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The Relationship of Body Heights, Gender and Anterior Teeth Dimensions in Malaysian Population

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ABSTRACT

Objective: To investigate the correlation between participants body heights and gender to the size particularly the widths and heights of anterior teeth of Malaysian population.

Materials and Methods: The study samples consisted of 363 participants, including 67 males and 296 females, aged between 20 and 40 years from the Malaysian population. Digital impressions were taken of all six anterior teeth, from the right canine to the left canine and were imported into 3D software to measure tooth widths and heights digitally. Body heights of participants were recorded. Data was analyzed to see the correlation of the body heights of the participants to the measurements of the teeth using Pearson correlation coefficients and descriptive analyses for the differences of the widths and heights of teeth according to gender.

Result: Pearson correlation analysis showed that several tooth measurements positively correlate with body height, indicating an increase in tooth length, particularly in right lateral incisor height, right canine height, left central incisor height, left lateral incisor height, and left canine height as height increases. On gender differences, males showed to have wider and taller teeth than females, with a notable similarity in right lateral incisor width.

Conclusion: This study concludes that tooth length increases with body height. Additionally, males exhibit larger tooth dimensions in both width and height across all six anterior teeth.

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1. INTRODUCTION

Studies have examined the relationship of particularly in predicting body size from tooth size in fossil primates for many decades (Garn et al., 1968; Gingerich, 1977; Jani et al., 2018; Wolpoff, 1985). The scientific study of the relationship between body parts and organ sizes is known as allometry (Garn et al., 1968; Gingerich et al., 1982; Ramirez-Rozzi & Romero, 2019; Turner & Richardson, 1989). Allometry is study on growth patterns or evolutionary changes in relation to the size of specific body parts or organs compared to the overall size of an organism. Some studies have documented these correlations, often comparing the size of teeth to various organs such as the chin, bones, and overall body height (Garn et al., 1968; Gingerich et al., 1982). It was also shown that correlation between tooth size and body weight, suggesting that tooth dimensions can serve as a reference for estimating body size or the size of other organs (Gingerich et al., 1982).

Since ancient times, the dimensions of teeth have been correlated with body height. Height is a key quantitative parameter in human body measurements, widely utilized in forensic medicine for individual identification through various body parts (Shalakizadeh et al., 2020). In forensic anthropology, body height, referred to as stature, is one of the four most important points in identifying skeletal remains (Anita et al., 2016). Measurements such as intercanine width, maxillary interpremolar width, and the mesiodistal width of six permanent teeth have been used to compare patient heights (Gingerich et al., 1982; Jani et al., 2018; Shalakizadeh et al., 2020) Another study also demonstrated that intercanine width significantly correlates with patient heights (Jani et al., 2018).

It is well understood by clinicians that individuals from various ethnic backgrounds possess distinct morphological characteristics, including variations in height. For instance, Scandinavian ethnic groups tend to have smaller body sizes, whereas Aboriginal Australians generally exhibit larger body sizes (Moyers, 1973). A study has indicated that tooth dimensions tend to be larger in men compared to women, with a more pronounced difference observed in the size of the canine teeth (Vandana & Savitha, 2005). These were also suggested that it was related to the gender-related differences in the odontogenic timing and the enamel thickness, and the larger body size in men compared to women, hormonal differences and the presence of chromosome X affect the tooth sizes (Kaushal & Agnihotri, 2003; Kieser JA, 1990). Another separate study also observed that the most significant difference in tooth size between the two genders pertains to the canine and premolar teeth (Bishara et al., 1989). Greater mesio-distal width in men compared to women were found in multiple studies with emphasis on molars being more pronouncedly wider than the premolar which was attributed to the differences in the thickness of dentin rather than enamel, and several studies also found that the maxillary first premolar tooth was larger in girls compared to boys (Bishara et al., 1989; Kaushal & Agnihotri, 2003; Kieser JA, 1990).

While these studies examined the general size of teeth and the body stature of participants, there are studies that have reported on the size of anterior teeth in relation to the heights of participants for comparison (Shree & Mohanraj, 2019; Zope et al., 2016). The most common anterior tooth that was reported on this comparison as observed would be canines where mesiobuccal-distolingual diameter of the canine teeth was proposed to be the best criterion for determining a subject's gender (Karaman, 2006). Based on earlier studies, many have reported of no significant differences in tooth sizes between right or left of the arch and the maximum size differences in the maxillary lateral incisors and first molars, with the lowest size observed in the mandibular incisors. It was also reported that the maximum size differences are found in the maxillary teeth compared to the mandibular teeth (J. Daskalogiannakis, 2000; Reddy et al., 2017).

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1.1 Restorative dentistry and body heights

The relationship between body height and tooth dimensions is not new. In restorative dentistry, this relationship guides clinicians in selecting denture tooth size and shape, as well as in finishing and polishing of restorative work, to achieve proportionate restorations that align with the patient's facial dimensions and body stature. For taller patients, line angles are adjusted to enhance tooth length, while for shorter patients, mesial and distal shifts create the illusion of wider teeth (Kup et al., 2015; Sarver, 2011). This approach is important for creating visual effects in ceramic work or direct composite restorative work and is usually implemented during the finishing and polishing stages, either chairside or in the laboratory (Shah & Bal, 2016; Tamam et al., 2023; Yin et al., 2019).

Although this concept has been explored, no studies have examined the relationship between body height and tooth dimensions in the Malaysian population. The null hypothesis was established that the height of the participant is related to the length the tooth and males possessed larger tooth than females. This study aims to investigate two aspects: (1) the correlation between body height and the height of maxillary anterior teeth (canine to canine) and (2) the relationship between gender and tooth dimension. The findings may assist dental clinicians in selecting tooth shapes and dimensions according to the body heights and gender of patients and refining finishing and polishing techniques.

2. METHODOLOGY

This cross-sectional quantitative study involved 363 subjects (67 males, 296 females), aged 20–40 years, recruited from private dental centres, clinics, and dental institutions across Malaysia, including dental students and clinic patients. The patients were selected from those seeking treatment or check-ups, while students from multiple dental schools in Malaysia were screened based on inclusion and exclusion criteria. Ethical approval was obtained from the UiTM ethics committee (Reference: 600-IRMI (5/1/6). Subjects were selected based on the following criteria (Table 1):

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
1. Natural anterior teeth with no restoration work e.g crowns, bridges and implants	1. Teeth with rotations, spacing and crowding
2. Never had any orthodontic treatment previously	2. Teeth with restorative work e.g veneers, crowns and bridges
3. Complete set of permanent healthy teeth with no periodontal disease, no teeth malformations e.g conoid tooth, non-carious and with acceptable alignment i.e aligned with no overlapping, spacing, crowding and rotations.	3. Teeth with generalised periodontal disease

Participants recruited for the study had no history of orthodontic treatment, as procedures like enamel stripping or interproximal reduction could alter tooth dimensions.

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2.1. Digital impressions

After obtaining consent and collecting information such as age, gender, and height using the stadiometer of the participants (Figure 3), digital impressions were taken using the 3Shape intraoral scanner (Trios 3) of the maxillary arch (Figure 1).

Fig. 1. Trios Move using the Trios 3 Software for the purpose of scanning (Image source - 3shape.com)

Participants were seated supine on a dental chair with their heads on the headrest, positioning the intraoral area at the operator's elbow level. Participants details were entered into the registration window before the scanner was calibrated for taking digital impressions of the maxillary arch. The arch selection button appeared upon completing registration. Digital impressions of the maxillary arch of each participant were obtained using the intraoral scanners, Trios 3 and Trios Move by 3 Shape, a digital dentistry company originated and headquartered in Copenhagen, Denmark (Figure 1). Scanners were positioned with tips directed toward the participants' upper teeth to capture optical impressions, focusing specifically on anterior teeth to ensure smooth and precise digital results. For this study, the focus was specifically on the anterior segment of the teeth, including the right canine, right lateral incisor, right central incisor, left central incisor, left lateral incisor, and left canine. A single operator performed all tasks, from taking digital impressions to measuring tooth width and height. Impressions were saved as STL files labelled with participant details and then opened in 3D software (MeshLab 2023.12) (Figure 2) for the measurements to be taken on the digital scans. MeshLab is an open-sourced system whose development was led by Visual Computing Lab originated and located in Pisa, Italy. The measurements were performed as follows; the widths of the teeth were measured from the most mesial to the most distal contact points of the tooth, and the height of the teeth was measured from the zenith of the tooth to the incisal edge using the measurement tool provided in the software (Murugesan & Sivakumar, 2020).

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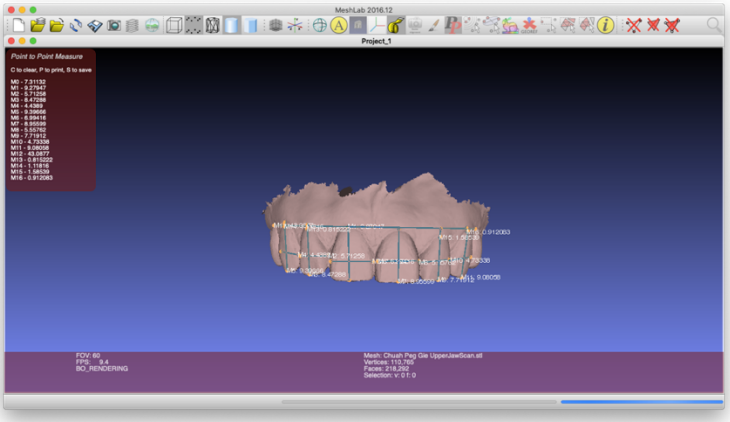

Fig. 2. An example of measurements done on 3D MeshLab software (MeshLab 2023.12).

A single investigator repeated each measurement three times, and the average was recorded as the confirmed measurement. If any reading differed by more than 0.2 mm, the measurement was repeated to determine the final measurement (Hasanreisoglu et al., 2005).

The body heights of the participants were measured using the portable stadiometer, Seca 213 (MDA Registration No.: GMD87158190517A) as shown in figure 3 after the digital impressions was completed.

Fig. 3. Stadiometer used to measure body heights (source photo: seca.com)

2.2 Statistical analysis

Statistical analysis was performed using Pearson Correlation Coefficient analysis to correlate body heights to length and width of teeth and descriptive analysis to analyze the relationship of teeth dimension in between males and females with a significance level set at $P \leq 0.05$. Intraclass correlation coefficient analysis was conducted to assess the reliability of intra-examiner measurements. Linear regression analysis was used to determine the increase in tooth length relative to body height.

3. RESULTS

The reporting of this section is divided into two parts: first, examining the relationship between body height and dimensions of six anterior teeth and the second part, exploring the relationship between gender and tooth dimensions.

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For the first part, we first analyzed the data according to body heights of the subjects to the measurements of the teeth accordingly which the widths and heights of the Right Central Incisor (RCI), Right Lateral Incisor (RLI), Right Canine (RC), Left Central Incisor (LCI), Left Lateral Incisor (LLI) and Left Canine (LC). Pearson correlation coefficient (r) was used for the analysis of this purpose as reported in the table below:

Table 2. The pearson correlation coefficient analysis of body heights to width and heights of each tooth

Variables	Pearson correlation (r)	p-value
Body heights vs RCIW	0.13	0.014*
Body Heights vs RCIH	0.17	0.002*
Body Heights vs RLIW	-0.009	0.86
Body Heights vs RLIH	0.20	<0.001*
Body Heights vs RCW	0.06	0.26
Body Heights vs RCH	0.13	0.012*
Body Heights vs LCIW	0.10	0.06
Variables	**Pearson correlation (r)**	**p-value**
Body Heights vs LLIW	-0.01	0.85
Body Heights vs LLIH	0.19	<0.001*
Body Heights vs LCW	0.01	0.88
Body Heights vs LCH	0.17	0.002*

*p-value < 0.05 indicates statistically significant

For the second part of the analysis, the widths and heights of the six teeth were analysed descriptively to see the difference in between the size of the teeth comparing males to females for each tooth:

Table 3. Descriptive analysis of width and heights of six anterior teeth according to gender

Measurement	Gender	Mean (mm)	95% CI (mm)	Median (mm)	Std Dev (mm)	Range (mm)	Skewness	Kurtosis
Right Central Incisor Width	Male	8.49	8.32-8.66	8.45	0.69	3.34	0.24	0.28
Right Central Incisor Width	Female	8.22	8.16-8.28	8.2	0.51	3.63	0.44	1.48
Right Central Incisor Height	Male	10.17	9.95-10.40	10.19	0.92	4.29	0.00	-0.23
Right Central Incisor Height	Female	9.72	9.59-9.84	9.78	1.07	11.51	-2.03	15.2
Right Lateral Incisor Width	Male	5.98	5.81-6.14	5.98	0.66	3.61	-0.39	1.001
Right Lateral Incisor Width	Female	5.99	5.90-6.07	5.99	0.77	8.94	-1.37	13.28
Right Lateral Incisor Height	Male	8.63	8.39-8.86	8.63	0.96	4.71	-0.23	0.01

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Right Lateral Incisor Height	Female	8.2	8.08-8.31	8.2	0.98	5.82	-0.05	0
Right Canine Width	Male	4.43	4.18-4.68	4.17	1.03	6.32	1.36	3.81
Right Canine Width	Female	4.21	4.10-4.33	4.05	1.0	7.15	1.18	3.14
Right Canine Height	Male	9.32	8.89-9.74	9.32	1.74	13.65	-2.85	16.72
Right Canine Height	Female	8.91	8.79-9.03	8.91	1.06	7.06	-0.08	-
Left Central Incisor Width	Male	8.38	8.25-8.52	8.38	0.55	2.82	0.47	0.69
Left Central Incisor Width	Female	8.18	8.11-8.25	8.25	0.64	7.09	Outlier	Outlier
Left Central Incisor Height	Male	10.26	10.04-10.48	10.23	0.91	4.29	-0.16	0.13
Left Central Incisor Height	Female	9.78	9.66-9.90	9.86	1.03	7.42	-0.57	-
Left Lateral Incisor Width	Male	6.20	6.03-6.37	6.21	0.68	3.99	0.61	2.35
Left Lateral Incisor Width	Female	6.07	5.99-6.15	6.03	0.7	4.4	0.18	0.59
Left Lateral Incisor Height	Male	8.71	8.50-8.93	8.69	0.88	4.34	-0.02	-0.02
Left Lateral Incisor Height	Female	8.44	8.31-8.56	8.41	1.08	5.98	0.418	0.26
Left Canine Width	Male	4.22	4.04-4.40	4.17	1.03	6.32	1.36	3.81
Left Canine Width	Female	4.14	4.04-4.24	4.05	1.0	7.15	1.18	3.14
Left Canine Height	Male	9.38	9.38-9.98	9.38	1.74	13.65	-2.85	16.72
Left Canine Height	Female	8.98	8.79-9.03	8.98	1.06	7.06	-0.08	-

Analysis results of part one (Table 2):

3.1 Analysis of correlation between body heights and tooth measurements

The table (Table 2) demonstrated the Pearson correlation coefficients (r) and corresponding p-values between body heights and various tooth measurements. Here is a detailed analysis of the data presented:

i. Right Central Incisor Width (RCIW): The correlation coefficient (r) was 0.13 with a p-value of 0.014, indicating a weak positive correlation that was statistically significant.
ii. Right Central Incisor Height (RCIH): The correlation coefficient (r) was 0.17 and the p-value was 0.002, showing a weak positive correlation that was statistically significant.
iii. Right Lateral Incisor Width (RLIW): The coefficient (r) was -0.009 with a p-value of 0.86, indicating no significant correlation.
iv. Right Lateral Incisor Height (RLIH): The coefficient (r) was 0.20 with a p-value of less than 0.001, suggesting a weak positive correlation that was statistically significant.
v. Right Canine Width (RCW): The coefficient (r) was 0.06 with a p-value of 0.26, indicating no significant correlation.

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vi. Right Canine Height (RCH): The coefficient (r) was 0.13 and the p-value was 0.012, showing a weak positive correlation that was statistically significant.
vii. Left Central Incisor Width (LCIW): The correlation coefficient (r) was 0.10 with a p-value of 0.06, indicating a very weak positive trend that was not statistically significant.
viii. Left Central Incisor Height (LCIH): The coefficient (r) was 0.19 with a p-value of less than 0.001, indicating a weak positive correlation that was statistically significant.
ix. Left Lateral Incisor Width (LLIW): The coefficient (r) was -0.01 with a p-value of 0.85, showing no significant correlation.
x. Left Lateral Incisor Height (LLIH): The coefficient (r) was 0.19 with a p-value of less than 0.001, indicating a weak positive correlation that was statistically significant.
xi. Left Canine Width (LCW): The coefficient (r) was 0.01 with a p-value of 0.88, showing no significant correlation.
xii. Left Canine Height (LCH): The coefficient (r) was 0.17 with a p-value of 0.002, indicating a weak positive correlation that was statistically significant.

These data were represented in a scatter plot to clearly visualise the significant results of the Pearson's correlation coefficient between body heights and the teeth as shown below:

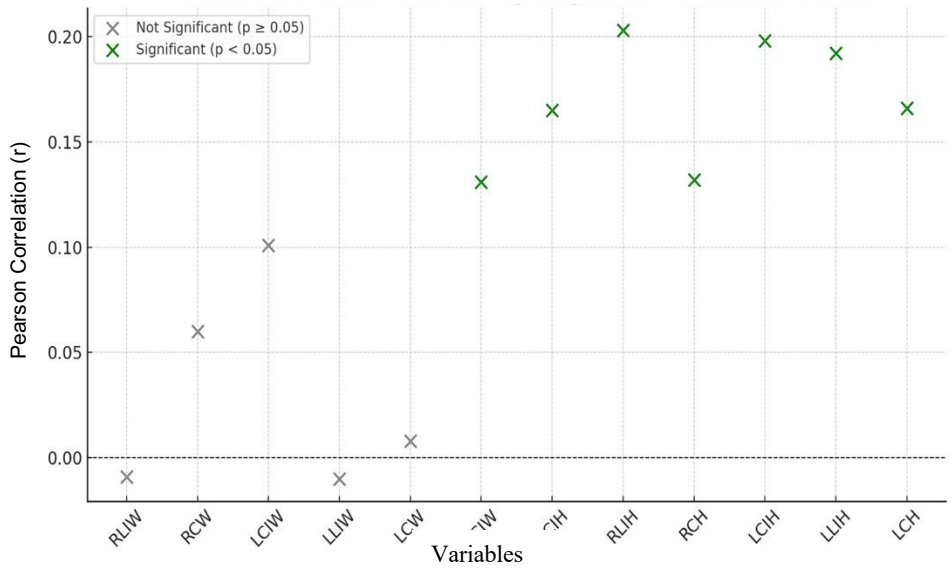

Fig. 4. The Scatter Plot of Pearson Correlation Coefficient of Body Heights and Each tooth. RLIW, Right Lateral Incisor Width; RCW, Right Canine Width; LCIW, Left Central Incisor Width; LCW, Left Canine Width; RCIW, Right Central Incisor Width; RCIH, Right Central Incisor Height; RLIH, Right Lateral Incisor Height; RCH, Right Canine Height; LCI, Left Central Incisor Height; LLIH, Left Lateral Incisor Height; LCH, Left Canine Height.

The analysis of the correlation between body heights and tooth measurements revealed several key points:

i. Statistically significant positive correlations existed between body height and tooth dimensions in RCIW, RCIH, RLIH, RCH, LCIH, LLIH, and LCH.
ii. The correlations were weak, indicating a limited positive relationship.

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iii. No significant correlations were found between body heights and the widths of the lateral incisors and canines (both right and left).

In summary, the analysis from the Pearson Correlation analysis revealed that several tooth measurements had positive correlations with body heights. This means that as body height increased, the measurements of these specific teeth tend to also increase slightly with an average of 0.03 mm for every 1cm increase in height (Table 5). Specifically, this relationship was observed in Right Lateral Incisor Height (RLIH), Right Canine Height (RCH), Left Central Incisor Height (LCIH), Left Lateral Incisor Height (LLIH), and Left Canine Height (LCH), all of which were statistically significant. Although the correlations were relatively weak, they were consistent enough to suggest a potential relationship. These results suggested that vertical tooth dimensions, particularly the heights of lateral incisors and canines, were positively associated with body height.
Analysis results of part two (Table 3):

3.2 Analysis of tooth widths and heights of RCI, RLI, RC, LCI, LLI and LC between genders.

For RCI and LCI, males had larger teeth in both width and height compared to females. Males generally had larger central incisors (both width and height) than females, as reflected in the means and medians. When evaluating the incisor height, males again exhibited larger dimensions, with a mean height of 10.17 mm compared to 9.72 mm in females in RCI and 10.25mm compared to 9.78mm in LCI.

For RLI, the widths for both male and female were similar, but males had taller lateral incisors with more consistent distribution compared to females. And for LLI, males had slightly wider (mean difference: 0.13mm) left lateral incisors than females and taller lateral incisors on average compared to females (0.28mm). This existed in both sides of right and left lateral incisors where males had taller size but may have similar widths on RLI with the females.

For RC and LC both teeth also reported that male generally had bigger teeth than females when considering both width and height. For RC males had a slightly larger mean width (4.43 mm vs. 4.21 mm in females) and for the heights of RC males had a more noticeable height difference, with a larger mean (9.32 mm vs. 8.91 mm in females), a difference of about 0.41 mm. For LC The mean width for males was slightly larger than that for females. Additionally, the median width for males (4.17) was also higher than for females (4.05) and the mean height for males was clearly larger than for females with mean for male was 9.38 and for female was 8.98.

Overall, the data suggested from the Pearson correlation coefficient that there was a tendency for taller individuals to have slight increase in length for incisor and canine heights with an average of 0.03mm for every 1cm increase in height , but widths of lateral incisors and canines did not show a significant relationship with body height, which means as the body heights increased, the length of these teeth – the lateral incisors and canines were also increasing, but the width of these teeth did not necessarily proportionately increase. These results aligned with previous study, affirming the relationship between dental measurements and body stature (Shree & Mohanraj, 2019). However, further research might be needed to explore these relationships in more detail.

3.3 Intra-examiner reliability

Intraclass correlation coefficients (ICC) using the two-way mixed-effects model was used to analyze the intra-examiner reliability for the measurements of the teeth dimensions (Table 4)(Koo & Li, 2016).

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Table 4. Intraclass correlation coefficients (ICC) using two-way mixed effects analysis for width and heights of the six anterior teeth. RLIW, Right Lateral Incisor Width; RCW, Right Canine Width; LCIW, Left Central Incisor Width; LCW, Left Canine Width; RCIW, Right Central Incisor Width; RCIH, Right Central Incisor Height; RLIH, Right Lateral Incisor Height; RCH, Right Canine Height; LCI, Left Central Incisor Height; LLIH, Left Lateral Incisor Height; LCH, Left Canine Height.

	ICC*	95% CI	Interpretation
RCIW	1.00	0.99, 0.99	Excellent reliability
RCIH	0.91	0.89, 0.92	Excellent reliability
RLIW	0.87	0.84, 0.89	Good reliability
RLIH	0.00	-0.06, 0.07	Inconsistent reliability
RCW	0.00	-0.06, 0.07	Inconsistent reliability
RCH	0.00	-0.06, 0.07	Inconsistent reliability
LCIW	0.99	0.99, 1.00	Excellent reliability
LCIH	0.92	0.90, 0.93	Excellent reliability
LLIW	0.00	-0.06, 0.07	Inconsistent reliability
LLIH	0.96	0.95, 0.96	Excellent reliability
LCW	0.00	-0.06, 0.07	Inconsistent reliability
LCH	1.00	0.99, 1.00	Excellent reliability

Values less than 0.50 were indicative of inconsistent reliability, values between 0.50 and 0.75 indicate moderate reliability, values between 0.75 and 0.90 indicate good reliability, and values greater than 0.90 indicate excellent reliability. RCIW, RCIH, LCIW, LCIH, LLIH, and LCH demonstrated excellent reliability, while RLIW showed good reliability. Inconsistent reliability was observed for RLIH, RCW, RCH, LLIW, and LCW.

3.4 Linear Regression Analysis of Body Height and Tooth Length

A linear regression analysis was conducted to determine the increase in tooth length corresponding to each centimetre increase in body height. The dependent variables were the heights of the central incisor, lateral incisor, and canine on both the right and left sides of the dental arch. The independent variable was body height (in cm).

The regression equation used was:

$$Y = \beta_0 + \beta_1 X + \boldsymbol{\varepsilon}$$

Where:
Y represents the tooth length (mm),
X represents body height (cm),
β_1 is the regression coefficient (indicating the increase in tooth length per cm increase in body height), and
ε is the error term.

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Table 5. The linear regression analysis following coefficients for the increase in tooth length per 1 cm increase in body height.

Tooth	Increase in Length (mm)
Right Central Incisor Height (RCIH)	0.028
Right Lateral Incisor Height (RLIH)	0.031
Right Canine Height (RCH)	0.026
Left Central Incisor Height (LCIH)	0.032
Left Lateral Incisor Height (LLIH)	0.031

The regression analysis confirmed a positive correlation between body height and tooth length, with an average increase of 0.03 mm in tooth length for every 1 cm increase in body height.

4. DISCUSSION

This study discusses two parts of findings, which the first part is the relationship of body heights and tooth measurements, and the second part the relationship of gender to their tooth sizes. Main objective of this study is to investigate the correlation between participants body heights and gender to the tooth dimensions particularly the widths and heights of anterior teeth of Malaysian population. The sample size was based on 60 % Malays, 30% Chinese and 10 % Indians.

This study found that as body heights increases the length of teeth particularly increases proportionately especially in Right Central Incisor Height (RCIH), Right Lateral Incisor Height (RLIH), Right Canine Height (RCH), Left Central Incisor Height (LCIH), Left Lateral Incisor Height (LLIH), and Left Canine Height (LCH) with an average of 0.03mm increase of the length of the teeth for every 1 cm increase in body height. This is in accordance with a study which found a significant correlation that was observed between heights and maxillary intercanine width reported in their study (Jani et al., 2018). The findings of males possessed larger and taller anterior maxillary teeth as opposed to the female counterparts are also proven through this research. The findings unequivocally demonstrated that males have teeth that are, on average, 0.15 mm wider than those of females and males have teeth that are on average 0.41 mm taller than females across all six anterior teeth. This current study proved to agree with earlier studies which have demonstrated the significance of tooth proportions in various dental disciplines, including orthodontics and restorative dentistry (Afb et al., 1994; Jain et al., 2015; Shyagali et al., 2021; Ward, 2007). These dimensions are very much related to the adjustments of the restorative work, tooth space discrepancy in orthodontics or the representation of malocclusion in many prosthodontically challenged cases (Agenter et al., 2009; W. Bolton, 1958; W. A. Bolton, 1962; Gaddam et al., 2015; German et al., 2016; Mahmoud et al., 2012; Mustafa & Abuaffan, 2021). While these findings are significant in clinical practice, they also hold relevance in forensic anthropology (Garn et al., 1968; Gingerich et al., 1982; Ramirez-Rozzi & Romero, 2019). Understanding size differences is essential for dental restorative procedures, enabling better customization of treatments based on patients' heights and genders. For instance, when performing a composite restoration, the visual appearance of the tooth can be adjusted to look taller and slimmer by comparing the patient's height and moving the line angles toward the center of the restoration (Kup et al., 2015; Sarver, 2011). This technique can create a more proportionate appearance for taller patients. Similarly, lab technicians constructing dentures or ceramic work must consider each tooth's presentation to mimic specific criteria, ensuring shorter and wider teeth for certain patient heights and taller, slender teeth for others (Baldwin, 1980; Blatz et al., 2019; Lukez et al., 2015; Prasad et al., 2018; Witt & Flores-Mir, 2011).

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In this study, intraclass correlation coefficients using a two-way mixed-fixed model was used to assess measurement reliability. Most measurements showed excellent to good reliability; although some demonstrated inconsistent reliability, measurement differences were minimal. These minor variations may result from examiner error in precisely identifying measurement points during repeated readings (Camardella et al., 2017). According to the literature, differences larger than 0.3 mm for the overjet, overbite, and tooth size (tooth diameter and tooth height) and larger than 0.4 mm for transverse and sagittal parameters were considered clinically relevant (Fleming et al., 2011; Leifert et al., 2009; Naidu & Freer, 2013).

This study findings also corroborate the existing literature on the relationship between tooth size and body height, emphasizing the potential of dental measurements in forensic anthropology. The significant correlation between intercanine width and body height particularly supports the use of this measurement as a reliable predictor of stature (Karaman, 2006; Kieser JA, 1990; Stroud et al., 1994). This current study demonstrates the correlation between anterior teeth dimensions and body height among Malaysian population with an average of 0.03mm increase of the tooth length for every 1 cm increase in body height. Although the correlations are relatively weak, they are consistent enough to suggest a potential relationship. These findings are aligned with multiple studies that suggest dental measurements, particularly intercanine width, can be used as reliable indicators of stature in forensic anthropology and for restorative and aesthetic work (Kaushal & Agnihotri, 2003; Schwefer et al., 2022; Shalakizadeh et al., 2020). Future research should explore the applicability of these findings across bigger range of the populations and examine the potential influence of genetic and environmental factors on the relationship between tooth size and body height.

These results indicate a potential proportional relationship between craniofacial structures and overall somatic growth, which may have clinical relevance. For instance, understanding these correlations could assist in tailoring restorative or prosthetic dental treatments to achieve optimal aesthetic outcomes, particularly in cases where proportionality with the patient's stature is a critical consideration.

In clinical practice, these insights could aid in designing anterior restorations or selecting tooth dimensions in prosthodontic rehabilitations to ensure harmony with a patient's physical characteristics. Furthermore, the lack of correlation between body height and tooth widths highlights that factors such as genetic predispositions or functional adaptations may play a more prominent role in influencing horizontal tooth dimensions. Nevertheless, understanding the relationship between dental dimensions and body height can improve identification methods in forensic investigations, especially when dealing with incomplete skeletal remains. The ability to estimate stature from dental measurements can provide crucial information for identifying unknown individuals.

5. CONCLUSION

This study highlights the clinical significance of the relationship between body height and anterior tooth widths and heights in Malaysian population and the differences of tooth sizes among males and females within this group. This study concludes with increase in heights there was an increase in length of teeth, and it was also shown that males have bigger size of teeth when width and heights of teeth are measured for all six anterior teeth. These findings suggest that understanding such proportional relationships can aid in planning aesthetic and functional dental restorations tailored to individual body proportions. Conversely, the lack of correlation between body height and tooth widths indicates that horizontal dimensions may be influenced by distinct genetic or environmental factors, warranting further investigation. Expanding this research with larger, more diverse populations could refine its application in restorative and prosthodontic dentistry.

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Overall, the data suggests that there is a tendency for taller individuals to have slightly larger central incisors, lateral incisors and canines. These results aligned with previous studies, affirming the relationship between dental measurements and body stature. However, further research might be needed to explore these relationships in more detail.

Further analysis indicated that males generally had larger intercanine widths and tooth sizes than females, reflecting the overall sexual dimorphism in body size. This difference also highlights the necessity of considering gender when using teeth measurements and to estimate body height in forensic investigations and also other disciplines in dentistry.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Nurul Huda Hasan. Carried out the research, wrote and revised the article. **Budi Aslinie Sabri and Mohamed Ibrahim Abu Hassan.** Conceptualised the central research idea and provided the theoretical framework. **Nurul Huda Hasan, Budi Aslinie Sabri and Mohamed Ibrahim Abu Hassan.** Designed the research, supervised research progress; **Mohamed Ibrahim Abu Hassan.** Anchored the review, revisions and approved the article submission.

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6. APPENDIX

A. About the authors

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Dr. Nurul Huda Hasan is currently serving as the Chief of Academics at the Dental Academy Malaysia and practices clinically in various dental centres across Klang Valley. She earned her Master of Science (Restorative and Aesthetic Dentistry) from King's College London in 2014. In her role as the academic coordinator for the Dental Academy Malaysia, a private dental training centre, Dr. Nurul oversees modular programs and workshops designed to enhance the clinical skills and competencies of both government and private dental practitioners and specialists, including international dentists. Her passion for aesthetic dentistry and smile design has led her to undertake a PhD study on the tooth proportions of the Malaysian population. Dr. Nurul has presented her research findings and clinical cases at international forums and has published several articles in both international and national journals. Notably, she is the Past President of the Malaysian Association of Aesthetic Dentistry, the President Elect of the Asian Academy of Aesthetic Dentistry, and serves on the Executive Council of the International Federation of Esthetic Dentistry.

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of Glasgow, FDSRCPS (Glasgow). Dr Mohamed Ibrahim has more 35 years teaching experience first at University of Malaya and then Universiti Teknologi MARA as the founding dean of the faculty. Currently Prof Dato'Dr Mohamed Ibrahim is the Dean, Faculty of Dentistry, MAHSA University, one of the biggest private university with a dental programme. Dr Mohamed Ibrahim had published more than 100 scientific papers in indexed and non-index journals. He had also several postgraduate's students at Master's and Doctorate level. He had also won several research grants at both a university and national level. He was Chairman of Malaysian Dental Dean's Council Chairman of Joint Technical Committee of Dental Specialty Programme. He was also appointed member of the Malaysian Dental Council and Malaysia Dental Association. Internationally, he was the President of SEAADE from 2014-2016 and currently an ex-officio. He is also the Regent of Fellow International College of Dentist (FICD) Region 33 for Malaysia & Brunei apart from being appointed as the Chairman of Education Committee International College of Dentist Section XV. He was also the Council Member of International Dental Collaboration of Mekong River (IDCMR). Due to his contribution to the University Dr Mohamed Ibrahim were awarded Academic Leader Award in 2013 and Distinguish Academic Award in 2018 by the University. He was awarded the Distinguish Fellow of International College of Dentist in 2016 (FICD). In 2019 Professor Dato' Dr Mohamed Ibrahim was awarded the prestigious Fellow of Academy Science of Malaysia (FASc) in 2019 from Academy of Science Malaysia. He was also granted the state.

Author 3

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