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Anthropometric Assessment of Intergenerational Height Differences among Indian Families

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Abstract

Introduction: Human body height undergoes changes across generations, and variations in stature can be observed among individuals belonging to different generational cohorts. This study investigates changes in body height among Indian Gen Z youth in comparison with their parents and grandparents. **Methods:** Data were collected using a structured questionnaire administered through Google Forms and distributed among Gen Z respondents. Participants were requested to provide the height measurements of themselves, their parents, and both paternal and maternal grandparents. A total of 98 valid responses were obtained for the study. The primary anthropometric variable examined was body height across three generations. Paired t-tests were employed to compare the height of sons and daughters with those of their parents, paternal grandparents, and maternal grandparents. **Results:** The findings indicate a significant increase in body height within the male lineage, from grandfathers to fathers and subsequently to sons (Gen Z males). A similar significant intergenerational change was also observed when comparing the heights of Gen Z males with those of their maternal ancestors. In contrast, the results show that the body height of daughters is not significantly greater than that of their parents and grandparents. **Conclusion:** The findings of this study provide valuable data for future public infrastructure facilities related to transports, educational institutions, public sector undertaking and private infrastructure facilities related to household utilities, private educational institutions etc.

Keywords: Anthropometry, Intergeneration, Height, Children, Parents, Grand Parents.

Resumen

Introducción: La estatura humana experimenta cambios a lo largo de las generaciones, y se pueden observar variaciones en la talla entre individuos pertenecientes a diferentes cohortes generacionales. Este estudio investiga los cambios en la estatura entre los jóvenes indios de la Generación Z en comparación con sus padres y abuelos. **Métodos:** Se recopilaron datos mediante un cuestionario estructurado administrado a través de Google Forms y distribuido entre encuestados de la Generación Z. Se solicitó a los participantes que proporcionaran sus propias medidas de estatura, así como las de sus padres y de sus abuelos (tanto paternos como maternos). Se obtuvieron un total de 98 respuestas válidas para el estudio. La principal variable antropométrica examinada fue la estatura a lo largo de tres generaciones. Se emplearon pruebas t para muestras pareadas para comparar la estatura de hijos e hijas con la de sus padres, abuelos paternos y abuelos maternos. **Resultados:** Los hallazgos indican un aumento significativo en la estatura dentro del linaje masculino, desde los abuelos hasta los padres y, posteriormente, hasta los hijos (varones de la Generación Z). También se observó un cambio intergeneracional significativo similar al comparar la estatura de los varones de la Generación Z con la de sus antepasados maternos. Por el contrario, los resultados muestran que la estatura de las hijas no es significativamente mayor que la de sus padres y abuelos. **Conclusión:** Los hallazgos de este estudio aportan datos valiosos para futuras infraestructuras públicas relacionadas con el transporte, las instituciones educativas y las empresas del sector público, así como para infraestructuras privadas relacionadas con servicios domésticos, instituciones educativas privadas, etc.

Palabras Clave: Antropometría, Intergeneracional, Estatura, Hijos, Padres, Abuelos.

Introduction

The measurement and recording of human body were done dated back to thousands of years ago (Raval and Mehta, 2022). Anthropometry involves the study of human body measurements in different dynamic statures which are useful in the various areas like clothing, ergonomics, anthropology, product design, spatial design etc., (Ashdown, 2014; Malkoc et al., 2014). Anthropometric dimensions of human vary based on various factors like age, ethnicity, geography, human intergeneration, etc. These changes in anthropometric dimensions of human significantly impact the human spaces or workspaces in the home, educational institutions, offices, public facilities etc (Balach et al., 2020; Raval and Mehta, 2022; Jeong and Park 1990).

In India, it has been observed that the anthropometric body height dimensions of intergenerational human tend to change between the generations, and it seems that the height of the current adolescent youth is higher than their parents and grandparents (Sinha et al., 2022; Sachdev et al., 2020; Malkoc et al., 2014). India being the largest populated country in the word, as of time, it is very much important to study the anthropometric body height changes and differences among the intergenerational family members.

This change in the anthropometry body height of the new generation people will have significant impact on consumption pattern of various products and services and also the ergonomics of various public utilities and services (Sachdev et al., 2020; Tur and Bibiloni, 2019). In this study we compare the height of three generation people viz. Gen Z youth, their parents and grandparents with gender as a category and studies the height difference among the intergeneration family members. Based on this, the research questions of this study are framed as follows:

RQ1: Is there any significant difference between the body height of current Gen Z youth and their parents with respect to gender wise?

RQ2: Is there any significant difference between the parents and the grandparents with respect to gender wise?

RQ3: Is there any significant difference between the body height of current Gen Z youth and their both paternal and maternal grandparents with respect to gender wise?

Materials and Methods

Anthropometry

Tur and Bibiloni (2019) refer that the term anthropometry originated from the Greek words ‘anthropos’ which means human and ‘metron’ which means ‘measure’ and the word ‘anthropometria’ was first recorded in a manual by Johann Sigismund Elsholtz in 17th century (Raval and Mehta, 2022). It is a study of organised collection of human body measurements primarily body height, body weight, body shape etc and analysing the correlation between these human body measurements. As anthropometric study deals with the factual human body measurements, it is very much useful to the designers in various field like fashion, furniture etc., to understand the size, shape, proportion etc., so that perfect fit could be provided to the end user of the product (Gouvali and Boudolos, 2006; Jeong and Park 1990; Mandal 1982; Oxford, 1969; Hira, 1980).

Secular trends in Adult Body Height

Human body height is one of the most widely used anthropometric indicators for assessing the nutritional, health and socio-economic conditions of populations. Adult stature reflects the cumulative effects of genetic inheritance, childhood nutrition, disease exposure, health care access and living standards experienced during the growth period. Consequently, secular changes in height across generations are frequently employed as indicators of biological well-being and human development. (NCD Risk Factor Collaboration [NCD-RisC], 2016).

Global height trends

From figure 1, it is observed that average of height of men for countries like Germany, Australia, US, Brazil etc., from 19th century to 20th century has increased steeply, with a difference of almost 10 cms over the century, whereas for India the increase in the height is very gradual with a difference of 5 cms over the century (Ritchie et al., 2024).

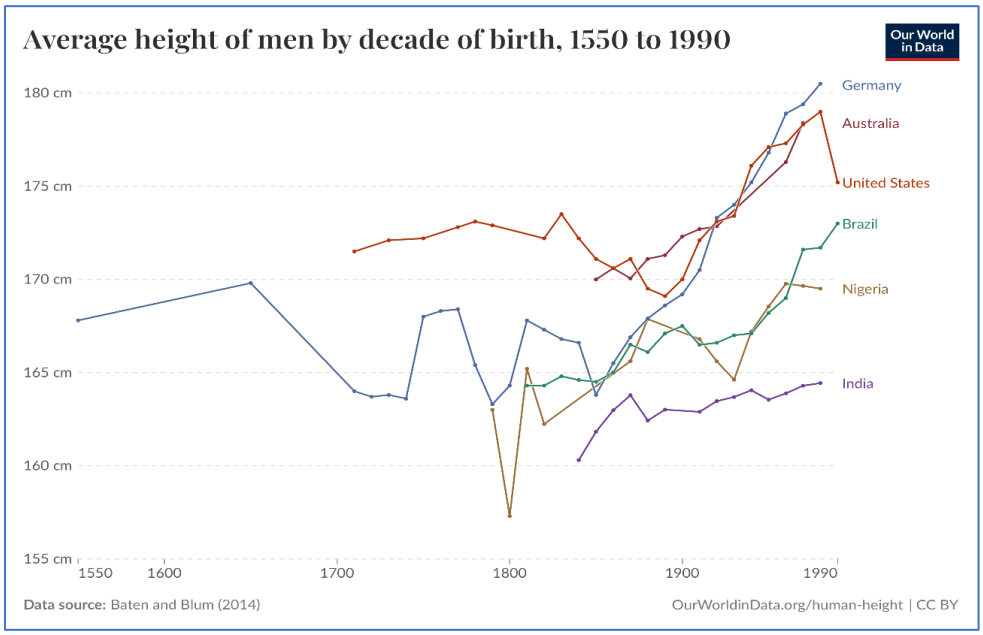

Figure 1. Average height of men by decade of birth of select countries. **Source:** Ritchie et al., (2024)

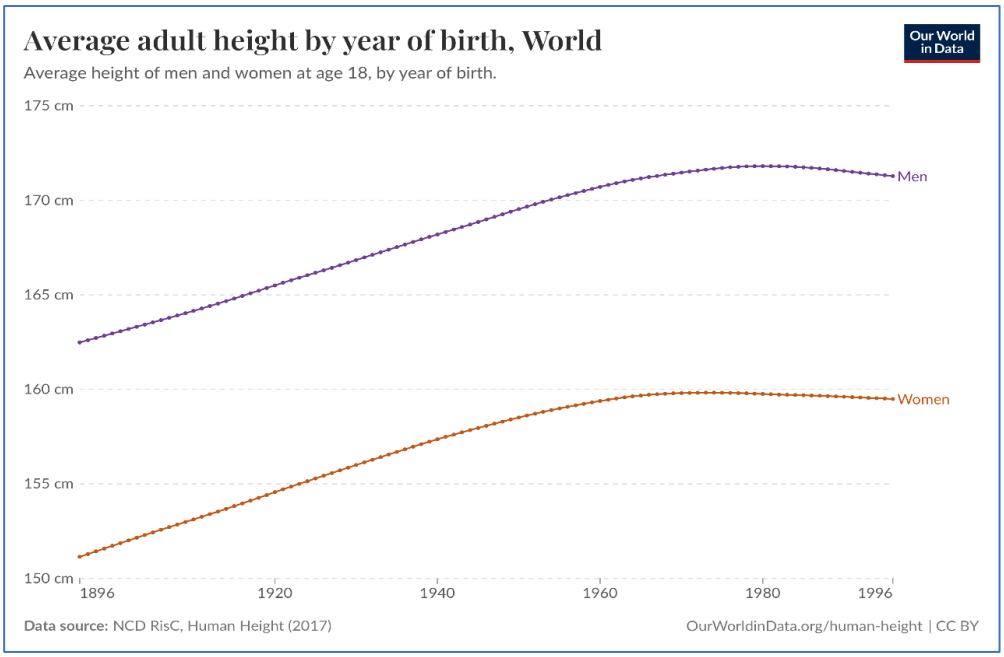

Figure 2. Average adult height by year of birth in the world.

From figure 2, it is observed that men born in 1896 had an average height of approximately 162.5 cms, which increased to aboutn172 cms among those born in 1996. Similarly, women exhibited an increase from approximately 151 cm to 160 cms during the same period. Thus, both genders experience an average gain of nearly 9 – 10 cm over the century. The trend demonstrates a steady increase until approximately the 1970 – 1980 birth cohorts, followed by a slight decline among later cohorts. Such improvements have been attributed primarily to enhanced childhood nutrition, reduced infectious disease burden, improved sanitation, better maternal health and increased socio-economic development throughout the 20th century. A notable feature of the global trend is the persistence of sexual dimorphism. Throughout the century, men remained approximately 11 – 12 cm taller than women. Although genders experienced similar absolute increase in stature, the gender gap remained relatively stable, suggesting that environmental improvements benefited both males and females proportionately (NCD-RisC, 2017).

Indian Height Trends

The Indian height trend differs considerably from the global pattern. The graph indicates that average male height increased from approximately 162 cms in 1896 to 165 cms in 1996, representing a gain of only 3 cms over

the century. Female height increased from approximately 148 cms to 152.6 cms, representing a gain of about 4.6 cms. Compared with global average increase of nearly 10 cms, India's gain were modest. The relatively slow growth in stature reflects persistent challenges related to childhood undernutrition, poverty, unequal access to health care, sanitation deficiencies and recurrent disease burdens that affected several generations during the 20th century. The Indian trend also shows a levelling off in height growth after the 1970 birth cohorts, suggesting that improvement in living conditions did not translate into substantial gains in adult stature at the same pace as observed in many other countries.

This phenomenon may be linked to persistent childhood stunting and nutritional inequalities, particularly among lower socio-economic groups (NCD, 2016).

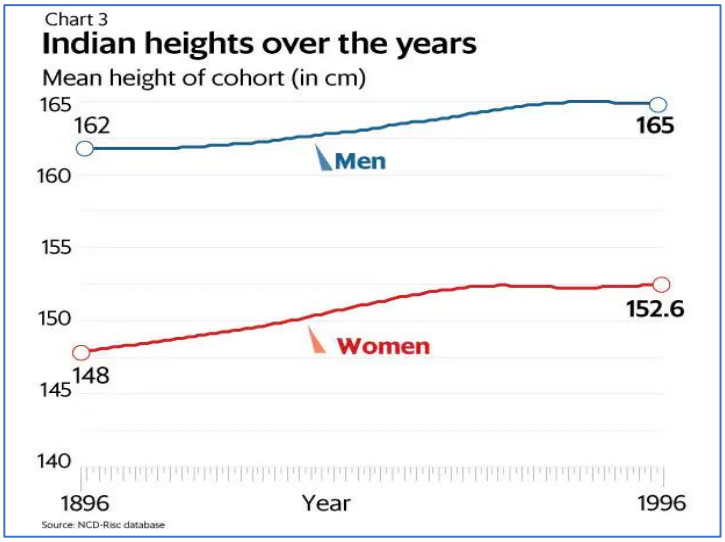

Figure 3. Average adult height by year of birth in India.

Source: NCD Risk Factor Collaboration (NCD-RisC). (2016)

Body Height Changes Among Generations

It has been observed that the anthropometric body measurement of human are varying from one generation to another generation which brings the need for the study of modern lifestyle (Fugiel et al., 2022) and its impact on the human body shape and size (Sinha et al., 2022; Sachdev et al., 2020; Malkoc et al., 2014). The various factors which may influence the change in human body dimensions between the generations are food habits, standard of living, changing lifestyle, adoption of new cultures, physical activities etc. and these changes in anthropometric dimensions brings the need for the periodical update of the human size charts (Balach et al., 2020;).

Continuous improvements in the common living environments will lead to substantial rise in the body metrics like height, weight, BMI etc., within the particular generation. Sikha et al., () find that in an urban middle class society, when the conditions of general living environment got improved, then the children below five year old, have become substantially taller and weightier; children between 5 – 10 years have grown heavier than their parents at the same corresponding years. The study found that generation next children were significantly taller than their parents at corresponding ages; for age categories of 0–5, 5–7.5, 7.5–10, 10–12.5 and >12.5 years, respectively. In absolute terms, this increase ranged from 3.5 cm (0–5 year-olds) to 7.5 cm (10–12.5 year-olds), resulted in the corresponding increases in the absolute BMI increase ranged from 1–3 kg/m^2 at >5 years age to ~3 kg/m^2 at >10-years of age. These changes in the body metrics among the intergenerational kids were comparable in both genders, but found to be greater in children born and measured later years. This result shows that favourable changes in socioeconomic conditions is associated with an increase in height across the intergeneration (Sikha et al., Ray et al., 1995).

Impact of anthropometry study

The development of designs related to the classroom or laboratory furniture and spatial designs should be based on the anthropometric measurements of school students else the furniture and spatial design would adversely affect the physical and psychological state of the school students as they spend most of the daytime in the school (Malkoc et al., 2014; Jeong, 1990; Floyd, 1958; Oxford, 1969; Yip et al., 1988). To improve the

functionality of the product design the relationship among the different body dimensions should be known (Kayış and Özok, 1986; Mandal, 1982*)* particularly in the field of mass production where ergonomics plays a vital role in the production efficiency and quality assurance (Hira, 1980; Floyd and Ward, 1969).

The body metrics of teenagers is also influenced by the environmental factors besides the other factors like genetic etc. Sleeping pattern, food habits, mental state, physical activities are also impact the body development and its related body metrics (Xiang et al., 2020).

Anthropometric measures of women agricultural workers are also to be considered for the streamlining the design of agricultural hand tools, instruments and equipment (Philip and Tewari, 2000; Tewari, 2007). Application of anthropometric data can be useful in the suitable design of tools for enhanced efficiency and better human comfort. Present anthropometric data of Indian farm workers could be useful in the design of farm equipment (Yadav et.al., 1997; Sen et.al., 1977; Singh et al., 2006). Gupta et.al., (1983) state that there is a substantial difference between the anthropometric measures of Indian and Western population. Therefore, anthropometric data of women is very much required for design development of any agriculture tool for the woman

Materials and Methods

Data related to height for this quantitative and descriptive study were collected between 2024 and 2026. The available data related to height based on the persons who are alive were collected through the Gen Z youth children. The same ancestral background of the participants was determined as grandparent–parent–Gen Z youth children. The sample size of Gen Z youth children was 97. A structured questionnaire using Google forms was circulated to the Gen Z youth who were selected based on purposive and convenience sampling method. The height and weight data of the Gen Z youth, their parents and their grand parents were collected from the Gen Z youths.

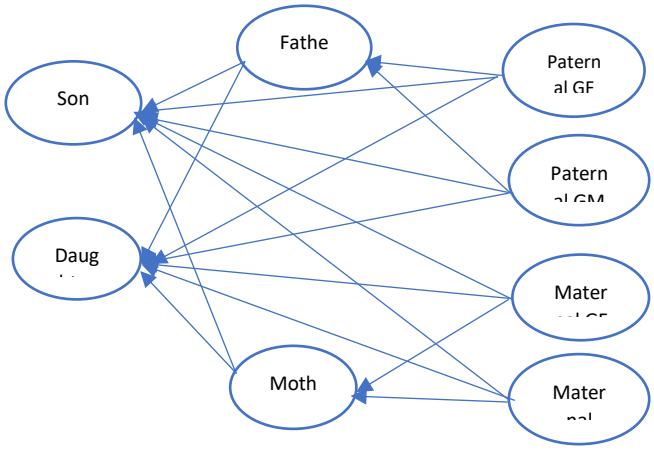

Figure 4. Conceptual Framework – Height differences in Intergeneration.

Source: Developed by author

Hypothesis

The hypotheses of this study are as follows:

H1: Body Height of Gen Z youth sons and their parents & grandparents are significantly different

- H1a: Height of Gen Z youth son is significantly greater than the height of their father
- H1b: Height of Gen Z youth son is significantly greater than the height of their mother
- H1c: Height of Gen Z youth Son is significantly greater than the height of their Paternal Grand Father
- H1d: Height of Gen Z youth son is significantly greater than the height of their Paternal Grand Mother
- H1e: Height of Gen Z youth son is significantly greater than the height of their Maternal Grand Father
- H1f: Height of Gen Z youth son is significantly greater than the height of their Maternal Grand Mother

H2: Body Height of Gen Z youth daughter's and their parents & grandparents are significantly different

- H2a: Height of Gen Z youth daughters' is significantly greater than the height of their Father
- H2b: Height of Gen Z youth daughters' is significantly greater than the height of their Mother
- H2c: Height of Gen Z youth daughters' is significantly greater than the height of their Paternal Grand Father
- H2d: Height of Gen Z youth daughters' is significantly greater than the height of their Paternal Grand Mother.
- H2e: Height of Gen Z youth daughters' is significantly greater than the height of their Maternal Grand Father
- H2f: Height of Gen Z youth daughters' is significantly greater than the height of their Maternal Grand Mother

H3: Body Height of Parents is significantly greater than the height of the grand parents

- H3a: Height of Father is significantly greater than the height of Paternal Grand Father
- H3b: Height of Father is significantly greater than the height of Paternal Grand Mother
- H3c: Height of Mother is significantly greater than the height of Maternal Grand Father
- H3d: Height of Mother is significantly greater than the height of Maternal Grand Mother

Results

Demographic Descriptives

Table 1 presents the demographic characteristics of the study participants. Of the 97 respondents, 24 (24.7%) were male and 73 (75.3%) were female, indicating a higher representation of female participants in the sample. Regarding residential location, 48 respondents (49.5%) were from semi-urban areas, followed by 30 (30.9%) from urban areas and 19 (19.6%) from rural areas. Thus, the sample was predominantly female and represented mainly semi-urban populations, as shown in Table 1.

Table 1. Demographic Descriptives

Demography	Category	Frequency	Percent
Gender	Male	24	24.7
	Female	73	75.3
	Total	**97**	**100.0**
Location	Urban	30	30.9
	Semi Urban	48	49.5
	Rural	19	19.6
	Total	**97**	**100.0**

Descriptive statistics

The descriptive statistics of the study is shown in the table 2.

Table 2. Descriptive statistics

	Daughters' Height	Sons' Height	Fathers' height	Mothers' height	Paternal Grand Fathers' Height	Paternal Grand Mothers' Height	Maternal Grand Fathers' Height	Maternal Grand Mothers' Height
N	73	24	97	96	52	65	57	67
Height (Mean)	159	172.3	169.2	157.2	168.7	153.5	168.4	154.5
SD	7.552	6.622	7.56	7.264	9.128	8.27	6.952	8.557
SE	0.884	1.352	0.768	0.741	1.266	1.026	0.921	1.045

From table 2., it is observed that the average height of daughter is 159 cms (n=73); son is 172.3 cms (n=24); father is 169.2 cms (n=97); mother is 157.2 cms (n = 96); paternal grandfather is 168.7 cms (n = 52); paternal grandmother is 153.5 cms (n = 65); maternal grandfather is 168.4 cms (n=57); and maternal grandmother is 154.5 cms (n=67).

Test for Son's height Vs parent's and Grandparent's height

Table.3 provides Paired Sample T-test results of Son's Height verses parent's and Grandparent's height.

Table 3. Paired Sample T-test Son's Height Vs parent's and Grandparent's height

Test	t	df	p
Son's height > Father's height	2.344	23	.014
Son's height -> Mother's height	7.191	23	< .001
Son's height > Paternal Grand Father's Height	1.212	18	.121
Son's height > Paternal Grand Mother's Height	8.194	19	< .001
Son's height > Maternal Grand Father's Height	1.890	16	.039
Son's height > Maternal Grand Mother's Height	8.647	18	< .001

Sons' height vs Fathers' height

The test result shows that the sons' height (m=172.3 cms) is significantly greater (t=2.344; p<.05) than the fathers' height (m=169.2 cms). The same has been shown in the figure 5. This result provide support for the hypothesis H1a that the height of Gen Z youth son is significantly greater than the height of their father. So H1a is accepted.

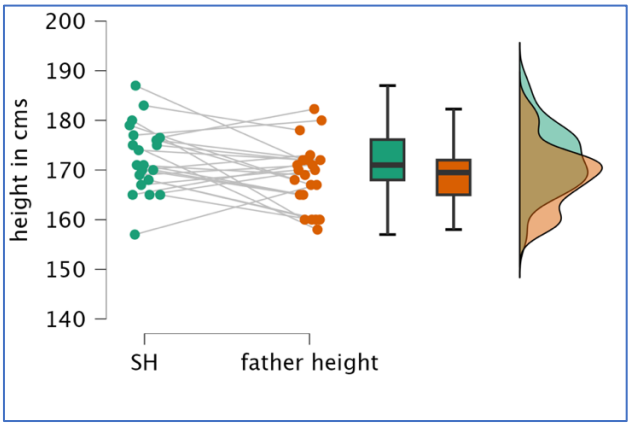

Figure 5. Rain cloud plot - Son's Height Vs Father's height.

Sons' height vs Mothers' height

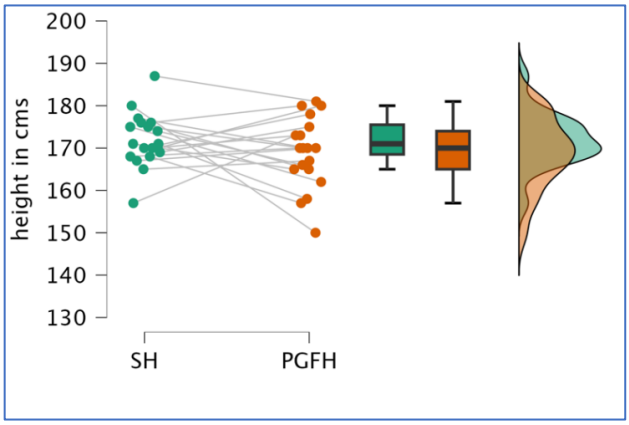

Figure 6. Rain cloud plot - Son's Height Vs Mother's height.

The test result shows that the sons' height (m=172.3 cms) is significantly greater than (t=7.191; p<.05) the mothers' height (m=157.2 cms). The same has been shown in the figure 6. This result provide support for the

hypothesis H1b that the height of Gen Z youth son is significantly greater than the height of their mother. So H1b is accepted.

Sons' height vs Paternal Grandfathers' height

The test result shows that the sons' height (mean=172.3 cms) is greater (t=1.212; p>.05) than the paternal grand fathers' height (mean=168.7 cms) but it is not significant. The same has been shown in the figure 7. This result does not fully support the hypothesis H1c that the height of Gen Z youth sons' is significantly greater than the height of their paternal grand fathers'. So H1c is partially accepted.

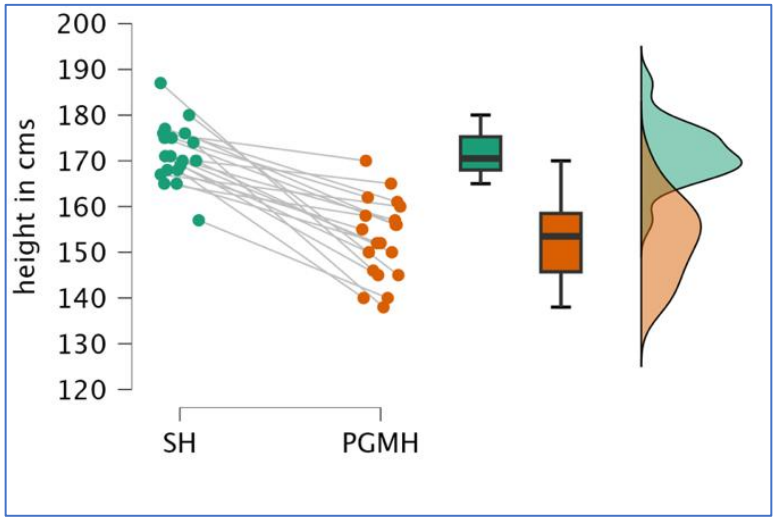

Figure 7. Rain cloud plot - Son's Height Vs Paternal Grand Father's height.

Sons' height vs Paternal Grand Mothers' height

The test result shows that the sons' height (mean=172.3 cms) is significantly greater than (t=8.194; p<.05) the paternal grand mothers' height (mean=153.5 cms). The same has been shown in the figure 8. This result provides support the hypothesis H1d that the height of Gen Z youth sons is significantly greater than the height of their paternal grand mothers is significantly different. So H1d is accepted.

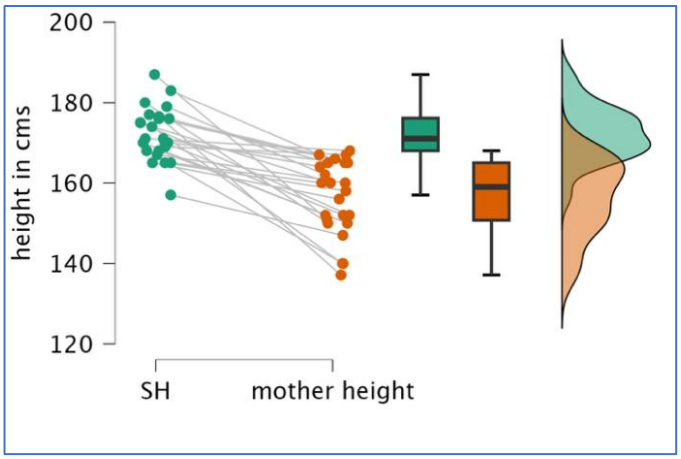

Figure 8. Rain cloud plot - Son's Height Vs Paternal Grand Mother's height.

Sons' height vs Maternal Grand Fathers' height

The test result shows that the sons' height (mean=172.3 cms) is significantly greater than (t=1.890; p<.05) the maternal grand fathers' height (mean=168.4 cms). The same has been shown in the figure 9. This result provides support the hypothesis H1e that the height of Gen Z youth sons is significantly greater than the height of their maternal grand fathers. So H1e is accepted.

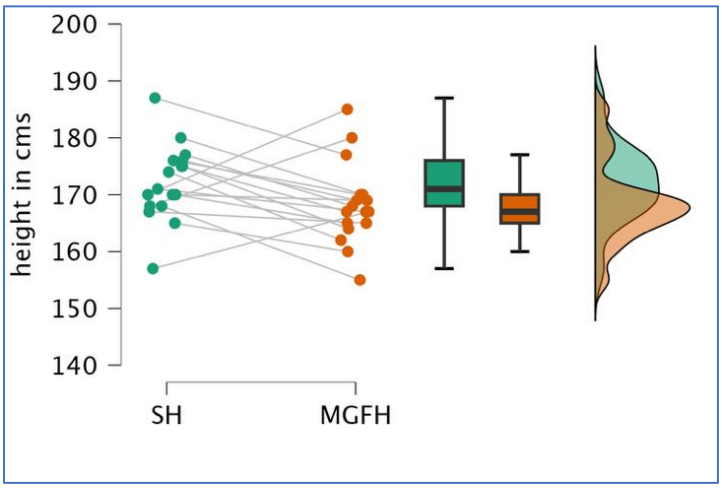

Figure 9. Rain cloud plot - Son's Height Vs Maternal Grand Father's height.

Sons' height vs Maternal Grand Mothers' height

The test result shows that the sons' height (mean=172.3 cms) is significantly greater than (t=8.647; p<.05) the maternal grand mothers' height (mean=154.5 cms). The same has been shown in the figure 10. This result provides support the hypothesis 1e that the height of Gen Z youth sons is significantly greater than the height of their maternal grand mothers. So H1e is accepted.

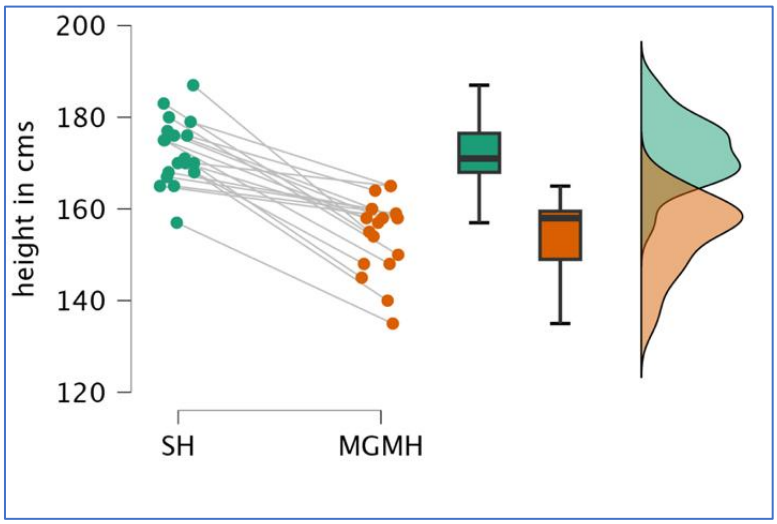

Figure 10. Rain cloud plot - Son's Height Vs Maternal Grand Mother's height.

Test for Daughters' height Vs Parents' and Grandparents' height

Table. 4. Paired Sample T-test Daughters' Height Vs parent's and Grandparent's height

Test	t	df	p
Daughters' height > Father's height	-10.51	72	1.000
Daughters' height > Mother's height	2.104	71	.019
Daughters' height > Paternal Grand Father's Height	-5.345	32	1.000
Daughters' height > Paternal Grand Mother's Height	3.013	44	.002
Daughters' height > Maternal Grand Father's Height	-6.749	39	1.000
Daughters' height > Maternal Grand Mother's Height	2.490	47	.008

`Table. 4 provides Paired Sample T-test results of Daughter's Height verses parent's and Grandparent's height.

Daughters' height vs Fathers' height

The test result shows that the daughters' height (mean=159.0 cms) is not significantly greater than (t= -10.51.647; p>.05) the fathers' height (mean=169.2 cms). The same has been shown in the figure 11. This result does not provide support the hypothesis H2a that the height of Gen Z youth daughter is significantly greater than the height of their fathers. So H2a is not accepted.

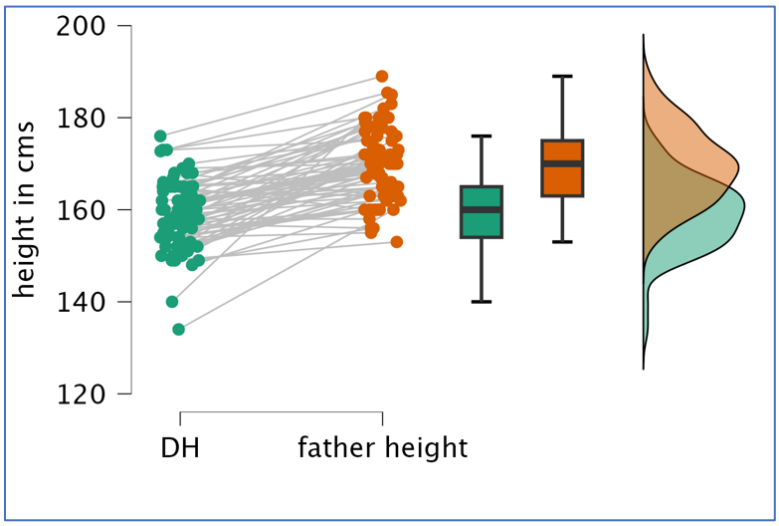

Figure 11. Rain cloud plot – Daughters' Height Vs Fathers' height.

Daughters' height vs Mothers' height

The test result shows that the daughters' height (mean=159.0 cms) is significantly greater than (t=2.104; p<.05) the mothers' height (mean=157.2 cms). The same has been shown in the figure 12. This result provide support for the hypothesis H2b that the height of Gen Z youth daughter is significantly greater than the height of their mothers. So H2b is accepted.

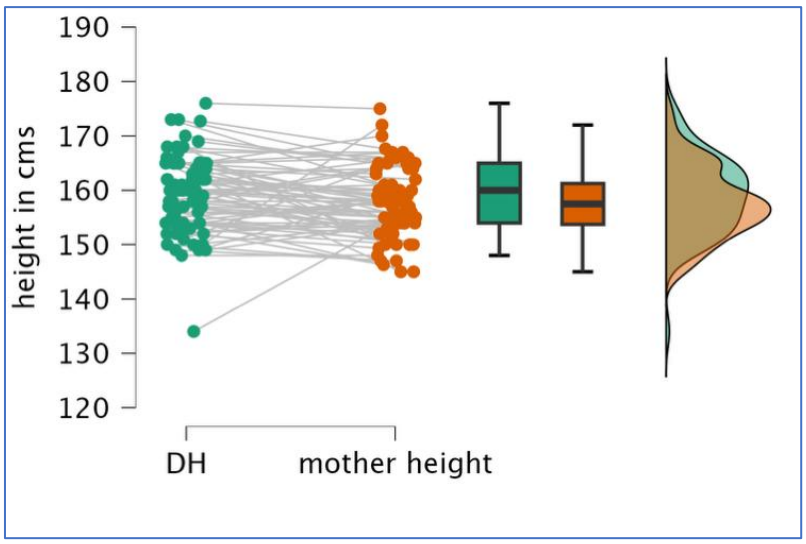

Figure 12. Rain cloud plot – Daughters' Height Vs Mothers' height.

Daughters' height vs Paternal Grand Fathers' height

The test result shows that the daughters' height (mean=159.0 cms) is not significantly greater than (t= -5.345; p>.05) the paternal grand fathers' height (mean=168.7 cms). The same has been shown in the figure 13. This result does not provide support for the hypothesis H2c that the height of Gen Z youth daughter is significantly greater than the height of their paternal grand fathers'. So H2c is not accepted.

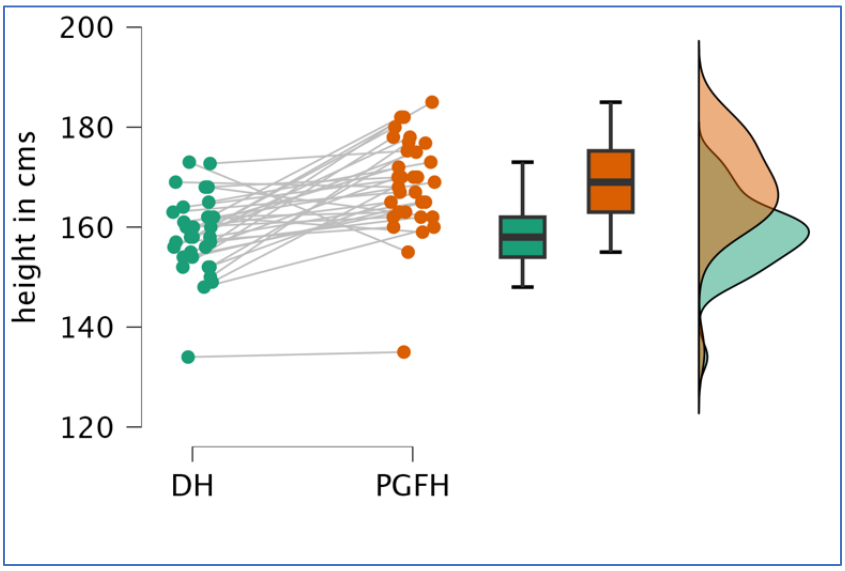

Figure 13. Rain cloud plot – Daughters' Height Vs Paternal Grand Fathers' height.

Daughters' height vs Paternal Grand Mothers' height

The test result shows that the daughters' height (mean=159.0 cms) is significantly greater than (t=3.013; p<.05) the paternal grand mothers' height (mean=153.5 cms). The same has been shown in the figure 14. This result provide support for the hypothesis H2d that the height of Gen Z youth daughter is significantly greater than the height of their paternal grand mothers. So H2d is accepted.

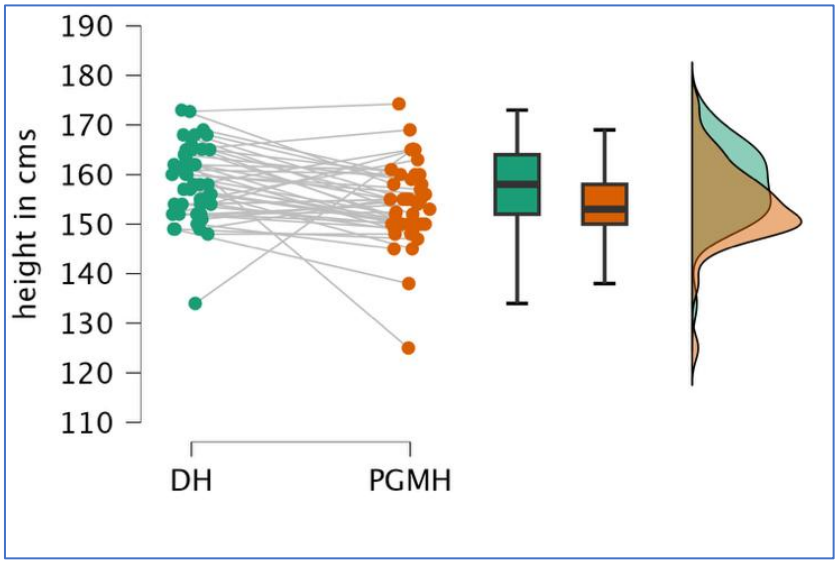

Figure 14. Rain cloud plot – Daughters' Height Vs paternal Grand Mothers' height.

Daughters' height vs Maternal Grand Fathers' height

The test result shows that the daughters' height (mean=159.0 cms) is not significantly greater than (t= -6.749; p>.05) the maternal grand fathers' height (mean=168.4 cms). The same has been shown in the figure 15. This result does not provide support for the hypothesis H2e that the height of Gen Z youth daughter is significantly greater than the height of their maternal grand fathers. So H2e is not accepted.

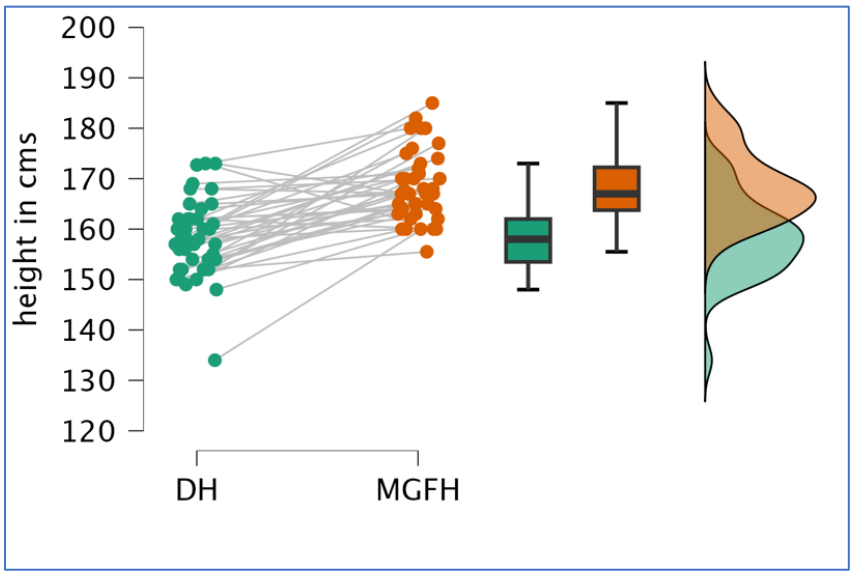

Figure 15. Rain cloud plot – Daughters' Height Vs maternal Grand Fathers' height.

Daughters' height vs Maternal Grand Mothers' height

The test result shows that the daughters' height (mean=159.0 cms) is significantly greater than (t=2.490; p<.05) the maternal grand mothers' height (mean=154.8 cms). The same has been shown in the figure 16. This result provide support for the hypothesis H2f that the height of Gen Z youth daughter is significantly greater than the height of their maternal grand mothers. So H2e is accepted.

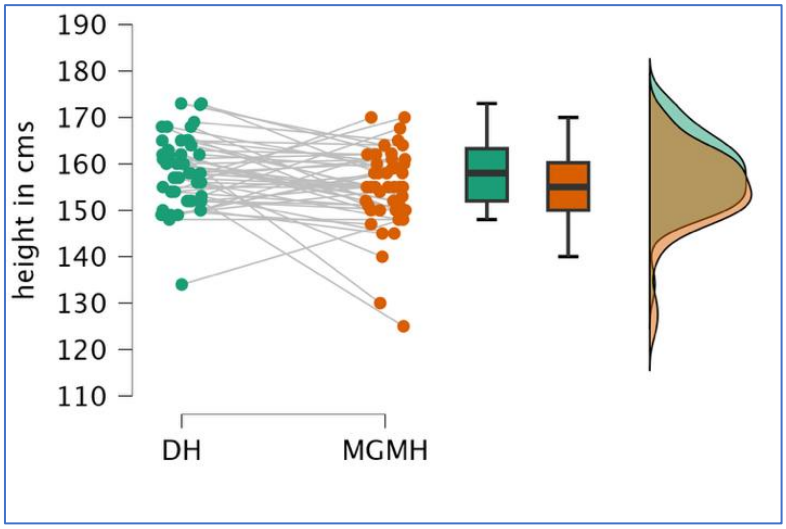

Figure 16. Rain cloud plot – Daughters' Height Vs maternal Grand mothers' height.

Test for Parents Height

Table 5. Paired Sample T-test Fathers' Height Vs Grandparents' height

Test	t	df	p
Father's height > Paternal Grand Father's Height	0.135	51	.893
Father's height > Paternal Grand Mother's Height	12.94	64	< .001
Mother's height > Maternal Grand Father's Height	-11.06	56	< .001
Mother's height > Maternal Grand Mother's Height	2.698	66	.009

Table. 5 provides the Paired Sample T-test Fathers' Height verses Grandparents' height.

Fathers' height vs Paternal Grand Fathers' height

The test result shows that the fathers' height (mean=169.2 cms) is greater than (t= 0.135; p>.05) the paternal grand fathers' height (mean=168.7 cms) but not significant. The same has been shown in the figure 17. This result partially provide support for the hypothesis H3a that the height of fathers is significantly greater than the height of paternal grandfathers. So H3a is partially accepted.

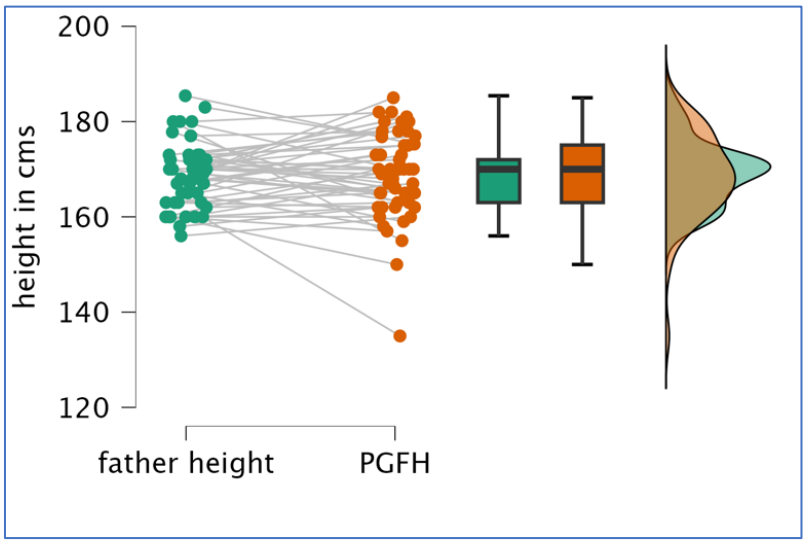

Figure 17. Rain cloud plot – Fathers' Height Vs paternal Grand Fathers' height.

Fathers' height vs Paternal Grand Mothers' height

The test result shows that the fathers' height (mean=169.2 cms) is significantly greater than (t= 12.94; p<.05) the paternal grand mothers' height (mean=153.5 cms). The same has been shown in the figure 18. This result partially provide support for the hypothesis H3b that the height of fathers is significantly greater than the height of paternal grand mothers. So H3b is accepted.

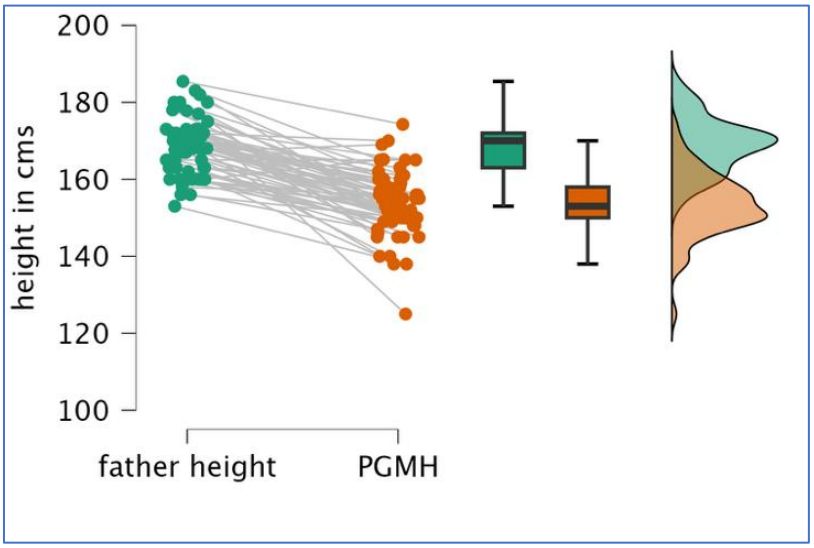

Figure 18. Rain cloud plot – Fathers' Height Vs paternal Grand Mothers' height

Mothers' height vs Maternal Grand Fathers' height

The test result shows that the mothers' height (mean=157.2 cms) is not significantly greater than (t= -11.06; p>.05) the maternal grand fathers' height (mean=168.4 cms). The same has been shown in the figure 19. This result does not provide support for the hypothesis H3c that the height of mothers is significantly greater than the height of maternal grand fathers. So H3c is not accepted.

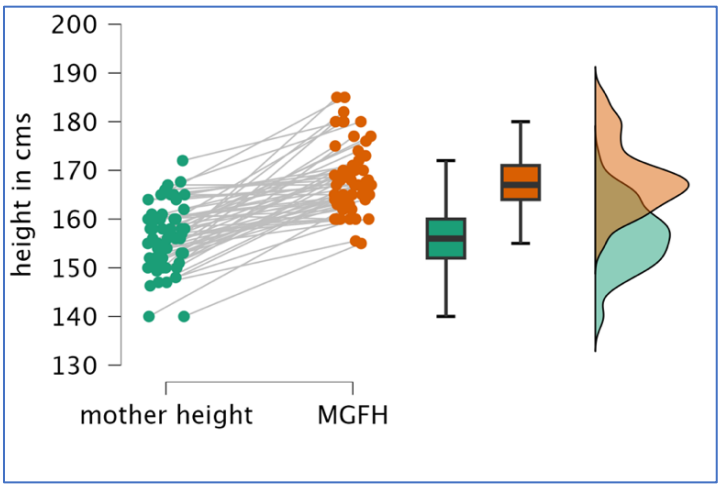

Figure 19. Rain cloud plot – Mothers' Height Vs maternal Grand fathers' height.

Mothers' height vs Maternal Grand Mothers' height

The test result shows that the mothers' height (mean=157.2 cms) is significantly greater than (t= 2.698; p<.05) the maternal grand mothers' height (mean=154.5 cms). The same has been shown in the figure 20. This result provides support for the hypothesis H3d that the height of mothers is significantly greater than the height of maternal grand mothers. So H3d is accepted.

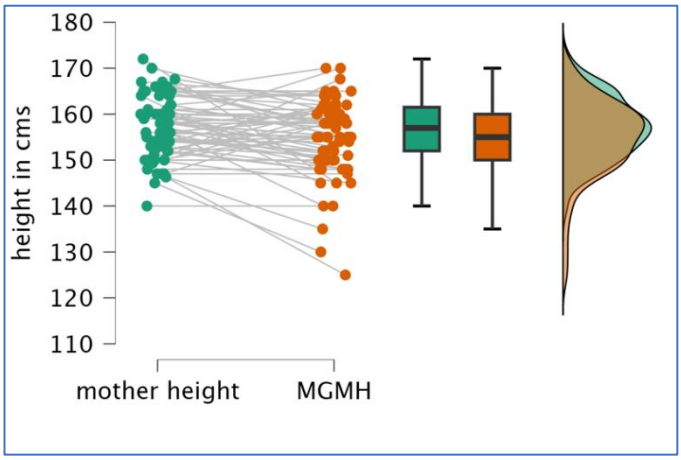

Figure 20. Rain cloud plot – Mothers' Height Vs maternal Grand Mothers' height.

Inter-generational Change in Height

Figure 21 shows the intergenerational change in height from grandparents to grandchildren. The average height of male generation has increased from the grandfathers to fathers to the son 168.55 cms to 169.2 cms to 172.3 cms respectively. The average height of female generation has increased from the grandmothers to mothers to the daughter 154 cms to 157 cms to 159 cms.

Figure 22, indicates that average male height increased from approximately 162 cms in 1896 to 165 cms in 1996 to 172.3 cms in GenZ male child, representing a gain of only 3 cms in a century but from 1996 to present Gen Z height it shows a significant increase of 7 cms in 30 years. For, female height increased from approximately 148 cms in 1896 to 152.6 cms in 1996 to 159 cms in present Gen Z female child representing a gain of about 6.4 cms in a century in 30 years.

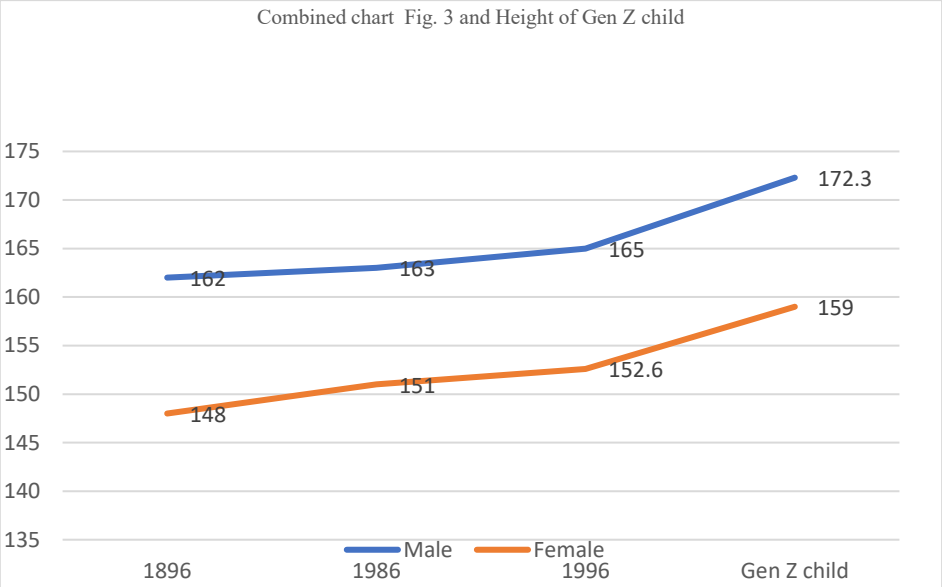

Figure 21. Inter-generational Change in Height.

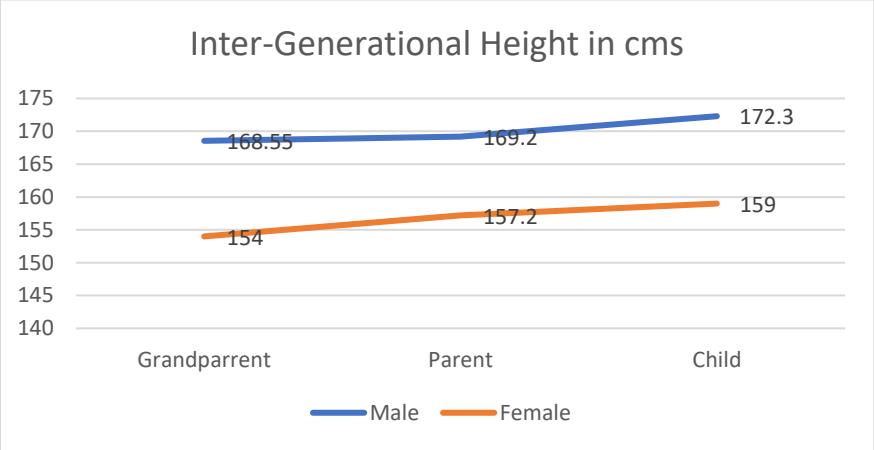

Figure 22. Combined Indian Height Change chart (Figure 3 and Gen Z height).

Discussions

The findings show that Gen Z Son height is significantly taller than their parents and grandparents. Gen Z daughter height is significantly taller than their mother and grandmothers but not for their father and grandfathers. Significant change in the height in the intergeneration within the same gender.

The increase in body height of the Gen Z children will have significant effect on the various things which are need to consider seriously in the future. The change in height mainly will have effect on the human body posture which subsequently will have effect on the various public and private infrastructure facilities and also the consumption patterns on various products like apparel, accessories etc. The main three human body postures here discussed are seating, standing and sleeping postures.

Seating

The increase in the body height dimensions will have a significant impact on the seating activities or postures. In a standard sitting posture, a person sits erect on horizontal, flat surface, pulled up to his full height and looking straight ahead. The height of the seat is adjusted until the thighs are horizontal and the lower legs are vertical (Pheasant, 2003). The seat surface also to be considered for provide proper shaping or padding to provide an appropriate distribution of pressure beneath the buttocks. The seat height, seat depth, seat width, back rest dimensions, back rest angle and seat angle, as shown in the figure. 23 (Pheasant, 2003). In future, proper necessary focus to be given on the seating facilities in both at workplaces, public transportation faculties and household facilities.

Similarly, the leg room space allocation also to be given much importance in above mentioned places. In a variety of sitting workstations, the provision of adequate lateral, vertical and forward leg room is essential to provide a satisfactory sitting posture to the users. Leg room allocation and calculation include lateral leg room, vertical leg room and forward leg room as shown in the figure. 24 (Pheasant, 2003).

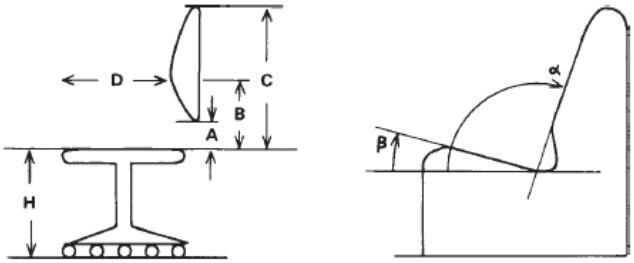

Figure 4.8 Seat dimensions.

Source: Phesant, 2002

Figure 23. Seating features.

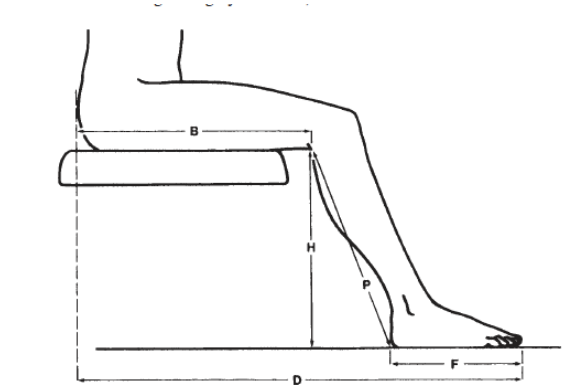

Figure 4.9 Calculation of forward leg room.

Figure 24. Legroom calculation

Source: Phesant, 2002

Because of the change in height and its related change in seating posture, the gap between the seats will be wider than before, in the transport facilities like bus, train, flight, car etc. Then the measurement of seats will be changed. If the gap between the seats becomes wider, then the number of seats in the transportation facilities like buses, trains, flights etc., will be reduced thus it will lead to occupy lesser number of passengers. This may affect the business turnover of these companies. In case of cars, the length of the cars might also to be increased because of the requirement of broader leg room. In apparel industry, in the sewing section the workers will work in the sitting poster so proper alterations to be made for the better production efficiency.

Class rooms and Auditoriums: The design of chair and classroom desks to be changed as per the latest anthropometric data.

Toilet seats: The design and size of the toilet seats need to be increased both in private facilities and public facilities. In trains and flights, the size of the toilet room to be increased further it will affect the space utilisation.

Workplace ergonomics: The increase in the height of Gen Z youth will have significant impact in the workplace ergonomics related to seat dimensions, space dimensions, machine layout calculation etc.,

Standing

In the standard standing posture, the person stands erect, pulling himself up to his full height and looking straight ahead, with his shoulders relaxed and his arms hanging loosely by his sides. The person stands fee of walls, measuring instruments etc (Pheasant, 2003). In future, proper necessary focus to be given on the standing facilities and its related criteria for optimal and satisfactory working heights in at workplaces, public transportation faculties and household facilities as shown in figure. 25. In apparel industry, in the fabric section, cutting section,

checking section, ironing section, packing section the workers will work in the standing poster so proper alterations to be made for the better production efficiency.

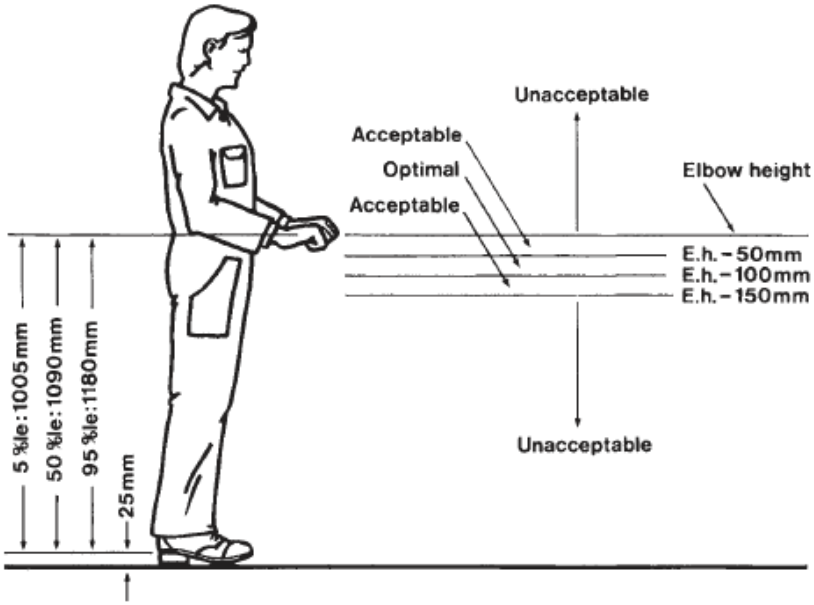

Figure 2.6 Criteria for optimal and satisfactory working heights in an industrial assembly task.

Figure 25. Standing posture

Source: Phesant, 2002

The inner height of various public facilities like ordinary public buses etc., and private vehicles like cars need to be increased.

Sleeping

The increase in height also will considerably affect the sleeping posture. The size of the bed, bedsheets, mattress, need to be increased accordingly. In Indian trains, in the sleeper coach the berth seat length is approximately 172 cms. The present berth length poses challenges for the Gen Z youth because their feet will be extended beyond the length reaching the aisle passage which will further give discomfort to both the sleeping passenger and the walking passenger. The same problem will occur in the sleeper buses and in the flights.

Clothing and Accessories

In apparel and clothing industry, the clothing consumption will increase by the users because of the increase in height and the need for new higher size of garments like in western countries to be included in the garment size planning. The size ranges may start from XS, S, M, L, XL, XXL and 3XL. Body size chart specific to Indian consumers have been developed by National Institute of Fashion Technology through their 'India Size Project' which can be referred for further purposes. The change in the body height will also impact the accessories like footwear, watch etc., where again the size range of the shoes, chappals, etc., to be increased as like in the case of apparel industry.

It is suggested that Periodical assessment and update of growth and development of anthropometrical data is necessary. Yip et al., (1988) suggest that the assessment and update of anthropometrical data should be done at every five years and some scholars (Sinha et al., 2022) suggest that anthropometric measurement values during the childhood should be updated at every ten years.

Conclusion

The work is aimed at to study the intergenerational body height changes in India and significant results were found in case of Gen Z youth son and with their parents and grandparents. The findings from the global and Indian height trends have important implications for anthropometric studies involving Generation Z and intergenerational comparisons. If the current Gen Z populations exhibit taller height than their parents and grandparents, such changes may reflect improvements in nutrition, healthcare and living standards. For studies investigating body height among Indian Gen Z youth and their parental and grandparental generations, secular

trends should be interpreted within the broader context of socioeconomic development, public health improvements, food habits etc. The findings of this study provide valuable data for future public infrastructure facilities related to transports, educational institutions, public sector undertaking and private infrastructure facilities related to house hold utilities, private educational institutions etc. Most importantly the findings provide a critical empirical data for apparel and its related industries. These findings will help into revise the garment fit, comfort and functional performance and their improvements. This study also helps in garment size customisation and garment design for the current Gen Z population.

References

Ashdown, S.P. (1998). An investigation of the structure of sizing systems. A comparison of three multidimensional optimized sizing systems generated from anthropometric data with the ASTM standard D5585-94. *International Journal of Clothing Science and Technology*. 10(5), 324–41. https://doi.org/10.1108/09556229810239324

Balach, M., Lesiakowska-Jablonska, M., Frydrych, I. (2020). Anthropometry and Size Groups in the Clothing Industry. *Autex Research Journal*, 20(1), 56-62. https://doi.org/10.2478/aut-2019-0001

Floyd, W. F., & Ward, J. S. (1969). Anthropometric and physiological considerations in school, office and factory seating. *Ergonomics,* 12(2), 132–139. https://doi.org/10.1080/00140136908931041

Floyd, W.F., Roberts, D.F. (1958). Anatomical and physiological principles in chair and table design. *Ergonomics,* 2(1), 1–16. https://doi.org/10.1080/00140135808930397

Fugiel, J., Kochan-Jache´c, K., Kozlenia, D., Domaradzki, J. (2022). Changes in anthropometric measurements and physical fitness of Polish students in 20-year period. *International Journal of Environmental Research and Public Health*, 19(24), 16885. https://doi.org/10.3390/ijerph192416885

Gouvali, M.K., Boudolos, K. (2006) Match between school furniture dimensions and children's anthropometry. *Applied Ergonomics,* 37(6), 765-773. https://doi.org/10.1016/j.apergo.2005.11.009

Gupta, P.K., A.P. Sharma, M.L. Gupta (1983). Anthropometric survey of Indian farm workers. *Agriculture Mechanization in Asia, Africa and Latin America* 16(1), 27– 30.

Hira, D.S. (1980). An ergonomic appraisal of educational desks. *Ergonomics*, 23(3), 213–221. https://doi.org/10.1080/00140138008924735

Jeong, B.Y., Park, K.S. (1990). Sex differences in anthropometry for school furniture design. Ergonomics, 33(12), 1511–1521. https://doi.org/10.1080/00140139008925350

Kayış, B., & Özok, A. F. (1986). İlkokul çocuklarının antropometrik ölçüleri ve sıra-masa boyutlarının optimizasyonu [Anthropometric measurements of primary school children and optimization of desk-chair dimensions]. *Endüstri Mühendisliği Dergisi*, (1), 15–23.

Malkoc, İ., Kaya, M.D., Erdogan, O., Kara, A., Yesilyurt, H., Ozkan, B. (2014). Are new generations getting bigger in size? Anthropometric measurements in Erzurum. *The Eurasian Journal of Medicine*, 46(3), 192–197. https://doi.org/10.5152/eajm.2014.54

Mandal, A.C. (1982). The correct height of school furniture. *Human Factors,* 24(3), 257–269. https://doi.org/10.1177/001872088202400301

NCD Risk Factor Collaboration (NCD-RisC). (2016). A century of trends in adult human height. *eLife, 5*, e13410. https://doi.org/10.7554/eLife.13410

Oxford, H.W. (1969). Anthropometric data for educational chairs. *Ergonomics,* 12(2), 140–161. https://doi.org/10.1080/00140136908931042

Pheasant, S., Haslegrave, C.M. (2003). *Bodyspace: Anthropometry, ergonomics and the design of work* (2nd ed.). Taylor & Francis.

Philip, G.S., Tewari, V.K. (2000). Anthropometry of Indian female agricultural workers and implication on tool design. *Agricultural Mechanization in Asia, Africa and Latin America,* 31(1), 63–66.

Raval, H.J., Mehta, S.P. (2022). Anthropometric measurements: A boon for recording vertical dimension of occlusion. *International Journal of Health Sciences,* 6(S3), 5729–5734. https://doi.org/10.53730/ijhs.v6nS3.7228

Ray, G.G., Ghosh, S., Atreya, V. (1995). An anthropometric survey of Indian schoolchildren aged 3–5 years. *Applied Ergonomics,* 26(1), 67–72. https://doi.org/10.1016/0003-6870(94)00002-G

Ritchie, H., Roser, M., Ortiz-Ospina, E. (2024). Human height. *Our World in Data*. https://ourworldindata.org/human-height

Sachdev, H.S., Kathuria, A.K., Sinha, S., Anand, D., Bhargava, S.K. (2020). *Association of human capital with physical growth from birth to adulthood: Evidence from the New Delhi Birth Cohort, India*. World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/212721596523665354

Sen, R.N., Nag, P.K., Ray, G.G. (1977). Some anthropometry of the people of Eastern India. *Journal of the Indian Anthropological Society, 12*, 199–207.

Singh, S.P., Gite, L.P., Agarwal, N. (2006). Improved farm tools and equipment for women workers for increased productivity and reduced drudgery. *Gender, Technology and Development,* 10(2), 229–244. https://doi.org/10.1177/097185240601000204

Sinha, S., Shah, D., Osmond, C., Fall, C.H.D., Bhargava, S.K., Sachdev, H.S. (2022). Intergenerational change in anthropometry of children and adolescents in the New Delhi Birth Cohort. *International Journal of Epidemiology,* 51(1), 291–302. https://doi.org/10.1093/ije/dyab142

Tewari, V. K., Ailavadi, R., Dewangan, K.N., Sharangi, S. (2007). Rationalized database of indian agricultural workers for equipment design. *International Commission of Agricultural Engineering,* 1-12. https://hdl.handle.net/1813/10227

Tur, J.A., Bibiloni, M.D.M. (2019). Anthropometry, Body Composition and Resting Energy Expenditure in Human. *Nutrients*, 11(8), 1891. https://doi.org/10.3390/nu11081891

Xiang, M., Zhang, Z., Kuwahara, K. (2020). Impact of COVID-19 pandemic on children and adolescents' lifestyle behavior larger than expected. *Progress in Cardiovascular Diseases,* 63(4), 531–532. https://doi.org/10.1016/j.pcad.2020.04.013

Yadav, R., Tewari, V.K., Prasad, N. (1997). Anthropometric data of Indian farm workers: A module analysis. *Applied Ergonomics,* 28(1), 69–71. https://doi.org/10.1016/S0003-6870(96)00022-1

Yip, R., Binkin, N.J., Trowbridge, F.L. (1988). Altitude and childhood growth. *The Journal of Pediatrics,* 113(3), 486–489. https://doi.org/10.1016/S0022-3476(88)80633-4

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