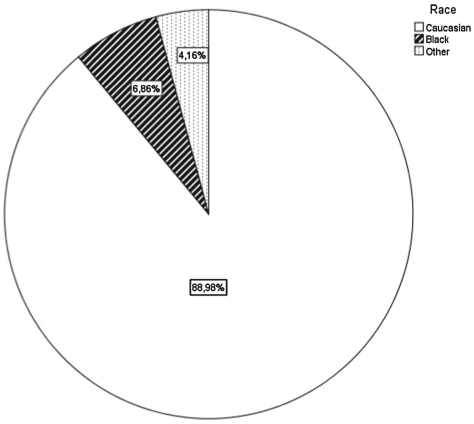

Fig. 1. Sample characterization (race).

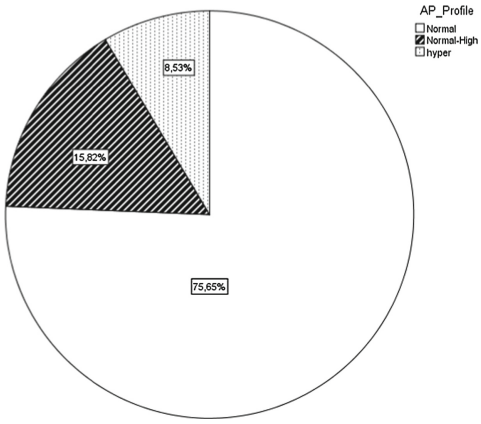

Fig. 2. AP distribution in sample (962 children).

In Fig. 2, we have the arterial pressure (AP) distribution in sample. We can observe that, in sample, 75.65% of child have normal level of BP; 15.82% of students have their AP profile classified has normal-high and 8.53% of students have pre-HBP. The blood pressure measurements and remaining information are analyzed statistically using a GLM approach. This sample, collected in LVT region, has a fewer percentage of children with normal AP profile than the case considered in [6] (less 10%).

The percentage of hypertensives by gender is different as we can see Fig. 3. 80% of the girls have a normal AP profile in opposite with 72% of boys. The distributions of AP profile per gender are statistically significant (means, medians, cdf). It means that there is statistical evidence that boys and girls have distinct AP profiles. The percentage of hypertension occurrence in boys is higher than

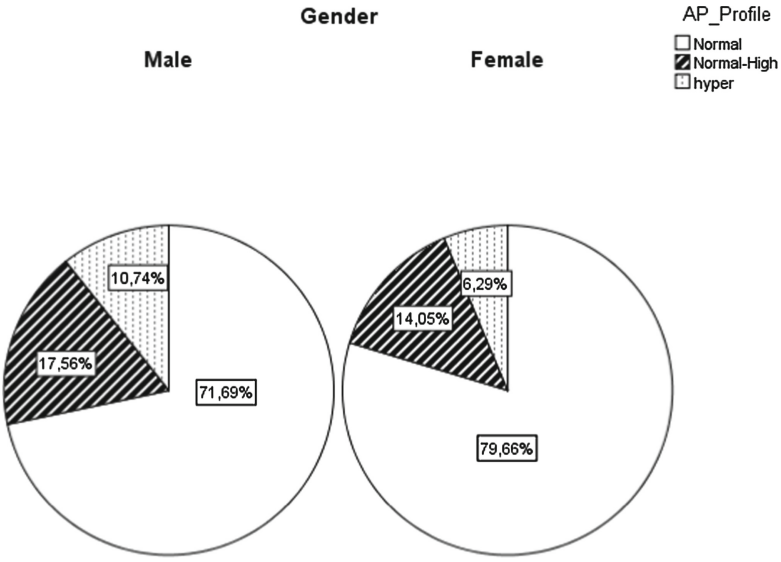

Fig. 3. Distribution of AP profile per gender.

in girls (10.74% versus 6.29%). More generally, there is a greater probability of an altered profile (normal-high BP or hypertension) for boys that for girls.

The box-plots of BP per age and per age group are represented in Fig. 4 (top and bottom respectively). It is visible that BP value tends to increase with the age.

Taking into consideration the age group defined previously, the differences between the 1st and 2nd groups, the 1st and 3rd groups and between the 2nd and 3rd groups gave conduced to distinct results. The tests were done separately for each situation. Testing the hypothesis that the older students have a higher HBP against the students of group 1 or group 2, the results provided that the groups 1 and 2 can be agglutinated, there is no significant difference; the group 3 presents higher and more significant values (difference of means parametric tests, difference of medians non-parametric test). In Fig. 4, we can observe that BP distribution per age and per age groups corroborates these results.

The sample distribution of weight (see Fig. 5) reveals that about 70% of young people have normal weight, being the remaining 30% weighted in excess[1]. Notice that the index of weight classification depends on gender and age and its construction depends on the BMI percentiles of young population for each age and gender (see Table 2).

[1] The index of weight classification (0-low; 1-normal; 2-Overweighted; 3-obesity type I, 4-obesity type II and III) is done acordingly with the rule established by National Helth service [16].

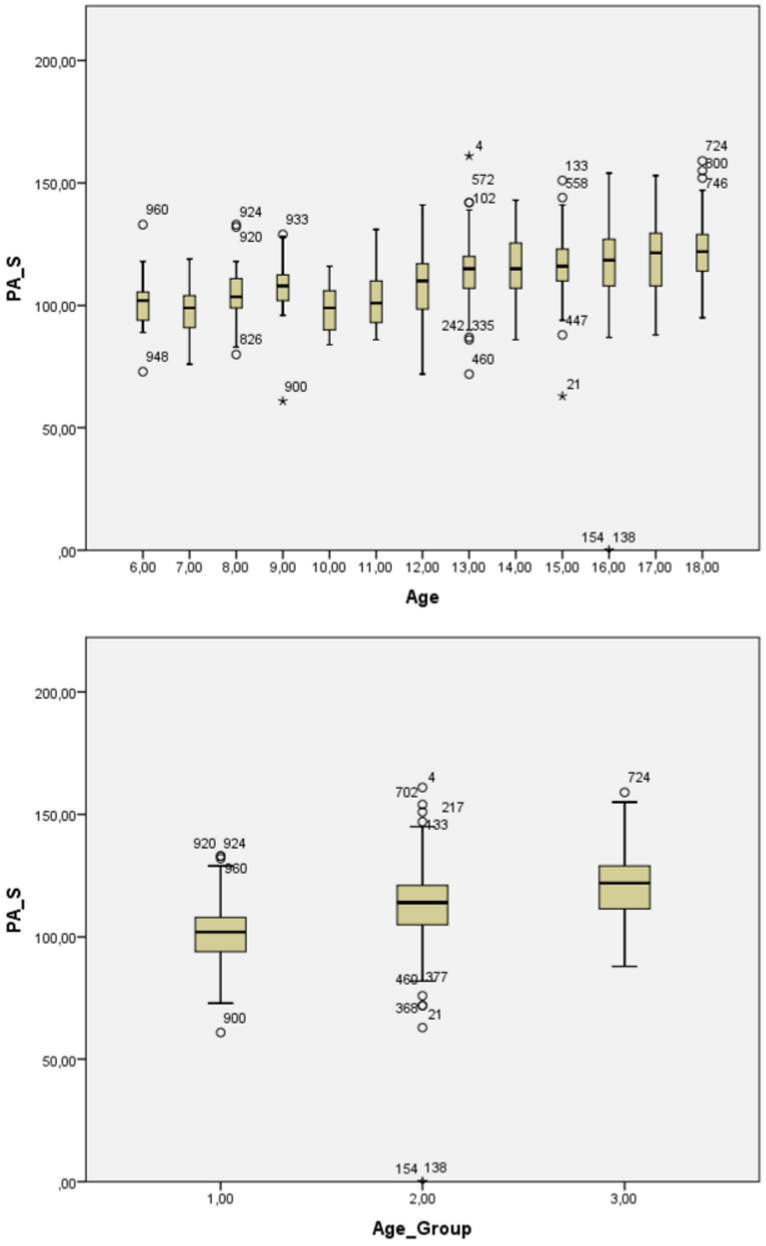

Fig. 4. Distribution of BP per age (top) and per age group (bottom).

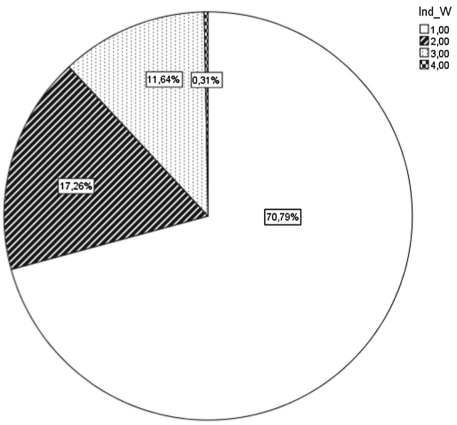

Fig. 5. Distribution of weight classification in sample.

Table 2. Weight classification for children and teenagers.

Weight	Rule	Classification
Less than percentile 10%	Low	0
Between percentile 10% and 85%	Normal	1
Between percentile 85% and 95%	Overweighted	2
Above percentile 95%	Obesity level I/Obesity level II and III	3/4

We have included the weight index (see Table 2) as an important information to include in our analysis. Figure 6 (top) evidences a positive relation between blood pressure and weight. The Spearman test is significant: there exists evidence of positive association between blood pressure and weight. At bottom of Fig. 6 we can see that the AP boxplots have a distinct behavior depending on the weight index.

Considering a multivariate regression test, we have performed an analysis of variance (ANOVA) with three factors, considering as main effects gender, age and weight index so we could analyze their influence on BP (see Table 3). The residual analysis was complete. The detailed results will be present in the extended version of this work. The heterogeneity of residual variance was taken into consideration.

The F test to evaluate the effect of gender, age group and weight index relatively to BP, can be found in Table 3. Notice that all factors have significant effects to BP when considered without interaction.

Other multivariate regression model was estimated, but including interaction between all factors (see Table 4).

In this case, and considering a significance level of 10%, the factor gender is not significant but its interaction with age Group is statistically important;

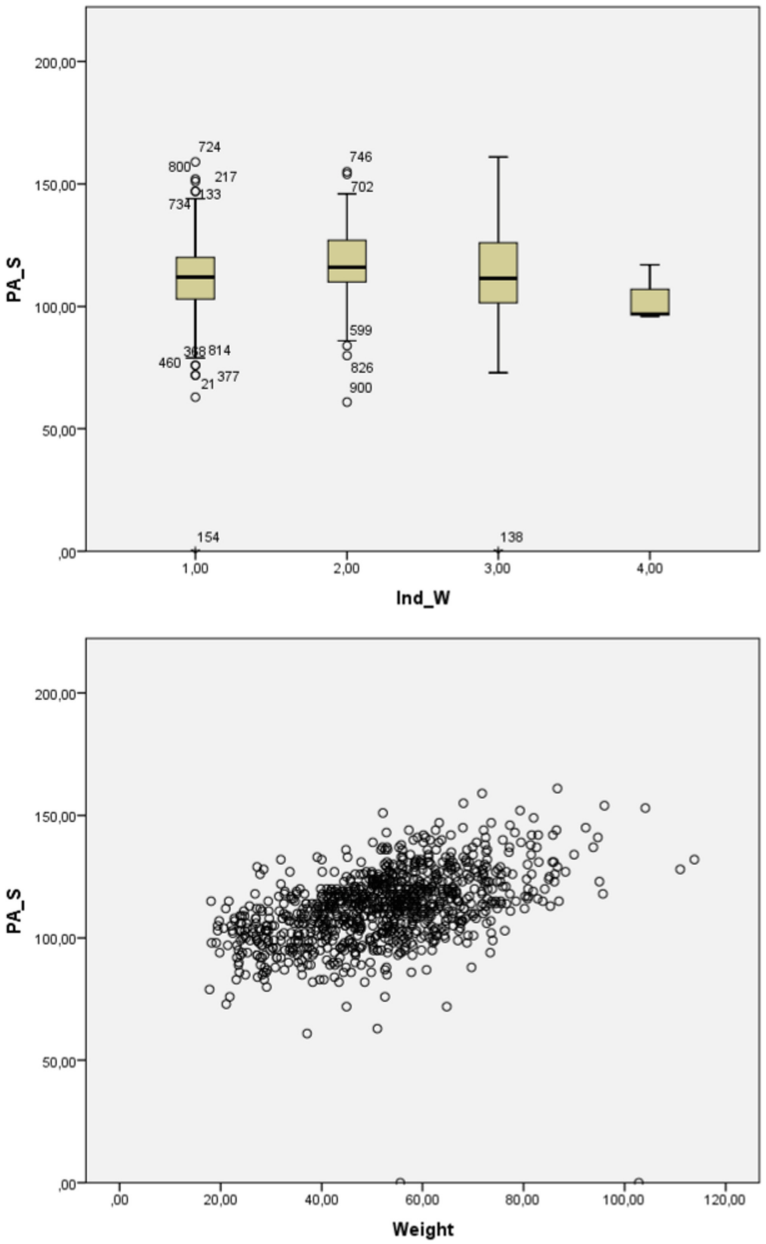

Fig. 6. Distribution of BP versus weight (top) and BP versus weight level (1-normal, 2, 3, 4-weight excess) (bottom).

Table 3. ANOVA results: F tests *p-value*. Design: Intercept + Gender + Age Group + Weight Index

Dependent Variable: AP_Profile

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	1734,037[a]	7	247,720	697,198	,000
Gender	5,159	1	5,159	14,521	,000
Ind_W	27,031	3	9,010	25,359	,000
Age_G	14,353	2	7,176	20,197	,000
Error	338,963	954	,355		
Total	2073,000	961			

a. R Squared = .836 (Adjusted R Squared = .835)

Table 4. ANOVA results: F tests *p-value*. Design: Intercept + Gender + Age Group + Weight Index + interactions

Tests of Between-Subjects Effects

Dependent Variable: AP_Profile

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	1748,583[a]	20	87,429	253,596	,000
Gender	,876	1	,876	2,542	,111
Ind_W	15,680	3	5,227	15,161	,000
Age_G	12,825	2	6,412	18,600	,000
Gender * Ind_W	1,755	3	,585	1,697	,166
Gender * Age_G	1,899	2	,950	2,754	,064
Ind_W * Age_G	4,765	4	1,191	3,455	,008
Gender * Ind_W * Age_G	1,738	4	,435	1,260	,284
Error	324,417	941	,345		
Total	2073,000	961			

a. R Squared = ,844 (Adjusted R Squared = ,840)

weight index and age group are statistically significant, also their interaction must be considered.

The pairwise comparison using the estimated marginal means, were studied in both models. This study concludes that, for a boy, BP has a mean greater than for a girl. An young individual with weight excess (not including level 4) has a BP mean greater than an young individual with normal weight. Identical

conclusions are obtained by the model with interaction between factors. When we consider the model with interaction, the same is verified, for a boy the BP mean is greater than for a girl, when both have similar age. Also, for a boy the BP mean is greater than for a girl, when both have similar weight index. For the same gender, a boy hasWe can conclude that, considering the same weight index, older students have BP mean greater than younger students, for the same gender, an individual with weight excess as the BP mean is greater than for an individual with normal weight.

4 Results and Final Remarks

While the data collection at national level is not complete, we analyse statistically a subset of that collection: the Lisboa and Vale do Tejo region. It is performed a descriptive analysis and applied an analysis of variance. Relationships between individual characteristic variables and blood pressure are evaluated.

Some important issues about pediatric hypertension were obtained, e.g. gender age and weight are related with pediatric high blood pressure, reinforcing the importance and need of a caregiver's knowledge improvement and prevention measures implementation about pediatric high blood pressure.

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