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A comparative analysis of height trend and nutrition among 1983 to 2005 birth cohort of Ilorin metropolis, Kwara State, Nigeria

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Abstract: Over the course of the years, numerous studies have been conducted to assess the trends in height across different generations and regions. This study seeks to add to the current data on secular height trend, by analyzing the trend in height, gender specific differences in height trend and relationship between socio-nutritional factors and increase in height trend among 1983–2005 birth cohort in the Ilorin metropolis. A total of 414 study participants aged 18–40 years (207 males and 207 females). Their height was obtained using the Tape stadiometer, information about dietary history (nutritional factors) that may affect height were gotten via the use of Questionnaires. Data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 27.0 and results were computed using Pearson's Chi-square analysis and ANOVA. P-values less than 0.05 were considered significant. Height was found to have positively increased among the 1983 to 2005 birth cohorts of Ilorin metropolis with the most significant increase being observed in the Males. This study also revealed a positive correlation between Diary and Carbohydrate consumption and increase in height, especially among males. No significant increase in height was found among females of the birth cohorts and no Association was found between the considered nutritional factors and female height.

KEY WORDS: height trend, nutrition, birth cohort, Ilorin

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Introduction

In the field of Anthropology, there is a significant emphasis on tracing evolutionary trends in the human body. Numerous studies have been conducted to investigate whether specific characteristics of the human body have undergone evolutionary changes over time. Over the course of civilization, numerous studies have been conducted to assess the trends in height or stature across different generations and regions.

In anthropometry, height refers to the measurement of a person's stature, which is the distance from the bottom of the feet to the highest point of the head. This assessment is conducted directly using a stadiometer. Measuring height is important for studying physical growth patterns and secular trends across regions and population groups, as population-specific height assessments can help identify areas of concern and target populations.

Ilorin, the capital city of Kwara State, Nigeria is located in the North – Central region of Nigeria. It is a significant urban center serving as a meeting point for various ethnic groups, such as Yoruba, Fulani, and Hausa (National Population Commission 2018). The residents of Ilorin metropolis primarily engage in a mix of agricultural activities, trading and small-scale industries. The diet in Ilorin is largely based on locally available foods, reflecting the agricultural and animal rearing practices of the region. Staple food includes various forms of carbohydrates, such as rice, yam, maize, complemented by proteins from poultry, cattle and Dairy products (Adebayo 2020). Dairy products, particularly in the form of milk and locally made cheese (Wara), is common, especially among the cattle herders (Oloyede 2019). Ilorin's environment is characterized by a tropical climate with distinct wet and dry seasons, which supports the cultivation of a variety of crops. The fertile land and favorable weather conditions enable the production of food items that form the basis of the local diet. This diet is generally rich in carbohydrates, providing the energy necessary for the physically demanding activities that many residents engage in. In addition, the consumption of dairy products, which are rich in calcium, plays an important role in the nutritional status of the population, contributing to the overall health and growth of the residents, particularly during childhood and adolescence (Adebayo 2020).

Globally, human height has increased steadily over the past 200 years with the average person today being taller compared to their ancestors living one hundred years ago. This trend is consistent with improvements in general health and nutrition during this time. The main aim of this research is to determine whether there is a significant difference in height trend between generations in Ilorin, as well as to analyze gender specific differences in height trend within the studied generation and to identify the relationship between nutrition history and any observed shifts in stature.

Several scholars have studied secular trends in height across various countries and regions in the world using, typically, two main data sources: conscript measurements and self-reported data from certain databases (Quintana-Domeque et al. 2012). Spijker et al. (2008) made analysis based on self-reported data, which revealed that height significantly increased throughout the 20th century. For example, individuals born in the 1980s were about 10 cm taller than those born in the 1910s.

Several studies using conscript data, including works by Martínez-Carrión (2005), indicate a consistent increase in the average adult stature of male conscripts in Spain from 160 cm in 1900 to 175 cm in the early 1990s. In a research on the evolution of height carried out by Quintana-Domeque et al. (2012) across Spanish regions, it was reported that the average heights of females and males born 1950 and 1980 increased by 1.7 cm and 1.6 cm per decade, respectively. Garcia and Quintana-Domeque (2007) carried out similar research on the evolution of adult height in 10 European countries for cohorts born between 1950 and 1980. Height data from Austria, Belgium, Denmark, Finland, Greece, Ireland, Italy, Portugal, Spain, and Sweden were collected and analyzed and it was reported that height increased in all the listed countries although countries from Southern Europe (Greece, Italy, Portugal, and Spain) experienced greater increase in height and stature compared to the Northern Europe (Austria, Belgium, Denmark, Finland, Ireland, and Sweden).

According to Komlos and Baur (2004), factors such as improved nutrition, healthcare, and living standards contribute to these positive height trends in many regions. Baird (2015) also stated that the small gain in average human height experienced in many countries over the last few hundred years was not due to genetic evolution. The most likely cause is improved nutrition and health as nutrition, specifically the quality of the diet, plays a huge role and is one of the strongest determinants of human height (Perkins et al. 2016).

Victoria et al. (2008) in their study emphasized the fact that adequate nutrition during crucial growth periods is critical for optimal height attainment, and malnutrition can lead to stunting. Grasgruber et al. (2014) found that the ratio of high-quality animal proteins, such as those from milk products, red meat, and fish, is the best indicator of male height in high-income countries where there is a high intake of animal protein. A study by Zhao et al. (2020) reported that males consumed more dietary energy, fats, proteins, and carbohydrates than females. Similarly, another study reported that males exhibited a pronounced preference for red meat and processed meats, while females showed a higher propensity to consume vegetables, whole grains, tofu, and dark chocolate (Feraco et al. 2024). A study of geographic differences in stature among young men from 45 countries of European origin demonstrated that nutrition level explained most of the differences in adult height, particularly the consumption of high-quality proteins from milk, pork, fish, and wheat (Grasgruber et al. 2014).

The study conducted by Takahashi (1984) found a significant association between nutrition and height by demonstrating a link between Japan's height trend to increased milk consumption since the Second World War. Similarly, milk consumption was positively associated with increase in adult height among a nationally representative sample from the United States (Wiley 2005). In addition, it was shown that the production and consumption of milk and beef provides insights into why Germanic people living outside the Roman Empire were taller compared to those residing at its core (Moradi and Baten 2005). This may be due to the fact that Milk contains calcium, which is an essential mineral for bone growth and elongation which contributes to an adult overall height (stature).

Height, as a comprehensive anthropometric indicator, offers a holistic view of a population's overall well-being, that consideres both historical and contemporary factors that shape human development. The primary aim of this study is to investigate generational shifts in stature among Ilorin residents born between 1983 and 2005, with a focus on understanding how height has changed over time.

Focusing specifically on the birth cohort between 1983 and 2005, this study aims to contextualize the influences shaping height trends among the residents of Ilorin, Kwara State, Nigeria, considering factors such as shifts in dietary patterns and lifestyle. This research also endeavors to enrich the existing body of knowledge by providing a comprehensive examination of generational shifts in stature among Ilorin Residents born between 1983 and 2005 and aspires to offer a nuanced understanding of the complex factors shaping human growth patterns over time. This research could also help predict generational shift in human stature in the future, factors that may contribute to it and contribute to the overall understanding of the secular trends in human height across generations over time.

Material and Methods

Two hundred and Fourteen subjects from the Ilorin Metropolis, Kwara State, Nigeria (comprising one hundred and seven males and one hundred and seven females) were used for this research. All measurements were taken by the same examiner (to reduce inter-observer error). Participants were healthy and within the age range of 18–40 years. Participants with severe physical health conditions that might affect stature (osteoporosis, spinal deformities, and amputated legs), cognitive impairments and who were born before 1983 or after 2005 were excluded from this study.

Ethical approval was obtained from the University Ethical Review Committee (UERC) for human experimentation of the University of Ilorin, Ilorin, Kwara State, Nigeria and this study was approved with ethical approval number UERC/ASN/2024/2758 on the 14th of March, 2024. All participants consented to participate in this research experiment.

Questionnaires were administered to collect information about demographic details (nationality, age, and sex), dietary history and stature.

The questionnaires contain structured questions about the participants typical diet during their formative years (childhood and adolescence) and questions about the frequency of consumption of specific food groups (dairy, protein and carbohydrates).

For the measurement of height, the participants were asked to stand barefooted with their back straight and upright against a flat surface after adequate explanation of the procedure is done since none of the procedure is invasive, neither harmful nor painful to the participants. The height measurement was taken using a stadiometer and measured in centimeters (cm).

The Statistical Package for Social Sciences (SPSS) Version 27.0 was used. Results were computed using Pearson's chi-square analysis and ANOVA method. P-values less than 0.05 were considered significant.

Results

Table 1 presents the trend in height among different birth year cohorts. It appears that the cohorts born between 1997–1999

and 2000–2002 have the highest average height with mean values of 169.20 cm and 169.82 cm respectively along with relatively low SD (8.16 cm and 8.24 cm). Following closely are the cohorts born between 1983–1986 and 2003–2005, with mean heights of 167.84 cm and 167.66 cm, respectively, and slightly higher standard deviations (6.14 cm and 8.65 cm). The cohort born within 1994–1996 has a slightly lower mean height of 166.97 cm but a higher standard deviation of 9.88 cm. The cohorts born between 1987–1989 and 1990–1993 have the lowest mean heights of 165.88 cm and 165.45 cm, respectively, with standard deviations of 7.15 cm and 6.98 cm. In addition, the provided p-value of 0.044 suggests that there is a statistically significant difference in mean height between at least two of the birth year cohorts (as it is <0.050). This indicates that there are indeed differences in height among the various birth year cohorts.

Table 1. Observed height difference between the considered birth cohorts in Ilorin

Birth Years	Height Difference (N=414)			ANOVA	
	Mean (SD)	Min	Max		
	(cm)	(cm)	(cm)	F-value	Sig.
1983–1986	167.84 (6.14)	156.00	179.00	2.180	**0.044**
1987–1989	165.88 (7.15)	156.00	179.00		
1990–1993	165.45 (6.98)	152.00	178.00		
1994–1996	166.97 (9.88)	153.50	200.70		
1997–1999	169.20 (8.16)	152.60	188.60		
2000–2002	169.82 (8.24)	154.00	187.50		
2003–2006	167.66 (8.65)	137.10	189.00		

Note: *SD= Standard deviation, N= Number of cases, Min= Minimum, Max= Maximum, F-value= Fisher's value*

Table 2. Height difference between the considered birth cohorts in Ilorin (Gender Based)

Birth Year	Height Difference			ANOVA	
	MALE (N=207)				
	Mean (SD)	Min	Max	F-value	Sig.
	(cm)	(cm)	(cm)		
1983–1986	169.95 (5.22)	157.00	179.00	5.390	**<0.001**
1987–1989	168.61 (7.90)	156.00	179.00		
1990–1993	168.83 (5.72)	159.00	178.00		
1994–1996	174.70 (7.98)	168.00	200.70		
1997–1999	174.70 (5.96)	166.00	188.60		
2000–2002	175.07 (6.03)	165.00	187.00		
2003–2006	173.87 (6.92)	157.50	189.00		

Table 2. (cont.)

Birth Year	Height Difference			**ANOVA**	
	FEMALE (N=207)				
	Mean (SD)	Min	Max	F-value	Sig.
	(cm)	(cm)	(cm)		
1983–1986	164.87 (6.24)	156.00	176.90	1.330	0.245
1987–1989	163.33 (5.46)	156.00	171.00		
1990–1993	161.57 (6.32)	152.00	176.00		
1994–1996	160.11 (5.20)	153.50	170.00		
1997–1999	163.70 (6.11)	152.60	175.00		
2000–2002	163.69 (5.94)	154.00	175.00		
2003–2006	162.66 (6.36)	137.10	177.00		

Note: *SD= Standard deviation, N= Number of cases, Min= Minimum, Max= Maximum, F-value= Fisher's value*

Table 2 presents height differences among males born in different birth year cohorts. It shows that the cohorts born within 1983–1986 have a mean height difference of 169.95 cm with a standard deviation of 9.95 cm. The cohorts born between 1987–1989 and 1990–1993 have slightly lower mean height of 168.61 cm and 168.83 cm, with standard deviations of 7.90 cm and 5.72 cm, respectively, indicating less variation in height differences within these groups. On the other hand, the cohorts born between 1994–1996 and 1997–1999 have higher mean height differences, both with a mean of 174.70 cm and standard deviations of 7.98 cm and 5.96 cm, respectively. The cohort born within 2000–2002 has the highest mean height difference of 175.07 cm, with a standard deviation of 6.03 cm, while the cohort born within 2003–2005 has a mean height difference of 173.87 cm with a standard deviation of 6.92 cm. The p-value of 0.001 suggests that there are statistically significant differences in height differences among the various birth year cohorts. In the table above, it can be observed that there was a gradual in the height trend of the males down the birth cohorts, this indicates that the differences in height observed between the cohorts are unlikely to be due to random chance and are likely meaningful.

Table 2 also presents height differences among females born in different birth year cohorts. It reveals that the cohorts born within 1983–1986 have the highest mean height difference, with a value of 164.87 cm and a standard deviation of 6.24 cm. Conversely, the cohorts born between 1990–1993 and 1994–1996 exhibit the lowest mean height differences, with values of 161.57 cm and 160.11 cm, respectively, and relatively low standard deviations (6.32 cm and 5.20 cm), indicating less variation in height differences within these groups. The cohorts born between 1987–1989, 1997–1999, and 2000–2002 have mean height differences slightly higher than the lowest groups, with mean values ranging from 163.33 cm to 163.69 cm and standard deviations ranging from 5.46 cm to 6.11 cm. The cohort born within 2003–2005

has a mean height difference of 162.66 cm with a standard deviation of 6.36 cm. The p-value of 0.245 suggests that there are no statistically significant differences in height differences among the various birth year cohorts (as it is >0.050). Instead, there seems to be some sort of fluctuations and reduction in the height trend among the birth cohort of the females.

Table 3. Pearson's chi-square analysis between Stature and considered nutritional history in the General population

	HEIGHT	VARIABLES	X^2
	df	p-value	
Diary Consumption	134.007 [a]	125	0.275
Protein Consumption	131.576[a]	125	0.326
Carbohydrates Consumption	158.913[a]	125	**0.022**

Note: *df= degree of freedom, X^2 =Chi square*

Table 3 shows that carbohydrate consumption has a statistically significant relationship with stature, indicated by a p-value of 0.022. This suggests that there is a significant association between carbohydrate consumption and stature in the study sample. On the other hand, the other nutritional factors, such as dairy and protein consumption did not show a statistically significant relationship with stature, as their p-values were greater than 0.050. This implies that these factors did not have a significant impact on stature in the research findings.

Table 4. Chi square analysis between stature and nutrition history in the general population (Gender based)

VARIABLES	MALES (stature)		FEMALES (stature)	
	X^2	p-value	X^2	p-value
Diary Consumption	98.705	**0.041**	21.392	1.000
Protein Consumption	79.949	0.356	76.602	0.459
Carbohydrates Consumption	136.640	**<0.001**	29.740	1.000

Note: *X^2 =Chi square*

Based on the information included in Table 4, the chi-square analysis of the association between stature and socio-economic factors, such as dairy, protein, and carbohydrate consumption in males and females revealed significant associations with carbohydrate and dairy consumption in males only. Specifically, the p-values for carbohydrate and dairy consumption in males were 0.001 and 0.041, respectively, indicating a significant association. In contrast, the p-values for all factors in females were greater than 0.050, suggesting no significant association. Overall, the findings of the chi-square analysis suggest that carbohydrate and dairy consumption may have a more significant impact on stature in males compared to females.

Discussion

In this study, height was found to have positively increased among the 1983 to 2005 birth cohorts of Ilorin metropolis. This agrees with the findings of Garcia and Quintana Domeque (2007) showing that there is indeed increase in height trends across several generations according to their study on the evolution of adult height between 1950 to1980 birth cohort in 10 European countries. This study also supports the study by Garenne (2020) which noted increase in height trend of Sub-Saharan and North African countries. According to a global study by NCD Risk factor collaboration (2016), it was noted that Mean height for males increased from 162 cm to 171 cm, and for females, it increased from 151 cm to 159 cm. But in this study, it was observed that the mean height for males within the 1983 to 2005 cohorts increased from 169.95 to 173.87, while that of the females showed no significant difference but fluctuates between 164 cm to 162 cm. The same increase in mean height of males was also observed in a study by Cole (2003) and Kolodziej et al. (2015). Also, according to Martinez Carrion (2005), there is a consistent increase in the average adult height of males from 160 cm to 175 cm based on his study on male conscripts in Spain, which according to this study was found to be a mean height increase of 169 cm to 172 cm. This study agrees with the reports of Jelenkovic et al. (2016) based on their research on the 1886 to 1994 cohorts, which noted that there is generally an increase in height trend with the mean height being greater in the males than females.

According to Roser et al. (2024), population wide distribution of height is influenced by non-genetic environmental factors such as Nutrition, Health and Lifestyle.

In this study, an association was observed between the increase in height and nutritional factors such as carbohydrate and dairy consumption. This finding is consistent with the reports by Baird (2015), who suggested that improved nutrition is a likely driver of height increase. In addition, the study supports the findings of Komolos and Baur (2004), indicating that factors such as nutrition and lifestyle contribute to a positive trend in height.

This study contradicts the findings of Allen and Uauy (1994), who claimed that the consumption of protein such as meat, eggs and dairy products positively correlates with height. However, this study observed that only the consumption of dairy products showed a significantly positive correlation with height increase, particularly in males. Interestingly, protein consumption was found to have no significant effect on height increase in both males and females.

This study also presents findings that correlates with the reports of Moradi and Baten (2005), Takahashi (1984), and Wiley (2005), which advocate for the notion that the increase in height is primarily attributed to increased milk or dairy consumption. Similar to these assertions, the results obtained from this research indicates a positive correlation between dairy consumption and height increase.

According to Moradi and Baten (2005), diets dependent on carbohydrates consumption such as rice, negatively correlates with increase in height trend. However, this study contradicts that finding, revealing that carbohydrate consumption is positively correlated with height in males, while showing no significant correlation with height in females.

These findings suggest that carbohydrate and dairy consumption may have a more significant impact on stature in males compared to females. This could be due to various factors, such as differences in dietary patterns, nutrient absorption, and metabolism between genders.

It is also worth noting that previous studies have reported gender differences in dietary patterns and nutrient intake. For instance, a study found that males consumed more dietary energy, fats, proteins, and carbohydrates than females ($p < 0.001$) (Zhao et al. 2020). Similarly, another study reported that males exhibited a pronounced preference for red meat and processed meats, while females showed a higher propensity to consume vegetables, whole grains, tofu, and dark chocolate (Feraco et al. 2024). These differences in nutrient intake could contribute to the observed gender differences in the relationship between stature and nutritional factors.

The findings of this study underscore the importance of understanding gender-specific nutritional needs and how they contribute to physical development. For researchers, this suggests that future studies should explore the underlying biological mechanisms and potential gender differences in nutritional impacts. In practice, the results could inform public health strategies aimed at improving dietary guidelines for adolescents, particularly in regions similar to Ilorin, to optimize growth and development outcomes.

Conclusion

This study demonstrated evidence that there is increase in height trend in males and that certain nutritional factors correlates with increase in height, with the males having a stronger correlation with carbohydrates and diary consumption than the females among Ilorin residents born 1983–2005. The observed increase in male height according to the findings of this research project may be due to its association with dairy and carbohydrate consumption as dairy products, rich in calcium, are essential for bone growth and elongation which contributes to height, and a diet rich in carbohydrates provides the necessary energy for growth processes and nutrient absorption. Together, these factors promote bone growth and development and support the proper functioning of growth plates, contributing to the increase in height observed. The lack of an increase in the height trend of the female birth cohort may also be attributed to the negative association that exists between increase in height trend and the nutritional history considered in this research.

There is need for further research involving a larger population in order to firmly establish these findings. With regards to the findings on the positive association between increase in height trend and socio-nutritional factors, more studies should be carried out to explore the underlying mechanisms and potential implications of these findings.

Conflict of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Authors' contribution

Alabi Ade Stephen – principal investigator and initiator of the research work; Olagunju Peace Eyitayo – Data collection; Alabi

Adeola, Owa Joshua Abidemi, Owa Yetunde Elizabeth – Data analysis and interpretation; Ayoola Abosede Mary, Dare Ezekiel Babatunde – Manuscript preparation; Olasehinde Oluwatoyin Ezekiel, Adeoye Titilayo Temitope – Manuscript editing.

All authors contributed the revision and proofreading of the manuscript.

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