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FACULDADE DE ODONTOLOGIA DE PIRACICABA

CRISTHIANE MARTINS SCHMIDT

SEXO E ANCESTRALIDADE EM BRASILEIROS: ESTUDO DE MEDIDAS DO CRÂNIOS, MANDÍBULAS E ATLAS.

SEX AND ANCESTRY IN BRAZILIANS: STUDY OF SKULLS, JAWS AND ATLAS MEASUREMENTS.

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Tese apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para obtenção do título de Doutora em Biologia Buco-Dental, área de Anatomia.

Thesis presented to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requeriments for the degree of Doctor in Dental Biology, in Anatomy area.

Orientador: Prof. Dr. Luiz Francesquini Júnior

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A Comissão Julgadora dos trabalhos de Defesa de Tese de Doutorado, em sessão pública realizada em 08 de Fevereiro de 2019, considerou a candidata CRISTHIANE MARTINS SCHMIDT aprovada.

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Oração ao Cadáver Desconhecido

"Ao curvar-te com a lâmina rija de teu bisturi sobre o cadáver desconhecido, lembra-te que este corpo nasceu do amor de duas almas; cresceu embalado pela fé e esperança daquela que em seu seio o agasalhou, sorriu e sonhou os mesmos sonhos das crianças e dos jovens; por certo amou e foi amado e sentiu saudades dos outros que partiram, acalentou um amanhã feliz e agora jaz na fria lousa, sem que por ele tivesse derramado uma lágrima sequer, sem que tivesse uma só prece. Seu nome só Deus o sabe; mas o destino inexorável deu-lhe o poder e a grandeza de servir a humanidade que por ele passou indiferente."

Karl Rokitansky (1876)

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“Feliz aquele que transfere o que sabe e aprende o que ensina”

Cora Coralina

RESUMO

O presente trabalho teve como objetivos: Avaliar medidas do ossos do crânio, mandíbula e atlas, com a finalidade de estimar o sexo e ancestralidade em uma amostra brasileira, do Biobanco Osteológico e Tomográfico Professor Dr. Eduardo Daruge FOP/UNICAMP. Metodologia: A amostra estudada baseou-se na análise de 259 crânios, mandíbulas e atlas de ossos humanos, sendo 146 do sexo masculino e 113 do sexo feminino. Com relação à ancestralidade, foram estudados 152 crânios, mandíbulas e atlas de ossos humanos de indivíduos brancos e 104 não brancos, sendo 3 não especificados, com ausência de anomalias morfológicas, traumatismos extensos, intervenções cirúrgicas ou quaisquer outras alterações que pudessem prejudicar a realização das medidas. Após a calibração inter e intra examinadores, foram realizadas as seguintes medidas: ZgMZgM, FMCOMP, FMLA, NaBa, BrENP, IMIM, BaSZyD, BaSZyE, IMZgmD, IMZgmE, GoGo, GnGoD, GnGoE, CRDTrans, CRDPost. Resultados: As amostras foram submetidas ao teste de Kolmogorov Sminorv, onde constatou-se a normalidade para as medidas NaBa, BrENP, IMIM, BaSZyD, BaSZyE, IMZgmD, IMZgmE, GoGO, CRDPost com valor de $p>0,05$, aceitando-se a hipótese de nulidade. Ao aplicar o teste t foi constatada que há diferenças entre os sexos nas medidas avaliadas ($p<0,05$). Foram testadas 15 variáveis do estudo, aplicando-se a regressão logística pelo método Stepwise-Forward. Também foi realizada a análise de correlação de Pearson, onde observou-se que as variáveis do modelo, mostraram-se altamente significativas para o dimorfismo sexual, obtendo a fórmula: **Logito = 35.948 + (-0.071xNaBa) + (-0.163xGoGo) + (-4.91xCRDPost).** Em relação à ancestralidade e após a análise das 15 medidas testadas, apenas as medidas Na-Ba, Go-Go e CRDPost, mostraram-se altamente significativas, sendo possível chegar a seguinte fórmula: **Logito = -2.678 + 0.80xZgMZgM + (-0.178xCRDTrans).** Conclusões: Diante dos resultados do presente estudo foi possível criar um modelo de regressão logística para determinar o sexo, resultando em 84,9% de sensibilidade, 69% de especificidade e 78,5% de acurácia, já em relação a ancestralidade, resultou-se em 83,5% de sensibilidade, 32% de especificidade e 62,9% de acurácia, sendo que ambos resultados mostraram-se mais eficazes na predição do sexo e ancestralidade, do que o mero acerto ao acaso.

Palavras chave: Características sexuais; Antropologia forense; Ancestralidade, Craniometria, Regressão Logística.

ABSTRACT

The present study hd as objectives: To evaluate measures of skull, jaw and atlas bones, with the purpose of estimating sex and ancestry in a Brazilian sample of the Osteological and Tomographic Biobanks Professor Dr. Eduardo Daruge FOP / UNICAMP. Methodology: The sample studied was based on the analysis of 259 skulls, jaws and atlases of human bones, 146 males and 113 females. The relation to the ancestrality, were studied 152, the deficiency and atlas human bones of white individuals and the not white, being 3 could be specified, with absence of morphological anomalies, extensive trauma, surgical interventions or any other alterations that could prejudice the realization of the measures. After inter- and intra-examiner calibration, the following measurements were performed: ZgMZgM, FMCOMP, FMLA, NaBa, BrENP, IMIM, BaSZyD, BaSZyE, IMZgmD, IMZgmE, GoGo, GnGoD, GnGoE, CRDTrans, CRDPost. Results: Samples were submitted to the Kolmogorov Sminorv test, where normality was measured for NaBa, BrENP, IMIM, BaSZyD, BaSZyE, IMZgmD, IMZgmE, GoGO, CRDPost with p value of 0.05, accepting the null hypothesis. When applying the t-test, it was found that there were differences between the sexes in the measures evaluated ($p < 0.05$). Fifteen variables of the study were tested, applying the logistic regression using the Stepwise-Forward method. Results: We also performed the Pearson correlation analysis, where it was observed that the model variables were highly significant for sexual dimorphism, obtaining the formula: **Logite = 35.948 + (-0.071xNaBa) + (-0.163xGoGo) + (-4.91xCRDPost).** In relation to the ancestry and after the analysis of the 15 measures tested, only the Na-Ba, Go-Go and CRDPost measurements were highly significant, and it is possible to arrive at the following formula:: **Logite = -2.678 + 0.80xZgMZgM + (-0.178xCRDTrans).** Conclusions: In view of the results of the present study, it was possible to create a logistic regression model to determine gender, resulting in 84.9% sensitivity, 69% specificity and 78.5% accuracy, already in relation to ancestry, were found to be 83.5% sensitive, 32% specificity and 62.9% accurate, both of which were more effective in predicting sex and ancestry, than the mere chance adjustment.

Keywords: Sexual characteristics; Forensic anthropology; Ancestry, Craniometry, Logistic Regression.

SUMÁRIO

1. INTRODUÇÃO

A Antropologia Física é a área que fornece às Ciências Forenses subsídios para auxiliar no processo de identificação humana. Em um território de dimensões continentais como o Brasil, é inviável, na atual conjuntura financeira, a criação de um banco de dados genéticos de toda a população. Além disso, o país não possui um registro de identidade único e nacional para seus habitantes, sendo estes ainda individualizados por meio de uma carteira de identidade padrão para cada estado da nação.

Com o aumento da violência, estudos em Antropologia tornam-se imprescindíveis, uma vez que, constantemente, são encontradas ossadas ou fragmentos destas, onde o perito deve apontar, por meio de características morfológicas e morfométricas, o sexo, a ancestralidade, além de estimar a idade e a estatura.

Antes de 2009, a Organização Internacional de Polícia Criminal (Interpol) indicava como metodologias primárias de identificação humana a Dactiloscopia e o ácido desoxirribonucleico (D.N.A.). Com o evento do tsunami ocorrido em 2004 na Tailândia, onde a grande parte dos mortos foi identificada por meio dos caracteres sinaléticos dentários, a Interpol reviu seus protocolos e adicionou, em 2009, o processo de identificação por meio das singularidades dentárias como método primário. Por fim, no ano de 2014, tal organização incluiu a numeração identificatória das placas protéticas como sendo a quarta técnica primária de individualização humana.

Porém, nem sempre o perito tem a possibilidade de utilizar os métodos primários de identificação, seja por deficiência na quantidade e/ou na qualidade do material a ser examinado. Nesses momentos, faz-se necessário o uso de métodos secundários, auxiliando no processo de identificação, sendo realizados no referente estudo, medidas linerares do ossos do crânio, mandíbula e atlas. Pesquisas demonstram que há uma diferenciação sexual entre homens e mulheres, sendo que o estudo da estimativa do sexo e ancestralidade é de grande importância para o auxílio da identificação em um ossada.

Segundo Franklin et al, 2008, ao utilizar medidas de mandíbulas para a estimativa do sexo em negros africanos (comprimentos de ramo e corpo mandibular), as mesmas demonstraram serem dimórficas, assim como vários outros estudos, demonstraram que medidas mandibulares são maiores no sexo masculino (Gamba, T.O.; Alves, A.C.; Haiter, F.N., 2016).

O crânio é considerado o segmento do corpo mais encontrado em cenas de local de crime, sendo de grande importância para o estudo da estimativa do sexo e ancestralidade, auxiliando nos métodos de identificação humana.

Sendo o Brasil, um país de grande extensão geográfica e com enorme miscigenação populacional, há a necessidade em desenvolver estudos com amostras nacionais para utilização nos IMLs, auxiliando nos estudos de Antropologia Forense.

Sendo assim, o presente estudo teve como objetivo avaliar medidas do ossos do crânio, mandíbula e atlas, para estimar o sexo e ancestralidade em uma amostra brasileira, do Biobanco Osteológico e Tomográfico Professor Dr. Eduardo Daruge FOP/UNICAMP.

2. ARTIGO: "SEX AND ANCESTRY IN BRAZILIANS: STUDY OF SKULL, JAW AND ATLAS MEASURES".

Artigo submetido ao periódico Journal of Applied Oral Science (anexo 1)

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Abstract:

Introduction: Sex and ancestry estimation facilitates the establishment process of the identity because it reduces the number of individuals to be evaluated. Objectives: Establish the sexual dimorphism and the ancestry through measurements of skulls, mandibles and atlas of skeletons in the osteological and tomographic biobank Prof. Eduardo Daruge at the Piracicaba Dental School of University of Campinas (FOP/UNICAMP). Material and methods: Observational, analytical and cross-sectional study conducted from linear measures obtained with a digital caliper. A total of 259 skulls, mandibles and atlas were assessed:146 were male and 113 female; 152 individuals had European ancestries and 107 individuals had non-European ancestries (African ancestry and other mixed-race Brazilians). The measures were analyzed by the Kolmogorov-Smirnov test to establish the distribution and equality of variances (homoscedasticity) of the variables under study. Unpaired t-test and Pearson correlation coefficient were conducted. A logistic regression was obtained by Stepwise-Forward method for sex and ancestry. This study fulfilled the requirements of resolution 466/12 through the approval of CEP 138/2014 and CAAE 38522714.6.0000.5418. Results: All measures are dimorphic and a mathematical model could be established with the data obtained: Sex Schmidt = [−23.7 + (0.18 × anteroposterior of vertebra) – (0.08 × cross-sectional diameter of rachidian canal) + (0.25 × maximum cross-sectional diameter]; resulting in 84.9% sensitivity, 69% specificity and 78.5% accuracy, proving to be effective in sex prediction. We also obtained the Logito Schmidt Ancestry = [−2.678 + 0.80 × ZgMZgM + (−0.178 × RDCCross] that allows the estimation of european and non-european skeletons, with 83.5% sensitivity, 32% specificity and 62.9% accuracy, proving to be effective in ancestry estimation. Conclusion: Conclude that the sex can be estimated by the Schmidt model with 78.5% precision and the ancestry with 62.9% precision.

Keywords: Forensic Anthropology. Ancestry. Sexual characteristics.

INTRODUCTION:

In Brazil, the study of Forensic Medicine is relatively recent. It is known that in Colonial Brazil there was the figure of the Major Surgeon, who had insufficient content of the Forensic Medicine developed in Europe in the 16th century. This study flourished in Brazil in the following centuries with the studies of Nina Rodrigues in Bahia, Afrânio Peixoto in Rio de Janeiro, among others. Almost all Forensic Medical Institutes (IML – *Instituto Médico Legal*) in the major Brazilian capitals, as Bahia and Rio de Janeiro, were named after these researchers. There after, several literary works were developed in this area[1] .

As for the Dentistry, it became a practice of Dental Surgeons in 1631; however, the teaching of Forensic Dentistry started only in 1931 through Art. 218 of Decree No. 19852/31[2] , having as first professor of the area the Henrique Tanner de Abreu, who published the book "*Medicina Legal Applicada á Arte Dentária (*Forensic Medicine Applied to Dental Art*)*" of 1929[3]. From this date onwards, numerous works on the theme have been elaborated. These intellectuals addressed the complete study of Forensic Dentistry and dental office management [3,4,5,6.] Vanrell[7] (2009) presented the study of theoretical and practical Forensic Dentistry. In this way, the knowledge developed in Brazil and accumulated over the area, is still quite restricted, with a lot to be expanded.

Nowadays, the Forensic Odontologist within an environment of official investigation [Forensic Medicine and Dentistry Institute (IMOL – *Instituto de Medicina e Odontologia Legal*) and/or Investigation Institute] can develop numerous activities, such as DNA analysis and forensic physical anthropology, among others. In addition, the professional can conduct corpus delicti

exams and participate in the thanatological process when practicing oral autopsy and identifications by dental signal characters, rugoscopy, cheiloscopy, smile line, among others[3]

The practice of Forensic Physical Anthropology by Forensic Odontologists in the IMLs is already a reality in several units in Brazil and has been gaining greater course load in the graduate education (*sensu strictu* and *sensu latu*)[3]

As well as other forensic activities in the last century, tables and mathematical models obtained from European and/or American population samples were used. With the same speed with which the activity was being developed in the IMLs at the Piracicaba Dental School of University of Campinas (FOP/UNICAMP), several logistic regression models were also developed. The existing models were validated through national sample using skeletons in the osteological and tomographic biobank Prof. Dr. Eduardo Daruge of FOP/UNICAMP.

The anthropological study allows to estimate the sex, the age, the ancestry and the stature, which facilitate the process of search for identity of the unidentified skeleton.

It is known that in practically all human bones the sex can be estimated and, according there is an ≥8% proportion of difference between male and female sexes[3,8].

In the qualitative aspect, several authors have stated this difference, emphasizing that the female sex is, in its essence, smaller and slimmer and that the various bony projections are less pronounced[3,9]

In the quantitative aspect, the sex can be estimated by the study of the fourth rib Çologlu[10] et al (1998), estimated the sex in study of the femur, tibia, fibula, umerus, radius, ulna, clavicle, Baker[11] et al (1957), ulna, Purkait[12] (2000), calcaneus[13], metatarsal, proximal phalanges and first distal phalanx, Smith[14] (1997) and skulls[15,16]. In our study, we sought to establish the sexual dimorphism and ancestry through the measurement of skulls, mandibles and atlas of the skeletons in the biobank of FOP/UNICAMP.

MATERIALS AND METHODS:

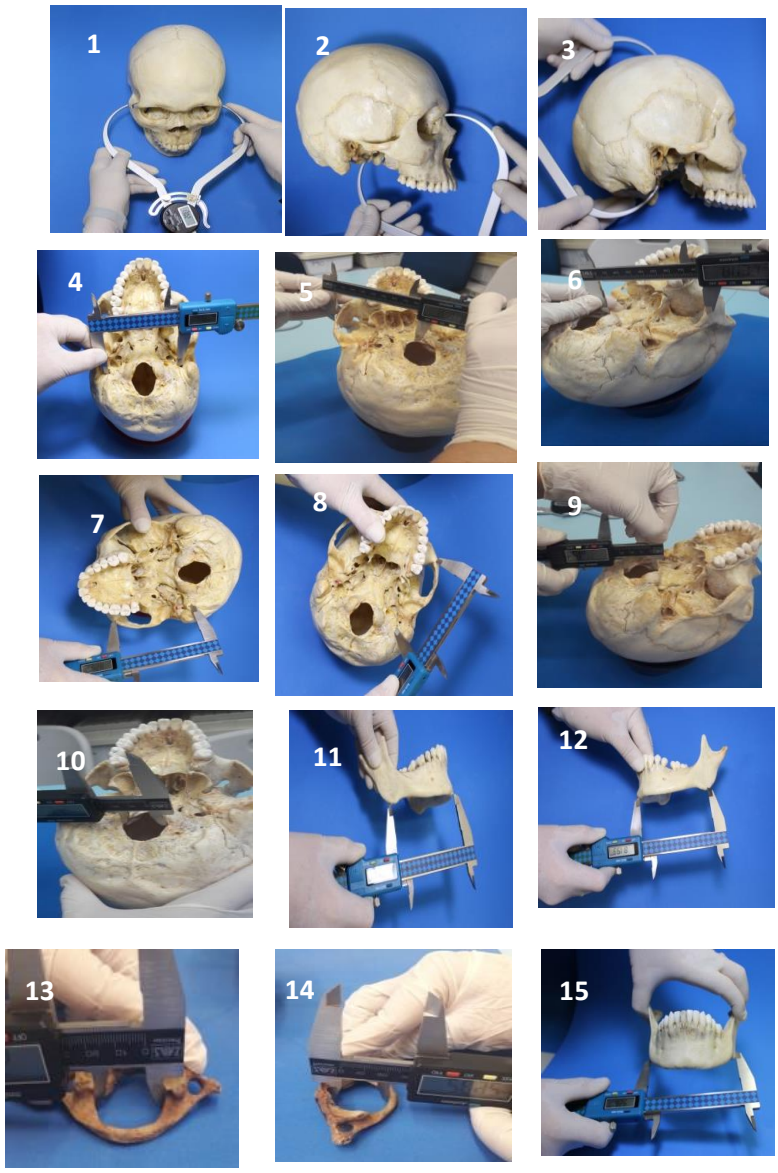
This research was idealized and complies with the determinations of resolution 466/12 through approval of CEP 138/2014 and CAAE 38522714.6.0000.5418. The aim was to evaluate numerous linear measures of skulls, mandibles and atlas of skeletons in the osteological and tomographic biobank Prof. Eduardo Daruge of FOP/UNICAMP, considering the sexual dimorphism and ancestry. It also aimed at building logistic regression models to estimate sex and ancestry.

All measures were taken with a digital caliper of the brand Stainless-harned® 150 mm, Mauá, São Paulo, Brazil.

Inter- and intra-examiner tests were conducted to verify the researcher's calibration. For that, 25 skulls, mandibles and atlas of 25 skeletons properly identified by gender, ancestry and age were measured in triplicate and at different times to obtain and compare the error margin percentage.

After descriptive analysis, it was found that, according to Szklo and Nieto[17] (2000), there was excellent agreement (ICC≥0.75) both in the inter-examiner analyses as in the intra-examiner analyses for the abovementioned measures. Once calibrated with standard of excellence, the remaining measures were finalized, totaling 259 skeletons. For data analysis, the program IBM® SPSS® 25 Statistics was used. The sample consisted of 259 skulls, mandibles and atlas of human beings. From these, 146 were male and 113 female; with regard to ancestry, 152 were europeans and 107, no-europeans.

The data of the measurements were analyzed using the test of Kolmogorov Sminorv to verify respectively the distribution and equality of variances. (homoscedasticity) of the variables under study, respectively. Unpaired t-test and Pearson correlation coefficient were conducted. A logistic regression was obtained by the Stepwise-Forward method.



The linear measures are: [Zygomatic bone to zygomatic bone (Figure 1), nasion to basion (Figure 2), bregma to posterior nasal spine (Figure 3), mastoid notch to mastoid notch (Figure 4), basion to zygion [right side (Figure 5) and left side (Figure 6)], mastoid notch to zygomatic suture [right side (Figure 7) and left side (Figure 8)], foramen magnum [length (Figure 9) and width (Figure 10)]; gnathion to gonion [right side (Figure 11) and left sider and 12)]; atlas in rachidian canal [cross-sectional tranverse diameter (Figure 13) and anteroposterior diameter (Figure 14)], gonion to gonion (Figure 15).

RESULTS:

The program IBM® SPSS® 25 Statistics was used for data analysis.

The sample consisted of 259 human skulls, mandibles and atlas. From these, 146 were male and 113, female, as shown in Table 1. With regard to ancestry, 152 were Europeans and 104 no-Europeans, with 3 unspecified, as shown in Table 2.

Table 1: Sample distribution for sex

	Frequency	%
Male	146	56.4
Female	113	43.6
Total	259	100.0

Table 2: Sample distribution for ancestry

	Frequency	%
European	152	58.7
No-European	104	40.2
Total	256	98.8
Not classified	3	1.2
Total	259	100.0

After verifying the general characteristics of the sample, data were submitted to the Kolmogorov-Smirnov test to establish normality of data, Table 3.

Table 3. Normality test by Kolmogorov-Smirnov test

		Normal parameters[a,b]		Most extreme differences				Asymp.
	N	Mean	Std. Deviation	Absolute	Positive	Negative	Test statistic	Sig. (2-tailed)
ZgMZgM	243	90.399	6.181	.052	.052	−.044	.052	.200[c,d]
FMLength	242	35.659	2.772	.033	.033	−.028	.033	.200[c,d]
FMWidth	243	30.726	2.581	.039	.039	−.032	.039	.200[c,d]
NaBa	226	97.658	6.893	.077	.065	−.077	*.077	.003[c]
BrPNS	217	138.706	9.438	.126	.126	−.110	*.126	.000[c]
MNMN	241	97.253	8.769	.128	.123	−.128	*.128	.000[c]
BaSZyR	239	72.144	6.445	.158	.093	−.158	*.158	.000[c]
BaSZyL	240	72.751	4.175	.040	.036	−.040	.040	.200[c,d]
MNZgMR	240	71.805	8.760	.151	.080	−.151	*.151	.000[c]
MNZgML	241	72.360	5.944	.076	.076	−.049	*.076	.002[c]
GoGo	173	91.780	6.891	.067	.067	−.031	*.067	.055[c]
GnGoR	173	78.721	6.389	.043	.043	−.028	.043	.200[c,d]
GnGoL	173	78.695	5.878	.040	.040	−.031	.040	.200[c,d]
RDCCross	167	28.173	2.515	.053	.053	−.036	.053	.200[c,d]
RDCAntero	160	30.106	3.497	.117	.102	−.117	*.117	.000[c]

a. Normal distribution

b. Calculated from data

c. Lilliefors Significance Correction

d. Lower bound of the true significance. (p>0.05*)

In analysis of Table 3, after application of normality test, the sample showed to be within the normality parameters for the measures NaBa, BrPNS, MNMN, BaSZyR, BaSZyL, MNZgMR, MNZgML, GoGo, RDCPost, with p>0.05 and acceptance of null hypothesis.

Then, the descriptive analysis was conducted through measures of central tendency, as mean and dispersion measures, as standard deviation for all measures, specified by sex, shown in Table 4.

Table 4: Descriptive statistics for sex

	Sex	N	Mean	Std. Deviation	Std. Error of the mean
ZgMZgM	Male	137	92.16	6.01	.51
	Female	106	88.12	5.64	.54
FMLength	Male	136	36.28	2.79	.23
	Female	106	34.86	2.53	.24
FMWidth	Male	137	31.32	2.49	.21
	Female	106	29.95	2.49	.24
NaBa	Male	123	99.80	6.11	.55
	Female	103	95.09	6.92	.68
BrPNS	Male	118	140.86	11.08	1.02
	Female	99	136.13	6.12	.61
MNMN	Male	134	99.17	6.27	.54
	Female	107	94.85	10.68	1.03
BaSZyR	Male	132	74.00	3.86	.33
	Female	107	69.84	8.06	.78
BaSZyL	Male	133	74.15	3.58	.31
	Female	107	71.00	4.21	.40
MNZgMR	Male	133	73.36	5.82	.50
	Female	107	69.86	11.13	1.07
MNZgML	Male	134	73.42	5.76	.49
	Female	107	71.02	5.91	.57
GoGo	Male	104	94.69	6.67	.65
	Female	69	87.38	4.47	.53
GnGoR	Male	104	80.03	6.66	.65
	Female	69	76.73	5.42	.65
GnGoL	Male	104	79.95	5.74	.56
	Female	69	76.794	5.59	.67
RDCCross	Male	102	28.57	2.28	.22
	Female	65	27.54	2.73	.33
RDCPost	Male	98	31.190	2.59	.26
	Female	62	28.39	4.03	.51

Table 5: Mean and standard deviation for ancestry

	Ancestry	n	Mean	Std. Deviation	Std. Error of the mean
ZgMZgM	European	144	89.31	6.36	.53
	No-European	97	91.87	5.56	.56
FMLength	European	144	35.70	2.76	.23
	No-European	95	35.61	2.81	.28
FMWidth	European	144	30.90	2.43	.20
	No-European	96	30.46	2.79	.28
NaBa	European	130	98.12	6.46	.56
	No-European	93	96.84	7.46	.77
BrPNS	European	127	138.53	8.05	.71
	No-European	87	138.96	11.33	1.21
MNMN	European	142	96.87	10.39	.871
	No-European	97	97.55	5.47	.55
BaSZyR	European	141	71.98	7.37	.62
	No-European	96	72.25	4.82	.49
BaSZyL	European	142	72.93	3.96	.332
	No-European	96	72.42	4.47	.45
MNZgMR	European	141	71.01	10.56	.88
	No-European	97	72.86	5.08	.51
MNZgML	European	142	71.82	6.41	.53
	No-European	97	73.06	5.15	.52
GoGo	European	101	91.83	7.20	.71
	No-European	70	91.48	6.30	.75
GnGoR	European	101	77.91	6.68	.66
	No-European	70	79.86	5.77	.68
GnGoL	European	101	77.93	5.96	.59
	No-European	70	79.70	5.65	.67
RDCCross	European	98	28.31	2.47	.24
	No-European	67	27.97	2.61	.31
RDCAntero	European	95	29.97	3.81	.39
	No-European	63	30.31	3.02	.38

Table 6. Independent samples t-test for sex

	Levene's test for equality of variances		T-test for equality of means						
								95% Confidence interval of the difference	
	F	Sig.	t	df	Sig. 2-tailed	Mean difference	Std. Error difference	Lower	Upper
ZgMZgM	1.099	.295	5.335	241	.000	4.04	.75	2.55	5.53
FMLength	.961	.328	4.083	240	.000	1.42	.34	.73	2.10
FMWidth	.007	.936	4.265	241	.000	1.37	.32	.74	2.01
NaBa	.006	.937	5.427	224	.000	4.70	.86	2.99	6.41
BrPNS	.727	.395	3.795	215	.000	4.73	1.24	2.27	7.19
MNMN	.456	.500	3.907	239	.000	4.31	1.10	2.13	6.49
BaSZyR	.311	.578	5.233	237	.000	4.16	.79	2.59	5.73
BaSZyL	.198	.657	6.261	238	.000	3.15	.50	2.16	4.14
MNZgMR	.667	.415	3.127	238	.002	3.49	1.11	1.29	5.69
MNZgML	1.800	.181	3.178	239	.002	2.40	.75	.914	3.89
GoGo	9.268	.003	7.990	171	.000	7.31	.91	5.50	9.12
GnGoR	2.420	.122	3.430	171	.001	3.30	.96	1.40	5.20
GnGoL	.065	.799	3.583	171	.000	3.16	.88	1.42	4.90
RDCCross	.722	.397	2.615	165	.010	1.02	.39	.25	1.80
RDCAntero	.005	.943	5.337	158	.000	2.79	.52	1.76	3.83

After t-test application, the hypothesis that there are differences between sexes in the measures evaluated was accepted due to a p-value<0.05.

Table 7. Independent samples t-test for ancestry.

	Levene's test for equality of variances		T-test for equality of means						
								95% Confidence interval of the difference	
	F	Sig.	t	df	Sig. tailed	2-Mean difference	Std. Error difference	Lower	Upper
ZgMZgM	2,001	,159	-3,218	239	,001	-2,55	,79	-4,12	-,99
FMLength	,000	,997	,248	237	,805*	,09	,36	-,63	,81
FMWidth	,239	,626	1,306	238	,193*	,44	,34	-,22	1,11
NaBa	,119	,730	1,359	221	,176*	1,27	,93	-,57	3,12
BrPNS	1,259	,263	-,326	212	,745*	-,43	1,32	-3,04	2,17
MNMN	1,667	,198	-,587	237	,558*	-,67	1,15	-2,94	1,59
BaSZyR	,463	,497	-,316	235	,752*	-,27	,85	-1,95	1,41
BaSZyL	,001	,979	,917	236	,360*	,50	,55	-,58	1,59
MNZgMR	4,338	,038	-1,601	236	,111*	-1,85	1,15	-4,12	,42
MNZgML	1,146	,286	,327	169	,744*	,34	1,06	-1,75	2,45
GoGo	1,210	,273	-1,983	169	,049	-1,95	,98	-3,89	-,00
GnGoR	,565	,453	-1,953	169	,052	-1,77	,90	-3,56	,01
GnGoL	,002	,964	,859	163	,392*	,34	,40	-,44	1,13
RDCCross	,001	,981	-,583	156	,560*	-,33	,57	-1,46	,79
RDCAntero	2,001	,159	-3,218	239	,001	-2,55	,79	-4,12	-,99

Considering the ancestry, was verified that the measures ZgMZgM; GnGoR; GnGoL presented sexual dimorphism.

Logistic regression for sex estimation

The 15 study variables were tested by applying logistic regression through the Stepwise-Forward method, which starts from the most simple model to the most complex one. Thus, according to Table 8, one can observed that the variables NaBa, GoGo and RDCPost were defined for preparation of the best model.

Table 8. Analysis of Stepwise-Forward logistic regression for sex estimation

						95% CI for EXP(B)	
B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
NaBa	−.071	.033	4.695	1	.030	.932	.874	.993
GoGo	−.163	.039	17.536	1	.000	.850	.787	.917
RDCAntero	−.491	.128	14.674	1	.000	.612	.476	.787
Constant	35.948	6.451	31.052	1	.000			

Table 9. Pearson correlation coefficient between variables of the model

			NaBa	GoGo	RDCAntero
NaBa	Pearson coefficient	correlation	1	.267**	.143
	Sig. (2-tailed)			.001	.081
	N		226	159	150
GoGo	Pearson coefficient	correlation	.267**	1	.294**
	Sig. (2-tailed)		.001		.000
	N		159	173	160
RDCAntero	Pearson coefficient	correlation	.143	.294**	1
	Sig. (2-tailed)		.081	.000	
	N		150	160	160

** Correlation is significant at 0.01 level (2-tailed).

Sex Schmidt [Logito = 35.948 + (−0.071 × NaBa) + (−0.163 × GoGo) + (−4.91 × RDCAntero)]

Table 10. Frequency distribution and correct percentages for sex estimation

		Model prediction		
		Sex		
		Male	Female	Correct percentage
Sex	Male	73	13	84.9
	Female	18	40	69.0
Correct overall percentage				78.5

This table shows that the method results in 84.9% sensitivity, 69% specificity and 78.5% accuracy, proving to be more effective in sex estimation rather than a hit at random, i.e. values greater than 0.5 (cut-off) would be considered as “male” and lower as “female”.

Logistic regression for ancestry estimation

The 15 study variables were tested by applying logistic regression through the Stepwise-Forward method, which starts from the most simple model to the most complex one. Thus, according to Table 11, one can observe that the variables ZgMZgM and RDCTrans were defined for preparation of the best model.

Table 11. Analysis of Stepwise-Forward logistic regression for ancestry estimation

						95% CI for EXP(B)		
B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper	
ZgMZgM	.080	.031	6.507	1	.011	1.083	1.019	1.151
RDCCross	−.178	.082	4.653	1	.031	.837	.712	.984
Constant	−2.678	3.183	.708	1	.400	.069		

Schmidt Ancestry [Logito = −2.678 + 0.80 × ZgMZgM + (−0.178 × RDCCross].

Table 12. Pearson correlation coefficient between variables of the model

		ZgMZgM	RDCCross
ZgMZgM	Pearson correlation coefficient	1	.086
	Sig. (2-tailed)		.276
	N	243	161
RDCCross	Pearson correlation coefficient	.086	1
	Sig. (2-tailed)	.276	
	N	161	167

Table 13. Frequency distribution and correct percentages for ancestry estimation

		Model prediction		
		Ancestry		
		European	No-European	Correct percentage
Ancestry	European	71	14	83.5
	No-European	39	19	32.8
Correct overall percentage				62.9

This table shows that the method resulted in 83.5% sensitivity, 32,8% specificity and 62.9% accuracy, proving to be more effective in ancestry estimation rather than a hit at random, i.e. values greater than 0.5 (cut-off) would be considered as European and lower as no European.

DISCUSSION:

The methodological study to establish the identity of a heap of bones follows a series of steps ranging from analysis of animal species to anthropological, dental and DNA examinations[3]

The establishment of animal species brings no difficulties to the expert when the skeleton is from an adult and is practically complete. However, when the skeleton is from a fetus or a newborn, or if it is fragmented and in partial destruction, histological examinations (bones and teeth) and/or DNA analysis[9].

After this step, the sex is estimated (qualitative and quantitative methodology) and, whenever possible, the sex obtained by the skull is confirmed with the sex obtained by the pelvis[18]

Age estimation (teeth, sutures, vertebrae and weld of vertebrae and bone structures, among others) is the next step to be conducted, followed by the estimate of ancestry. In Brazil, after the first contact of natives, Europeans and Africans, it generated a great miscegenation in the population. In the 20th and 21st century, Asian immigrants (Japanese, Korean, Chinese and other immigrants) started to entry the country. Some characteristics of dental anthropometry and they can be used for the establishment of ancestry[19]

Some characteristics still remain of the original population (pyriform aperture, dental format and characteristics, among others). The angles of Cloquet, Rivert, Jacquard and Walker allow only the distinction between Europeans and no-Europeans[20] Other methods are being validated and soon will be made available to the public.

The stature is evaluated through long bones and is based on the human proportionality between upper and lower extremities and real stature. Vitruvius developed numerous mathematical models based on body segments that allowed to establish the stature[21]

Once the anthropometric analysis is finished, a reduced population is obtained to search for the identity establishment through dental and DNA examinations, with that, time and resources are saved; saves time, resources, providing greater accuracy to the process of human identification allowing still the their reproducibility in any global identification center [22]

In this study, we found that all measures are dimorphic. A mathematical model with 78.5% accuracy was established for sex estimation.

These results correspond to the research of Fasemore[23] et al (2018), which investigated the measures of the nutritive foramen of the tibia and fibula. They evaluated 206 tibias and 204 fibulas of South African Africans (SAA) and South African Europeans (SAW) in the Raymond A. Dart Collection of Modern Human Skeletons, at University of the Witwatersrand. The sex was correctly classified for the tibia, with accuracy ranging from 79 to 82% on AAG and from 84 to 88% on SAW. They also found an accuracy from 69 to 74% in SAA and from 70 to 77% in SAW for measures combined in fibula.

Krüger[24] et al. (2015) tested the reliability and precision of the method of Walker[25] (2008) to estimate the sex in 245 skulls of South Africans (blacks and Europeans) in Pretoria Bone Collection, University of Pretoria. They verified an 80% or more higher for combinations of

glabella, mastoid and mentum, and between 68% and 73% for mentum, mastoid, orbital, and neck margin using logistic equations.

However Gama[26] et al. (2014) achieved greater accuracy when measuring 190 axes in skeletons of the 21st Century Identified Skeletal Collection from the University of Coimbra. They created a logistic regression model and validated it in independent test sample, formed by 47 individuals from such collection and verified that the model estimated correctly the sex known in 86.7 to 89.7% of cases.

Navega[27] et al. (2015) performed the metric analysis (18 measures of width, length and height) of the bones in the tarsus of 300 skeletons in the Skeletal Collection of Coimbra. They established the logistic regression, classification trees and artificial neural networks. Also, the models (cross-validation of 10 times) were validated in an independent sample with 60 males and 60 females of such collection. Researchers obtained, along with the simple multivariate algorithm based on tree statistical method, measures of the calcaneus, talus, and first and third cuneiform cuboid resulting in 88.3% of correct sex estimate.

Lima[28] et al. (2016), studied the distance between the orbital zygomatic points (left and right) distance between the zygomatic orbital points, anterior nasal spine and the area of the triangle formed by these three points in 160 skulls from the Study and Research Center in Forensic Medicine and Forensic Anthropology of the Union of Education and Culture (UNIME) University. They obtained a 71.3% precision degree through the logistic regression method and the accuracy level of formulas was 67.33%.

Tambawala[29] et al. (2016) evaluated 266 CBCT examinations with 111 male patients and 115 female patients, in Western India. the data were submitted to descriptive analysis, given that the four parameters were not proven significant as sex estimation. It was noted that the study area was the best significant for sex (66.4%). the study of the foramen magnum region was not statistically significant for the estimation of sex.

In the present study, acuracy was verified for estimating ancestry with 62.9%.

McDowell[30] et al. (2012) evaluated 310 tomographies of africans, europeans and no europeans South Africans' skulls in Pretoria Bone Collection (University of Pretoria); in Raymond A. Dart Collection (University of the Witwatersrand); and in Kirsten Collection (Stellenbosch University). They verified that african women were between 38.2% and 51% and african men between 32.3% and 60.9% correctly classified for all methods.

Casado[31] (2017), studied 158 European and African skulls from the Maxwell Documented Collection of the University of New Mexico and Tennessee's Bass Collection, obtaining a sex estimate of 69.9% for males and 74.7% for females.

Studies aiming to create models of logistic regression for ancestry are scarce and generally present dubious results. In Brazil, such studies are even more scarce and generally divide the sample into europeans and no europeans, probably due to the fact that African characteristics are dominant and during the miscegenation process, it remains in the descendants.

All models validated shall be adjusted in a near future in software for use in Brazilian IMLs for generation of the benefits that are concomitantly associated (reduction of time and reliability).

CONCLUSION:

It was possible to verify that the measures studied are dimorphic and the logistic regression models obtained allow sex estimation with 78.5% precision and ancestry estimation with 62.9% precision.

After analyzing the results, it was concluded that only 2 linear measures were better for the estimation of sex and ancestry, but with reservations, since they should be used in conjunction with other measures to obtain a better result for the estimation of sex and ancestry.

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3. CONCLUSÃO

Concluiu-se que por meio do presente estudo, foi possível criar um modelo de regressão logística para determinar o sexo, resultando em 84,9% de sensibilidade, 69% de especificidade e 78,5% de acurácia; para a ancestralidade, resultou-se em 83,5% de sensibilidade, 32% de especificidade e 62,9% de acurácia, sendo que ambos resultados mostraram-se mais eficazes na predição do sexo e ancestralidade, do que o mero acerto ao acaso

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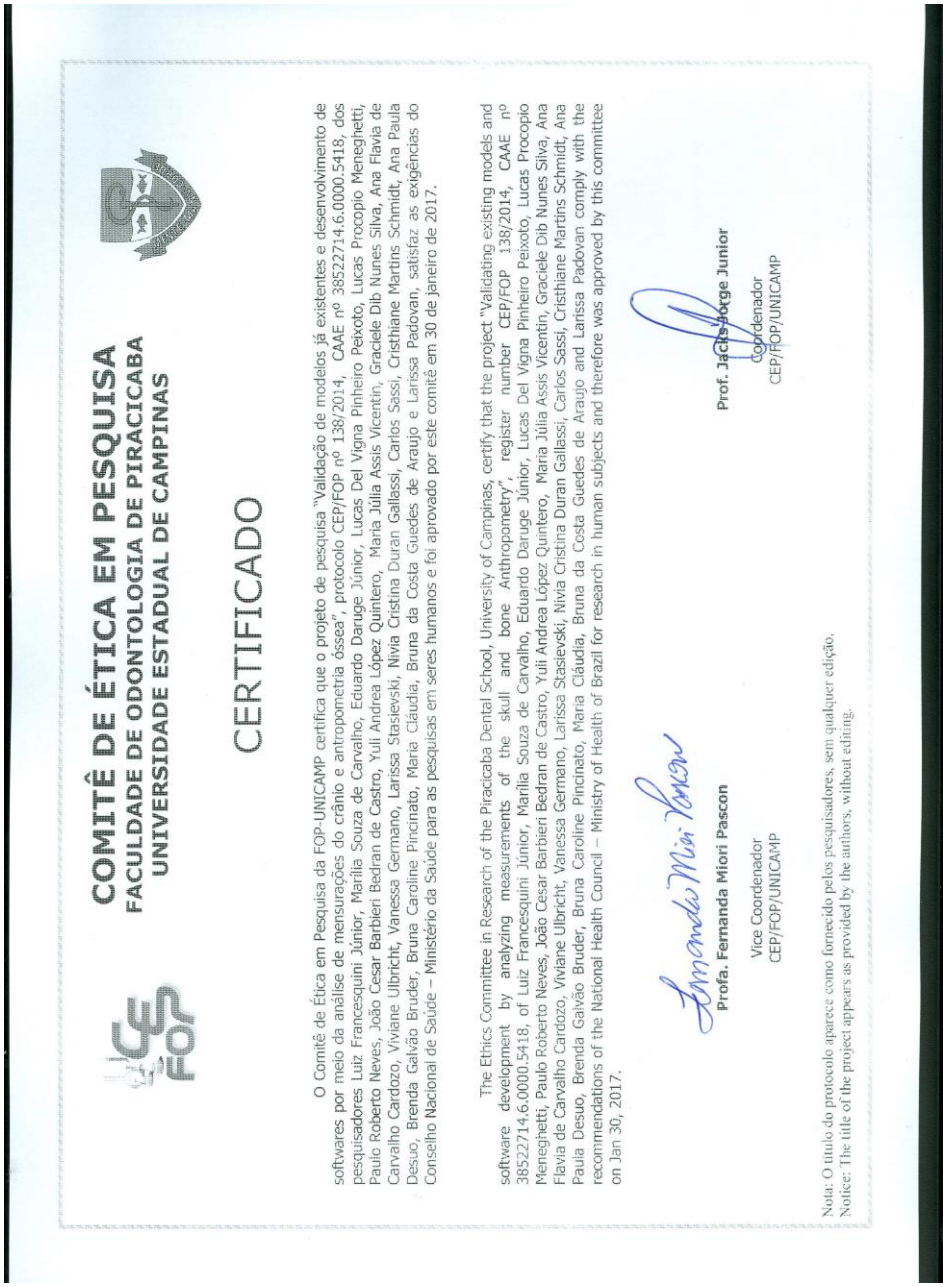
ANEXOS

Anexo 1

Parecer do Comitê de Ética em Pesquisa da FOP UNICAMP



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CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa "Validação de modelos já existentes e desenvolvimento de softwares por meio da análise de mensurações do crânio e antropometria óssea", protocolo CEP/FOP nº 138/2014, CAAE nº 38522714.6.0000.5418, dos pesquisadores Luiz Francesquini Júnior, Marilia Souza de Carvalho, Eduardo Daruge Júnior, Lucas Del Vigna Pinheiro Peixoto, Lucas Procopio Meneghetti, Paulo Roberto Neves, João Cesar Barbieri Bedran de Castro, Yuli Andrea López Quintero, Maria Júlia Assis Vicentin, Graciele Dib Nunes Silva, Ana Flavia de Carvalho Cardozo, Viviane Ulbricht, Vanessa Germano, Larissa Stasievski, Nivia Cristina Duran Gallassi, Carlos Sassi, Cristhiane Martins Schmidt, Ana Paula Desuo, Brenda Galvão Bruder, Bruna Caroline Pincinato, Maria Cláudia, Bruna da Costa Guedes de Araujo e Larissa Padovan, satisfaz as exigências do Conselho Nacional de Saúde – Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 30 de janeiro de 2017.

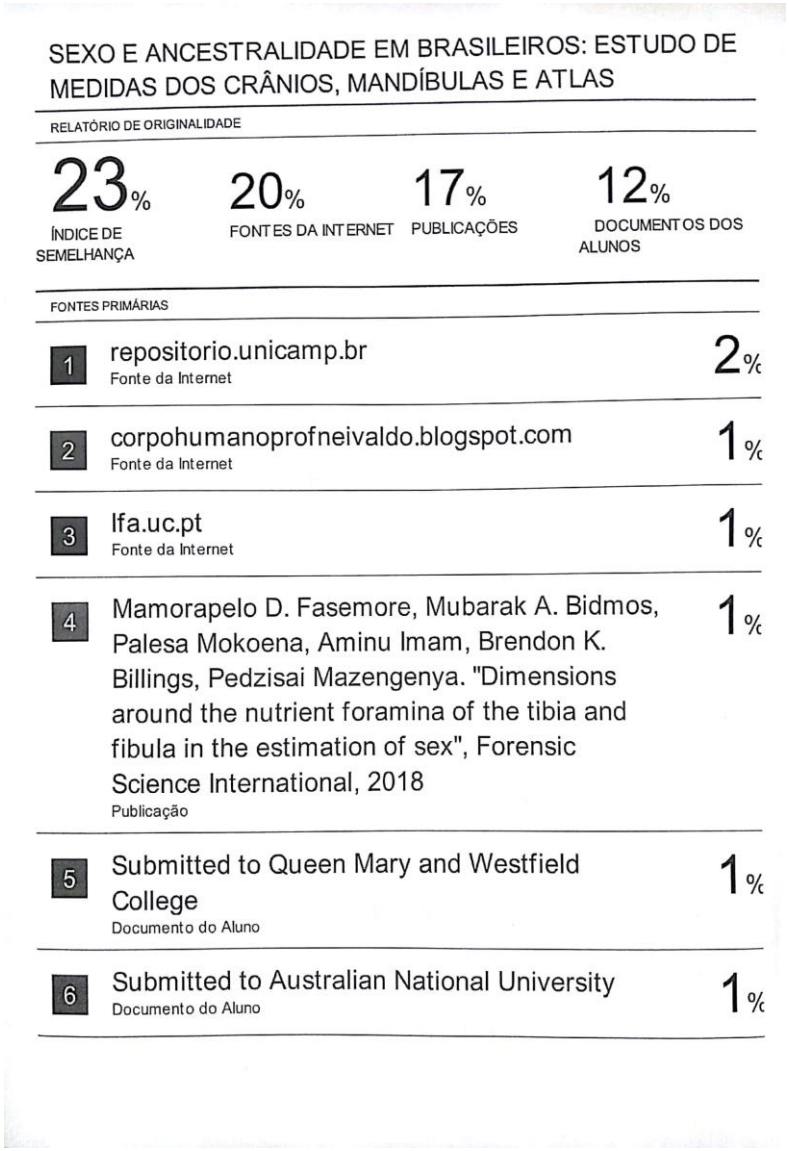
The Ethics Committee in Research of the Piracicaba Dental School, University of Campinas, certify that the project "Validating existing models and software development by analyzing measurements of the skull and bone Anthropometry", register number CEP/FOP 138/2014, CAAE nº 38522714.6.0000.5418, of Luiz Francesquini Júnior, Marilia Souza de Carvalho, Eduardo Daruge Júnior, Lucas Del Vigna Pinheiro Peixoto, Lucas Procopio Meneghetti, Paulo Roberto Neves, João Cesar Barbieri Bedran de Castro, Yuli Andrea López Quintero, Maria Júlia Assis Vicentin, Graciele Dib Nunes Silva, Ana Flavia de Carvalho Cardozo, Viviane Ulbricht, Vanessa Germano, Larissa Stasievski, Nivia Cristina Duran Gallassi, Carlos Sassi, Cristhiane Martins Schmidt, Ana Paula Desuo, Brenda Galvão Bruder, Bruna Caroline Pincinato, Maria Cláudia, Bruna da Costa Guedes de Araujo and Larissa Padovan comply with the recommendations of the National Health Council – Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee on Jan 30, 2017.

Profa. Fernanda Miori Pascon
Vice Coordenador
CEP/FOP/UNICAMP

Prof. Jacks Jorge Junior
Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo aparece como fornecido pelos pesquisadores, sem qualquer edição.
Notice: The title of the project appears as provided by the authors, without editing.

Anexo 2: Anti plágio



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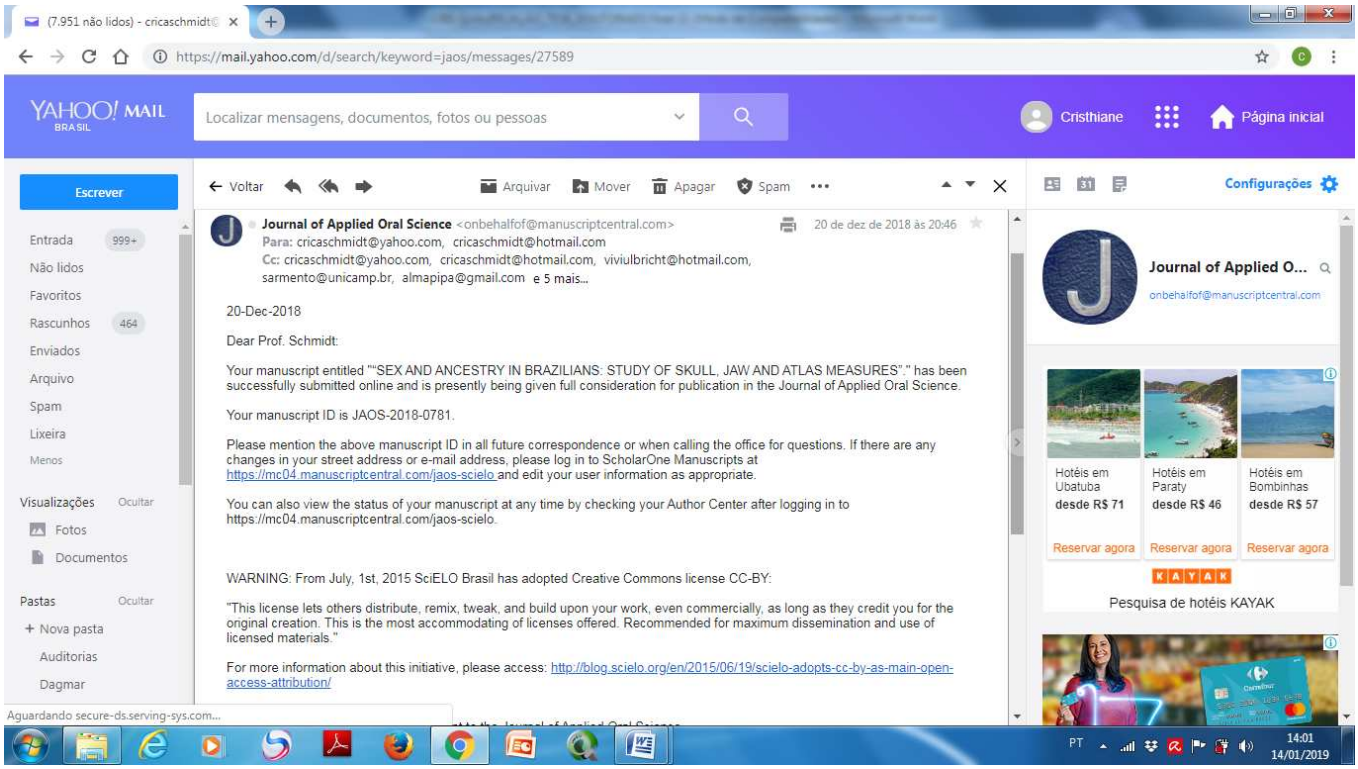

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