RESEARCH PAPER

Intergenerational Change in Anthropometric Indices and Their Predictors Among Children in New Delhi Birth Cohort

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Objective: To evaluate intergenerational change in anthropometric indices of children and their predictors.

Design: Prospective cohort.

Participants: New Delhi Birth Cohort participants (F1), born between 1969 and 1972, were followed-up for anthropometry at birth and 6-monthly intervals until 21 years. Their children (F2) below 10 years were evaluated anthropometrically.

Outcome measure: Intergenerational change (F2-F1) in height, weight and body mass index (BMI) of children in comparison to their parents at corresponding ages.

Results: 432 F2-F1 pairs were analyzed in age-groups of 0-5 (26.9%) and 5-10 (73.1%) years. Children were considerably taller (0-5 years 0.99 SD; 5-10 years 1.17 SD) and heavier (0-5 years 0.77 SD; 5-10 years 1.52 SD) while only those aged 5-10 years were broader (had a higher BMI; 1.03 SD), than their parents. These increases for 0-5 and 5-10 years, respectively corresponded to 3.9 and 6.4 cm for height, 1.3 and 5.4 kg for weight and 0.2 and 1.9 kg/m^2 for BMI. Lower parents' anthropometric indices and poor water supply and sanitation facilities; higher age of parents at child birth and of children when measured (for height and weight); and more parental education (for weight and BMI), were associated with greater intergenerational gains in children.

Conclusion: Over one generation in an urban middle-class population, whose general living conditions had improved, under-five children have become considerably taller and heavier, and 5-10 year old children have additionally become broader, than their parents at corresponding ages. Child populations probably 'grow up' before 'growing out'.

Keyword: *Anthropometry, Body mass index, Intergenerational effect, Secular trend.*

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There is a perception that despite considerable economic growth, India has not made commensurate progress in addressing anthropometric (weight-for-age, height-for-age and weight-for-height or body mass index-for-age) undernutrition [1]. The current national prevalence of undernutrition in children below five years is still high; 39% are stunted, 29% are underweight and 15% are wasted [2]. However, this common belief appears somewhat flawed; there has been substantial improvement in stunting and underweight over the years [3,4]. A comparison of the two latest national surveys, National Family Health Survey-3 (2005-06) and Rapid Survey on Children (2013-14), reveals a decline in stunting (48% to 39%) and underweight (43% to 29%), but only a marginal reduction in wasting (20% to 15%) [2,5]. Similarly, available data from 14 states in the recent National Family Health Survey-4 (2015-16) confirms a decline in stunting and underweight. However, wasting decreased in only six states (by 2% to 15%) and paradoxically increased in eight states (by 1% to 9%) [6].

Accompanying Editorial: Pages 183-84.

National surveys and regional cross-sectional studies do not provide a robust indication of secular change and its quantum, especially in those reaping the benefits of development, for example, the middle socio-economic strata in urban settings. Information of this nature would provide a reasonable yardstick for improvement goals in childhood anthropometry, especially if novel nutrition interventions are being considered. Further, such data would identify the potential burden of over-nutrition in children born to relatively undernourished parents; a nutrition transition pattern that could explain the emerging epidemic of non-communicable diseases (NCDs) in the country [7].

A robust estimate could be obtained through an intergenerational cohort design. This would offer the advantages of partially controlling for genetic variations while comparing anthropometry of children with their parents at similar ages. To the best of our knowledge, no such data are available in the Indian context to inform policy. This communication reports the intergenerational change in anthropometric indices of children below ten years of age and their predictors in the New Delhi Birth Cohort (NDBC).

METHODS

The NDBC was drawn from a population of 119,799 living in 12 km^2 area of South Delhi during 1969-72 [8,9]; 20,755 married women of reproductive age were recruited and followed regularly every other month to record menstrual dates. Information on the socio-demographic profile of the family were collected during recruitment by a social worker. These included maternal (F0 generation) schooling, paternal (F0 generation) occupation, and household socio-economic characteristics (type of family and house, and water supply and sanitation facilities). Women who became pregnant were visited every two months initially and on alternate days from the 37th week of gestation. There were 9169 pregnancies resulting in 8181 live births of cohort children (F1 generation). Trained personnel recorded the length and weight of the infants within 72 hours of birth, at the ages of 3, 6, 9 and 12 months (± 7 days) and every 6 months (± 15 days) until 14-21 years using standardized techniques [9]. These F1 participants were again followed-up at 26-33, 33-39, 36-42 and 42-46 years for anthropometry and cardio-metabolic risk factors. Socio-demographic profile recorded during these visits included education and occupation of the F1participant, occupation of F1 spouse, type of housing, material possessions, family size, toilet, drinking water source and supply, and general water source and supply. Simultaneously, their children (F2 generation) below ten years of age were invited to attend the clinics for anthropometry. The study was approved by the respective institutional ethics committees. After obtaining informed consent from parents (F1) and assent from children (F2, >6 years of age), the length/height and weight of the F2 generation were recorded using standardized techniques [10]. Recumbent length in children below 2 years of age was measured using an infantometer, and height in children ≥2 years of age using a portable stadiometer to the nearest 0.1 cm. Weight was measured using calibrated digital weighing scales with a sensitivity of 0.1 kg. Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared.

Statistical analysis: Data analysis was performed using SPSS 20.0. The intergenerational change in anthropometry was computed using two types of standardized scores (Z-scores); the World Health Organization (WHO) reference and internally within the cohort. For the former, F2 and F1 generation anthropometry was converted to WHO length/height-for-age, weight-for-age and BMI-for-age Z-scores at the date of measurement, using an SPSS macro for age-groups 0-5 years [11] and 5-19 years [12]. For the internal cohort Z-scores, the longitudinal height, weight and BMI measurements for the F1 generation were modelled into growth charts using Cole's LMS method [13,14]. These charts were used to compute age- and sex-specific Z-scores for F2 children at the date of measurement. To compare intergenerational anthropometry at similar ages, the F1 Z-score was interpolated at the exact age of the F2 measurement, using neighbouring F1 measurements. The interpolation was acceptable if the F1 observation was within 6 months for ages up to 1 year; within 1 year for ages 1 to 2 years; within 1.5 years for ages 2 to 3 years; and within 2 years thereafter. To estimate the comparison in absolute units, the interpolated F1 Z-score at the exact date of F2 measurement was back-transformed using the L, M and S values for the cohort Z-scores [15].

The intergenerational change in size was computed as F2-F1. This intergenerational model had a 3-level data structure comprising the F0 generation having one or more F1 children (F1-F1 siblings) and the F1 generation having one or more F2 children (F2-F2 siblings). Thus, a mixed model [16] approach was used to allow for this structure. There were 13 sibships among the F1 generation. We fitted models to allow for this third level of variation, but there were too few sibships to disturb the intergenerational effect size estimates and their standard errors; so subsequently we ignored this variance component.

The change was quantified in two age groups: 0-5 years and 5-10 years, adjusting for all combinations of the sex of the child and parent. This intergenerational change was further adjusted for socio-demographic characteristics. These included maternal (F0) schooling, wealth and water supply, sanitation and hygiene (WASH) score at F1 birth; and education of the F1 parent (cohort subject), wealth and WASH score at F2 measurement. We used the 1st principal component score [17] to derive the wealth and WASH scores at F1 birth and F2 measurement from the individual variables (listed in the footnotes of the relevant tables). These covariates were used in multivariate models as standardized units (mean 0), so that uncentered variables do not cause shifts in computed intergenerational changes.

RESULTS

Among the 337 F1 participants there were 13 pairs of F1-F1 siblings and among the 432 F2 children, 245 were single children, 89 were paired siblings and 3 were three siblings (***Fig.* 1**). We thus analyzed 432 F2-F1 pairs, which included 178 (41.2%) father-son, 138 (31.9%) father-daughter, 71 (16.4%) mother-son and 45 (10.4%) mother-daughter comparisons. Among them, 116 (72 boys) were aged 0-5 years and 316 (177 boys) were 5-10 years old, with mean (SD) ages of 3.5 (1.2) and 7.9 (1.3) years, respectively. The mean (SD) height-for-age, weight-for-age and BMI-for-age (WHO Z-scores) were -0.97 (1.39), -0.68 (1.19) and -0.08 (1.37), respectively for younger children and -0.42 (1.22), -0.31 (1.55) and -0.12 (1.49), respectively for older children.

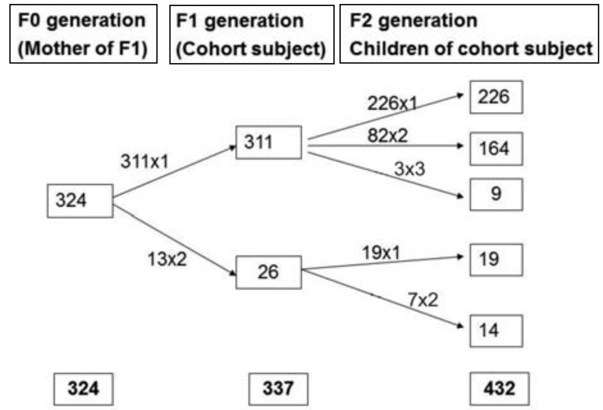


FIG. 1 *The three level structure of the intergenerational data set.*

The socio-demographic characteristics at the time of the parent's (F1 generation) birth and at the time of the child's (F2 generation) measurement are summarized in ***Web Table* 1**. Comparatively, parents (F1) had a poorer socio-demographic profile; one-third were residing in a flat or bungalow, the mean (SD) members sharing a room were 3.6 (1.7), four-fifths had shared toilet facilities, 60% had a common water supply and only one-fourth of their F0 mothers had completed 10 or more years of education. In contrast, at the time of the child's measurement, almost all of them were living in either flat or independent house, mean (SD) members sharing a room were 1.9 (0.9), most had separate toilet facilities (96%) and water supply (81%), and 62% of their F1 mothers had 15 or more years of education (graduate).

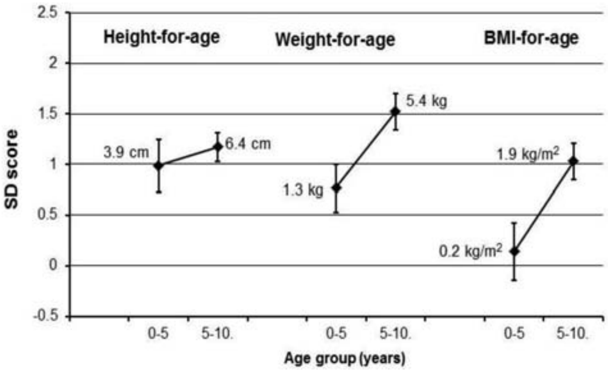
Table* I** summarizes the intergenerational change (F2-F1) in anthropometry. Children were significantly (P<0.001) taller and heavier than their parents at corresponding ages; the increase was similar (~1 SD) for height in both age groups but was higher for weight in older children (1.52 *vs* 0.77 WHO Z-score; non-overlapping confidence intervals). However, the BMI-for-age increase (1 SD) was significant (P<0.001) only in the age-group of 5-10 years. Considering the entire age range (0-10 years), the mean (95% CI) intergenerational increases (SD) in anthropometric indices were: Length/Height-for-age: 1.13 (1.01, 1.26), Weight-for-age: 1.32 (1.17, 1.47), and BMI-for-age: 0.79 (0.63, 0.95) (P<0.001 for all). These average Z-score increases for the 0-5 and 5-10 year age-groups, respectively corresponded to 3.9 and 6.4 cm for height, 1.3 and 5.4 kg for weight, and 0.2 and 1.9 kg/m^2 for BMI (Fig.* 2**). The intergenerational change among boys and girls was comparable. Sensitivity analyses, using internal cohort Z- scores and narrower window ranges for F1 Z-score interpolation at the exact age of F2 measurement revealed similar findings (data not shown).

Using the WHO definition [18], in comparison to their parents, under-five children had a substantially lower prevalence of stunting (44.7% *vs* 18.4%; n=114) and

TABLE I INTERGENERATIONAL CHANGES IN ANTHROPOMETRY

Anthropometric change (F2-F1)	*0-5 years*			*5-10 years*		
	N	*Mean (95% CI)*	*P value*	*No.*	*Mean (95% CI)*	*P value*
WHO Z-score						
Height for age	114	0.99 (0.73; 1.25)	<0.001	315	1.17 (1.03; 1.31)	<0.001
Weight for age	112	0.77 (0.53; 1.00)	<0.001	305*	1.52 (1.34; 1.70)	<0.001
BMI for age	110	0.14 (-0.14; 0.42)	0.310	310	1.03 (0.85; 1.21)	<0.001
Absolute units						
Height (cm)	114	3.9 (2.9; 4.9)	<0.001	315	6.4 (5.6; 7.2)	<0.001
Weight (kg)	112	1.3 (0.8; 1.7)	<0.001	311	5.4 (4.7; 6.1)	<0.001
BMI (kg/m^2)	110	0.2 (-0.2; 0.6)	0.255	310	1.9 (1.5; 2.2)	<0.001

Mixed model adjusted for the sex of the children and parents.
** WHO weight-for-age could not be interpolated for 6 parents because the reference stops at 10 years of age.*



Mixed model adjusted for the sex of the children and parents. Error bars represent 95% confidence intervals.

FIG. 2 *Intergenerational changes in anthropometric indices (WHO Z-scores).*

underweight (25.9% *vs* 12.5%; *n*=112). However, wasting remained unchanged (4.6% *vs* 5.5%; *n*=109).

Table **II** depicts the multivariate associations of intergenerational change. Parents' (F1) anthropometry had the most consistent and strongest associations (*P* <0.001), with effect sizes ranging from 0.47 to 0.65 SD decrease per SD. Thus children of shorter, lighter and thinner parents had gained more in height, weight and BMI, respectively. The age of the parent (F1) at child birth and the age of the child (F2) at measurement were significant (*P*<0.001) positive predictors for F2 height-for-age and weight-for-age but not for BMI-for-age. Amongst the socio-demographics characteristics, poorer WASH status at the F1 parents' birth predicted greater increase in all three F2 indices. In contrast, higher parental (F1) education predicted greater F2 gain in weight and BMI, and had no association with F2 height gain. ***Table*** **III** quantifies the adjusted intergenerational changes across sub-groups of various predictors.

The scatterplot in ***Fig.*** **3** illustrates the transition in BMI categories among parents and children at the same age. The cut-offs were slightly modified from WHO recommendations [19] to ensure sufficient numbers in each category: Thin <-1.5 Z, Normal -1.5 to 0.5 Z, and Overweig`ht >0.5 Z. In comparison to 127 children, only 29 parents were overweight at the same age. While a higher proportion of children of overweight parents were overweight, the greatest increase in BMI categories occurred in thin parents. A quarter of their children were overweight while half were normal. In contrast, among all children born to overweight parents, only 41% were overweight and 59% were normal.

TABLE II PREDICTORS OF INTERGENERATIONAL CHANGE IN ANTHROPOMETRIC INDICES (MULTIVARIATE MODEL)

Predictors(Standardized units)	*Height for age (n=331) Effect size (95% CI); P value*	*Weight for age (n=323) Effect size (95% CI); P value*	*BMI for age (n=325) Effect size (95% CI); P value*
Parent anthropometry‡	-0.47 (-0.62,-0.31); <0.001	-0.49 (-0.67, -0.32); <0.001	-0.65 (-0.82, -0.49); <0.001
Age of parent at child birth	0.34 (0.18, 0.51); <0.001	0.37 (0.19, 0.56); <0.001	0.17 (-0.02. 0.36); 0.080
Age of child	0.25 (0.09, 0.40); 0.002	0.32 (0.14, 0.50); <0.001	0.12 (-0.08, 0.31); 0.246
At parent birth			
Maternal (F0) Schooling	0.01 (-0.17, 0.18); 0.954	-0.02 (-0.22, 0.19); 0.874	-0.02 (-0.23, 0.18); 0.816
Wealth, Housing, paternal (F0) occupation*	0.08 (-0.10, 0.25); 0.393	0.15 (-0.07, 0.36); 0.176	0.16 (-0.05, 0.37); 0.125
WASH (Sanitation & water supply)#	-0.17 (-0.32, -0.03); 0.021	-0.25 (-0.43, -0.08); 0.004	-0.22 (-0.39, -0.04); 0.014
At child measurement			
Education of parent (F1)	0.11 (-0.07, 0.29); 0.221	0.26 (0.05, 0.47); 0.015	0.29 (0.08, 0.50); 0.007
Wealth, Housing, maternal & paternal (F1) occupation$	0.08 (-0.11, 0.26); 0.421	0.10 (-0.12, 0.32); 0.374	0.05 (-0.17, 0.26); 0.672
WASH (Sanitation & water supply)^	0.00 (-0.14, 0.14); 0.969	-0.07 (-0.23, 0.09); 0.375	-0.10 (-0.26, 0.06); 0.236

*Mixed model analysis adjusted for the sex of the children and parents. All other predictors were also inserted simultaneously in the multivariate model as standardized units. The intraclass correlation coefficients (ICC) were 0.14 for height-for-age, 0.27 for weight-for-age and 0.20 for BMI-for-age; ‡Parental measurement and intergenerational change were for the same anthropometric index (WHO reference); *Wealth score at F1 birth was generated from type of family, combination of type of housing and ownership, paternal (F0) occupation, per capita household annual income and crowding; #WASH score at F1 birth was generated from type of toilet, water supply and facilities for sanitation and water supply; $Wealth score at F2 measurement was generated using maternal and paternal (F1) occupation, material possession score and crowding; ^WASH score at F2 measurement was generated from toilet and water supply (general and drinking water) facilities.*

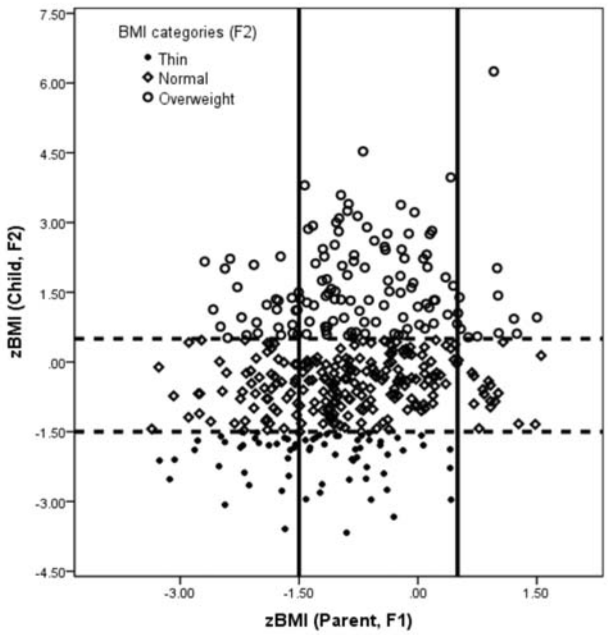
TABLE III ADJUSTED INTERGENERATIONAL CHANGES ACROSS DIFFERENT SUBGROUPS OF PREDICTORS (MULTIVARIATE MODEL)

Predictors	*Length/Height-for-age*			*Weight-for-age*			*BMI-for-age*		
	n	*Mean change (95% CI)*	*P*	*n*	*Mean change (95% CI)*	*P*	*n*	*Mean change (95% CI)*	*P*
F2 sex									
Male	191	1.19 (1.02, 1.37)	0.478	184	1.33 (1.11, 1.54)	0.916	186	0.76 (0.55, 0.97)	0.501
Female	140	1.05 (0.85, 1.25)		139	1.21 (1.00, 1.42)		139	0.75 (0.52, 0.98)	
F1 sex									
Male	248	1.13 (0.96, 1.29)	0.756	239	1.29 (1.11, 1.48)	0.637	242	0.77 (0.60, 0.95)	0.822
Female	83	1.18 (0.98, 1.39)		84	1.32 (1.02, 1.63)		83	0.72 (0.36, 1.09)	
Parent anthropometry with WHO reference									
1st tertile	110	1.57 (1.31, 1.83)	<0.001	110	1.62 (1.36, 1.89)	<0.001	113	1.45 (1.20, 1.69)	<0.001
2nd tertile	114	1.07 (0.84, 1.29)		107	1.55 (1.33, 1.78)		99	0.58 (0.28, 0.88)	
3rd tertile	107	0.77 (0.53, 1.01)		106	0.77 (0.45, 1.09)		113	0.21 (-0.09, 0.52)	
Age of parent at child birth									
1st tertile	117	0.79 (0.54, 1.03)	<0.001	112	1.06 (0.75, 1.37)	<0.001	117	0.80 (0.54, 1.07)	0.080
2nd tertile	116	1.28 (1.09, 1.48)		117	1.21 (0.98, 1.45)		116	0.53 (0.30, 0.76)	
3rd tertile	98	1.32 (1.08, 1.56)		94	1.58 (1.33, 1.83)		92	0.97 (0.64, 1.31)	
Age of child									
0-5 years	95	1.02 (0.74, 1.31)	0.002	94	0.78 (0.56, 1.01)	<0.001	92	0.20 (-0.10, 0.49)	0.246
5-10 years	236	1.16 (1.01, 1.31)		229	1.45 (1.25, 1.64)		233	0.96 (0.77, 1.14)	
At parent birth Maternal schooling (F0)									
Illiterate	126	1.19 (0.99, 1.39)	0.954	123	1.19 (0.95, 1.42)	0.874	124	0.51 (0.28, 0.74)	0.816
Primary to middle	123	1.09 (0.86, 1.31)		118	1.41 (1.14, 1.67)		120	0.99 (0.72, 1.26)	
Matric or above	82	1.06 (0.76, 1.37)		82	1.09 (0.76, 1.42)		81	0.58 (0.28, 0.88)	
Wealth, housing, parental (F0) occupation									
1st tertile	110	1.11 (0.86, 1.35)	0.393	105	1.22 (0.94, 1.50)	0.176	106	0.64 (0.34, 0.93)	0.125
2nd tertile	112	1.21 (1.00, 1.43)		110	1.31 (1.04, 1.57)		111	0.74 (0.48, 0.99)	
3rd tertile	109	1.01 (0.78, 1.25)		108	1.20 (0.94, 1.46)		108	0.78 (0.55, 1.01)	
WASH (Sanitation & water supply)									
Below median	174	1.28 (1.10, 1.46)	0.021	169	1.43 (1.22, 1.64)	0.004	171	0.80 (0.58, 1.01)	0.014
Above median	157	0.92 (0.73, 1.12)		154	1.04 (0.81, 1.26)		154	0.59 (0.38, 0.80)	
At child measurement Education of parent (F1)									
Up to High school+	153	1.07 (0.85, 1.29)	0.221	148	1.09 (0.85, 1.32)	0.015	151	0.50 (0.26, 0.73)	0.007
Graduate or above	178	1.19 (1.03, 1.36)		175	1.46 (1.25, 1.67)		174	0.95 (0.74, 1.17)	
Wealth, Housing, maternal & paternal (F1) occupation									
1st tertile	119	1.23 (1.01, 1.46)	0.421	115	1.13 (0.87, 1.38)	0.374	117	0.39 (0.13, 0.65)	0.672
2nd tertile	104	0.99 (0.72, 1.27)		101	1.39 (1.10, 1.69)		102	1.04 (0.73, 1.34)	
3rd tertile	108	1.13 (0.92, 1.35)		107	1.35 (1.09, 1.60)		106	0.83 (0.59, 1.07)	
WASH (Sanitation & water supply)									
Below median	86	1.19 (0.93, 1.45)	0.969	84	1.43 (1.09, 1.76)	0.375	85	0.88 (0.54, 1.22)	0.236
Above median	245	1.09 (0.93, 1.24)		239	1.20 (1.03, 1.38)		240	0.69 (0.51, 0.86)	

Multivariate mixed model adjusted for sex of the child and parent, parent anthropometry, age of parent at child birth, age of child, F0 maternal schooling, F1 parent education, wealth and WASH score at F1 birth and F2 measurement; All variables were used in standardized units (centred). P value is estimated from a continuous scale of covariates as in Table II.

DISCUSSION

In this intergenerational study, we documented that children below ten years of age were considerably taller (~1 SD) and heavier (0.8 to1.5 SD), while only 5-10 years old were broader (~1 SD), than their parents at corresponding ages. Independent predictors of greater gains in children included parents with lower anthropometric indices and poorer WASH facilities; higher age of parents at child birth and of children at measurement (height and weight); and more parental education (weight and BMI).



These categories were defined using WHO BMI Z-score as follows: Thin <–1.5, Normal –1.5 to 0.5, and Overweight >0.5.

FIG. 3 *Scatterplot of transition in Body Mass Index (WHO Z scores) in parents and their children at corresponding ages.*

Important limitations of this study include a somewhat small sample size based on a proportion of the currently available cohort. Among the parents, there was a considerably higher representation of fathers because outmigration after marriage was common in female participants (F1). The main strengths of our study include the comparison of children and their parents at corresponding ages from carefully collected prospective data for the latter, an urban LMIC setting of relatively rapid socio-economic development, and appropriate multi-level modelling with available confounder adjustment.

These data from an urban middle-class population provide evidence of substantial increases in the body size of Indian children over one recent generation. The findings are in broad agreement with the observed decline in anthropometric under-nutrition from national surveys [2-6]. Interestingly, the 26% reduction in stunting over 30 years in this small sample roughly corresponds to the 1% annual decline documented nationally [2-6]. A scarcity of similar data preclude emphatic international comparisons. A recent analysis of a century of trends in adult human height (1896 to 1996 births) concluded that South Asians (including Indians) were among the shortest and had experienced little increase (<5 cm) during this era [20]. We could locate only one directly comparable estimate from Britain, pertaining to a 15 years earlier period, with similar or better development index status than our cohort [21,22]. At 7 years, these offspring were only slightly taller (0.19 SD or 1 cm) and broader (boys: 0.16 SD or 0.23 kg/m^2 and girls: 0.25 SD or 0.46 kg/m^2) than their parents. The substantially larger intergenerational increases seen in our cohort children will probably translate into commensurate or greater absolute (cm, kg, kg/m^2) gains in adulthood. These findings should inspire optimism that with rapid improvements in living conditions, anthropometric gaps from high-income countries will reduce, particularly because a plateauing trend for height is evident in some developed nations [20].

In the absence of targeted food or nutrient supplementation, it is reasonable to ascribe these intergenerational gains to improvements in general living conditions. However, from a policy perspective, filtering out important predictors is desirable. Poorer water supply and sanitation facilities of the parents (F1) at birth predicted greater F2 gains. A Cochrane systematic review of cluster randomized trials, intervening for only 9-12 months also suggests that WASH interventions confer a small benefit on linear growth (~0.1 SD) in under-five children [23]. The current national impetus on “Swach Bharat Abhiyaan” is therefore timely and appropriate. In conformity with earlier experiences [24,25], higher parental literacy was a positive predictor, thereby re-emphasizing the importance of improving education. Higher ages of parents at child birth and of children at measurement were important positive predictors of intergenerational gains in height and weight. A quadratic relation of childhood anthropometry with age of child birth has been documented in pooled analyses of cohorts from low- and middle- income countries (LMICs) [26]; our sample was probably constituted by the linear component of this association. However, both these variables are also proxies for exposure duration, thereby suggesting that sustained improvement in living conditions resulted in greater benefit.

Poorer parental anthropometry had the strongest and most consistent predictive ability for greater intergenerational gains. Potential explanations for this include statistical regression to the mean, narrowing of socio-economic inequalities and greater biological response among deprived strata. This observation augurs well for attempting equity for secular increases in the height of populations. However, excessive BMI gain in children of thin parents, if primarily due to increased adiposity, could be providing the backdrop for the current escalation of cardio-metabolic risk factors in Indian children and adolescents [7,27,28]. This hypothesis is in

WHAT IS ALREADY KNOWN?

- National surveys suggest a decline in anthropometric undernutrition but there is no robust quantification of secular increases in body size of children over a recent generation.

WHAT THIS STUDY ADDS?

- Children below ten years were considerably taller and heavier, while only 5-10 year old children were broader (higher BMI), than their parents at corresponding ages.

concordance with our earlier observation of increased risk of diabetes mellitus in adults who were relatively thin as children but continued to become obese relative to themselves [9].

Under-five children were considerably taller and heavier but only older subjects were additionally broader than their parents. This provides more direct evidence of the earlier postulate, based on cross-sectional comparisons [29], that children "grow up" (get taller) before "growing out" (get broader). This observation is also consistent with the increased prevalence of obesity in older children from India [28] and other countries [29-31]. The underlying mechanisms for this phenomenon are unclear to us and merit further exploration.

Our data suggest that sustained improvement in general living conditions leads to considerable increases in height, weight and BMI within one generation. The current governance focus on inclusive development is therefore apt, especially if the benefits percolate preferentially to the underprivileged. Isolated vertical interventions (for example, nutrient supplementation) should only be entertained if there is convincing evidence of substantial benefit above that expected from developmental transition. Findings from the NFHS-4 survey of notable reductions in stunting and underweight with nearly stagnant or even increased wasting prevalence in some states should not fuel exaggerated concerns and action to screen for and treat for severe acute malnutrition; as this phenomenon may occur in a population undergoing development-related anthropometric transition. Vigilance may be required to address the potential of greater cardio-metabolic risk in families showing large intergenerational increases in BMI.

In conclusion, over one generation in an urban middle-class population, whose general living conditions had improved, under-five children have become considerably taller and heavier and 5-10 year old children have additionally become broader, than their parents at corresponding ages. Child populations probably "grow up" before "growing out".

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