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To What Extent are Bone Age Readings Different between Paediatric Endocrinologists and Radiologists in Nigeria?

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Abstract **Background**: Accurate bone age reading for endocrine evaluation of children is important for accurate diagnosis and eventual treatment with hormones or other medications. Requests made to radiology have often overestimated the bone ages in our setting. **Objective**: To test inter rater reliability of bone age readings by paediatric endocrinologists and radiologists, and the validity between these readings and the BoneXpert® software. **Methods**: Twenty-seven raters (12 paediatric endocrinologists and 15 radiologists) were requested to score 4 images, using whatever methods were convenient for them. An interrater correlation coefficient (ICC) was used to assess the level of agreement between the two disciplines and paired sample t test was used to validate the scores between the raters and BoneXpert® software. **Results**: The interrater reliability for the raters were 0.984 (paediatric endocrinologists) and 0.986 (radiologists). When validated with BoneXpert® reading, 46.6% of radiologists had significantly higher bone age scores vs 16.6% of paediatric endocrinologists. Radiologists were less consulted and performed fewer bone age reading than paediatric endocrinologists. **Conclusion**: Interrater reliability of bone age reading between paediatric endocrinologists and radiologists in Nigeria were similar, however, more radiologists exaggerated the bone ages of the X radiographs presented to them. The frequency of bone age reading by the specialists positively influenced their proficiency when rated with the BoneXpert software.

Keywords: *bone age reading, paediatric endocrinologist, radiologist, interrater reliability, Nigeria*

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1. Introduction

Oftentimes paediatric endocrinologists make request for bone age assessment and interpretation for the diagnosis of various endocrine disorders, including but not limited to short stature, precocious puberty or delayed puberty and other genetic disorders. [1] This tool is also used in determining chronologic ages of adopted children or migrants. [1] In sports medicine, this tool is needed to determine the age of an athlete to prevent cheating and for forensic dating. [2,3] Traditionally, these bone age readings are done using various methods, including Tanner-Whitehouse (T&W), Guerlich and Pyle (G&P), magnetic resonance imaging, and more recently BoneXpert®. [4,5,6,7] The accuracy with which this bone age readings are done, determines diagnosis of several conditions, and whether treatment is needed or not. Noting that the treatments involve hormones, the diagnosis must be accurate.

Paediatric endocrinologists require the expertise of bone age reading and assessment to pass their board examinations just as radiologists, but few paediatric endocrinologists make requests or rely on the results retrieved from radiologists. [3] There are occasional wide variations between the results obtained from the radiologists and the paediatric endocrinologists as reported by Eital et al [3] and Kaplowitz et al [4], and they recommended independent reviews of bone ages when needed. It is for this and many other reasons that the application BoneXpert® [8] was developed some 15 years ago, which uses automated calculations of bone age according to the G&P and Tanner Whitehouse standards. The software provides standard deviations scores for each hand radiograph and compares patient with standards. The BoneXpert® softwares are very expensive and inaccessible to many patients in need of this service, so they are left with the bone age determination using X-radiographs.

Since bone age determination using hand X-radiograph and reading with either Tanner Whitehouse or Guerlich and Pyle are the most accessible methods for this region, the accuracy of the reading cannot be overemphasised. This means the exposure, contrast, brightness, and other factors of the X ray film will be perfect, so the reading is accurate to pick the ossifications of each bone that is to be scutinised. This is to reduce the inter and intra observer variability in the results assessed and give as much accuracy as possible. To reduce this intra and inter

observer variability in the bone age reading, training of radiologists and paediatric endocrinologists will be needed. For this to happen, objective measurements of any such variability are needed prompting this study, as no such measurement has been conducted in Nigeria or Africa before. Our hypothesis was that the bone age readings between radiologists and paediatric endocrinologists would be significantly different.

The objective of this study is to determine the extent to which radiologists and paediatric endocrinologists bone age readings are different, and to correlate the bone ages assessed using traditional methods with the BoneXpert® reading. We also sought to find the factors that may be responsible for these variabilities within and between the 2 specialists in Nigeria.

2. Methods

Randomly selected radiologists and paediatric endocrinologists from a pool of physicians in the West African College of Physicians and West African College of Surgeons were sent a google form with X-radiographs of four girls to read their bone ages. These consultants were selected from a Microsoft excel sheet that had their names and email contacts, using the formular =rand () and the first 20 from each college were asked to participate in the study. The form was open to receive responses for a period of 2 weeks after which, it was closed.

The X radiographs were done using Phillips, Villa sistemi medicali, model Stand geo SFD® (Milan Italy) X ray machine. Images were printed and pictures of the images were scanned and included in the Google form. The X ray images were those of females who presented to our hospital for minor injuries in the other extremities apart from the left hand and forearm. The girls had no chronic illnesses, skeletal malformations or dysplasia. The ages were determined using independent experts (HO, YY) and they independently declared ages, 5 – 5.5 years, 10-11 years, 8 – 8.5 years, and 12- 13 years.

The main instruction to raters was to read the bone ages as accurately as possible and to narrow the age range as best as possible. The images were also sent to Professor Lorenzo Iughetti in University of Moderna, Italy to use the software, BoneXpert®, an automated radiological tool to read all and standardise them for the analyses. It reconstructs the borders of 15 bones automatically and then computes individual bone ages for each of 13 bones (radius, ulna, and 11 short bones). Finally, it transforms the intrinsic bone ages into Guerlich Pyle (GP) or Tanner Whitehouse (TW) bone age. The raters were blinded to the actual chronologic ages of the patients and were only made to know the gender. Variables analysed included years of practice of the physicians, specialty, frequency each respondent is consulted to read bone age, reasons for these referrals, and method(s) by which bone age is read.

2.1. Statistical Analyses

The mean differences in bone ages between radiologists and paediatric endocrinologists were performed using 2 sample T tests. An inter-rater reliability was evaluated using interclass coefficient using Cohen kappa, and validity of the scores given by the raters was tested with the BoneXpert® report using paired sample t test. For all statistics, a p value <0.05 was considered significant.

3. Results

Twenty-seven consultants, made up of 12 paediatric endocrinologists and 15 radiologists completed the survey giving a response rate of 67.5%. The mean duration of practice for paediatric endocrinologists was 9.58 ± 3.2 years and for radiologist, 12.93 ± 6.63 years, but the difference was not significant, t = -1.722, p = 0.10. Seventeen (62.9%) used only Guerlich and Pyle, 6 (22.2%) used both Guerlich and Pyle and Tanner and Whitehouse methods, 2 (7.4%) used Bayley-Pinneau method and 2 (7.4%) used only Tanner and Whitehouse method.

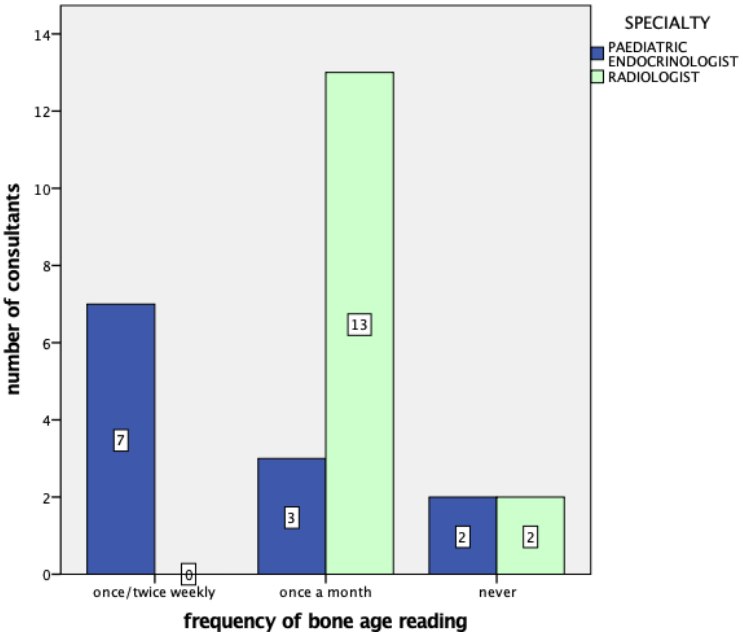

Figure 1. The frequency of bone age reading by raters, differentiating between paediatric endocrinologists and radiologists

Seven paediatric endocrinologists read bone ages at least twice a week, 13 radiologists had once a month bone age reading, and 4 raters had never been done bone age reading in their practice, Figure 1. The difference in the frequency of bone age reading by paediatric endocrinologists and radiologist was significant, $\chi^2 = 13.08$, $p = 0.001$.

Mean bone age readings of the X radiographs between paediatric endocrinologists and radiologists.

For each picture presented, there was no significant difference in mean age though the paediatric endocrinologists gave lower mean scores in the first 2 pictures see Table 1 below.

Table 1. The mean and SD of each bone age X radiograph compared between paediatric endocrinologists and radiologists.

	Paed Endo	Radiologists	T test	P value
Picture 1	5.77 ± 0.91	6.42 ± 1.79	-1.20	0.24
Picture 2	10.93 ± 1.78	10.99± 1.73	-0.209	0.837
Picture 3	8.19 ± 1.80	7.97 ± 1.77	0.318	0.753
Picture 4	12.15 ± 1.97	11.30 ± 1.64	1.216	0.235

3.1. Interrater Reliability

3.1.1. Paediatric Endocrinologists

The mean bone ages for all four pictures were rated within the paediatric endocrinologists and the intraclass correlation coefficient was 0.984 (95% CI: 0.968–0.994), and the level of agreement or internal consistency (Cronbach alpha) was 0.988. Checking reliability with the BoneXpert® report, it was excellent with 0.984 (95% CI: 0.978–0.996).

3.1.2. Radiologists

The mean bone ages for all four pictures were rated within the radiologists and the intraclass correlation coefficient was 0.986 (95% CI: 0.971–0.995), and the level of agreement or internal consistency (Cronbach alpha) was 0.988. Checking reliability with the BoneXpert® report, it was excellent with 0.985 (95% CI: 0.970–0.995).

3.1.3. Validity

The BoneXpert validity was very good in general as shown in Table 2. There were 2 paediatric endocrinologists that had significantly different mean readings from the BoneXpert® scores, as against 7 radiologists.

Table 2. The paired sample t test between each rater and the BoneXpert score for validity

Mean		SD	95% Confidence Interval		T test	Sig (2 tailed)
			Lower	Upper		
PE1	.06538	.74060	-.38216	.51293	.318	.756
PE2	1.21923	2.55787	-.32648	2.76494	1.719	.111
PE3	-.16538	.95227	-.74084	.41007	-.626	.543
PE4	.46923	1.31300	-.32421	1.26267	1.289	.222
PE5	.06538	.71045	-.36394	.49471	.332	.746
PE6	**1.75000**	**2.24388**	**.39404**	**3.10596**	**2.812**	**.016***
PE7	.41154	1.64027	-.57967	1.40274	.905	.383
PE8	1.21923	2.55787	-.32648	2.76494	1.719	.111
PE9	-.16538	.95227	-.74084	.41007	-.626	.543
PE10	.29615	1.36160	-.52665	1.11896	.784	.448
PE11	.00769	.76508	-.45464	.47003	.036	.972
PE12	**1.27692**	**1.70485**	**.24669**	**2.30715**	**2.701**	**.019***
RAD1	**2.25769**	**2.70145**	**.62522**	**3.89016**	**3.013**	**.011***
RAD2	**-1.31923**	**.59949**	**-1.68150**	**-.95696**	**-7.934**	**.000***
RAD3	**1.75769**	**1.34859**	**.94275**	**2.57264**	**4.699**	**.001***
RAD4	**2.33462**	**2.58170**	**.77451**	**3.89472**	**3.260**	**.007***
RAD5	-.08846	1.50515	-.99802	.82109	-.212	.836
RAD6	.14231	.94975	-.43162	.71623	.540	.599
RAD7	-.55000	2.09672	-1.81704	.71704	-.946	.363
RAD8	**1.75769**	**2.20178**	**.42717**	**3.08822**	**2.878**	**.014***
RAD9	**-1.24231**	**.56820**	**-1.58567**	**-.89895**	**-7.883**	**.000***
RAD10	**1.81538**	**1.31361**	**1.02158**	**2.60919**	**4.983**	**.000***
RAD11	.95000	1.98966	-.25234	2.15234	1.722	.111
RAD12	-.08846	1.50515	-.99802	.82109	-.212	.836
RAD13	-.20385	.82398	-.70177	.29408	-.892	.390
RAD14	.25769	2.10008	-1.01138	1.52676	.442	.666

The mean scores given by the raters were mostly similar to that generated by the BoneXpert except for 9 raters. PE = Paediatric endocrinologist, RAD = radiologist.

4. Discussion

This study showed acceptable and comparable reliability for the bone age scores within the paediatric endocrinologist and radiologists and between the two specialties, which was also seen in other studies. [3,9] The mean scores of the bone ages of the radiographs were similar between the two specialties and so reject our original null hypothesis. This is however different from anecdotal experiences where the bone age scores reported by radiologists have wide ranges. The instruction in this study that the scores should be within a narrow range may have caused the results we received. This result is similar to the study by Kaplowitz et al, [4] who alluded that in a controlled setting, the bone age report from radiologists is more accurate, especially as they are aware the X radiographs are a part of a research.

Using the BoneXpert® to validate the scores given by raters was considered because it reads bone ages accurately in 98% of the time. [6,8,10] It has also been used by many other researchers since its inception in 2009, and not many resource-limited hospitals can afford this. The result shows our original hypothesis was right in that almost 50% of the radiologists had mean differences that were significantly higher than the BoneXpert® scores. The 2 paediatric endocrinologists that had significant differences from the BoneXpert® scores were also higher, which means traditional methods have more tendency to read bone ages higher.

Following the results from this study, it will be cautious optimism for paediatric endocrinologist to rely completely on the bone age reading from radiologists, but it will be best to identify radiologists that are specialist in paediatric radiology and have expertise in bone age reading. [11] Since many hospitals in resource-limited cannot afford the BoneXpert® software, the traditional methods of GP or TW2 will continue to serve their purpose. The more frequently a doctor practices his skill, the more proficient he becomes. It is therefore understandable that paediatric endocrinologists who get consulted frequently for puberty disorders, short stature, disorders of sex differentiation will be more proficient than their radiology counterparts who wait for requests from paediatricians and endocrinologists for bone age reading or forensic investigations.

In conclusion, while there is interrater reliability in bone age reading between paediatric endocrinologists and radiologists in Nigeria, more radiologists exaggerated the bone ages of the X radiographs presented to them. The frequency of bone age reading by the specialists positively influenced their proficiency when rated with the BoneXpert® software. It may be more cost and time saving if paediatric endocrinologists were trained to be more proficient in bone age reading so the radiologists can concentrate on other aspects of their profession.

5. Limitations of the Study

This study is limited by the online method of data gathering, where raters' preferred methods could not be assessed real time. Like many other surveys, information may be biased and because this was a research, and raters were instructed to have a limited range, the scores given may not be in tandem with real situations. For future studies, researchers will need to be with the raters at the time of bone age reading and training instituted immediately.

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