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Altered Growth Patterns of a Mountain Ok Population of Papua New Guinea Over 25 Years of Change

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- **Abstract**
- **Context**
- The Mountain Ok (Mt Ok) people of Telefomin, who live at the interior of Papua New Guinea (PNG), were documented over 25 years ago to be one of the shortest populations on record, with average adult height below the fifth percentile (US). Serum Growth Hormone was detectable, Insulin-like Growth Factor-1 and serum indicators of protein nutritional status fell within the normal range, suggesting that these were not primary factors for their relative short stature.
- **Objective**
- Since the Telefomin people have experienced recent socioeconomic changes, they were re-evaluated in 2008, to examine height, weight, and body mass index (BMI), for insight into relative contributions of environment and other factors that modulate stature in children and adults.
- **Study Design and Setting**
- Cross-sectional anthropometric data were collected from 474 individuals at Telefomin in 2008, and compared with anthropometric data from 342 individuals measured in 1983.
- **Results**
- The height of Telefomin subjects, below the fifth percentile in 1983, remained below the fifth percentile in 2008. Weight and BMI of peripubertal and adult age groups increased from 1983 to 2008. Male and female heights at peripubertal ages were significantly greater in 2008. Nevertheless, final adult height did not change significantly over the 25 years.
- **Conclusions**
- Recent socioeconomic changes appear to contribute to increased weight, BMI, and stature at younger ages in the Mt Ok at Telefomin. In contrast, unchanging adult stature may reflect a delay in the impact of socioeconomic changes, or genetic influences that modulate responsiveness to other growth regulators. *Am. J. Hum. Biol.*, 2011. © 2010 Wiley-Liss, Inc.

Determinants of Stature

- Environment
- Nutrition
- Hormone
- Genetics



The Mountain Ok people in PNG

- One of the shortest on record in 1983 (Schwartz et al., 1987)
- Growth hormone =sufficient

Ok Tedi Gold and Copper Mining

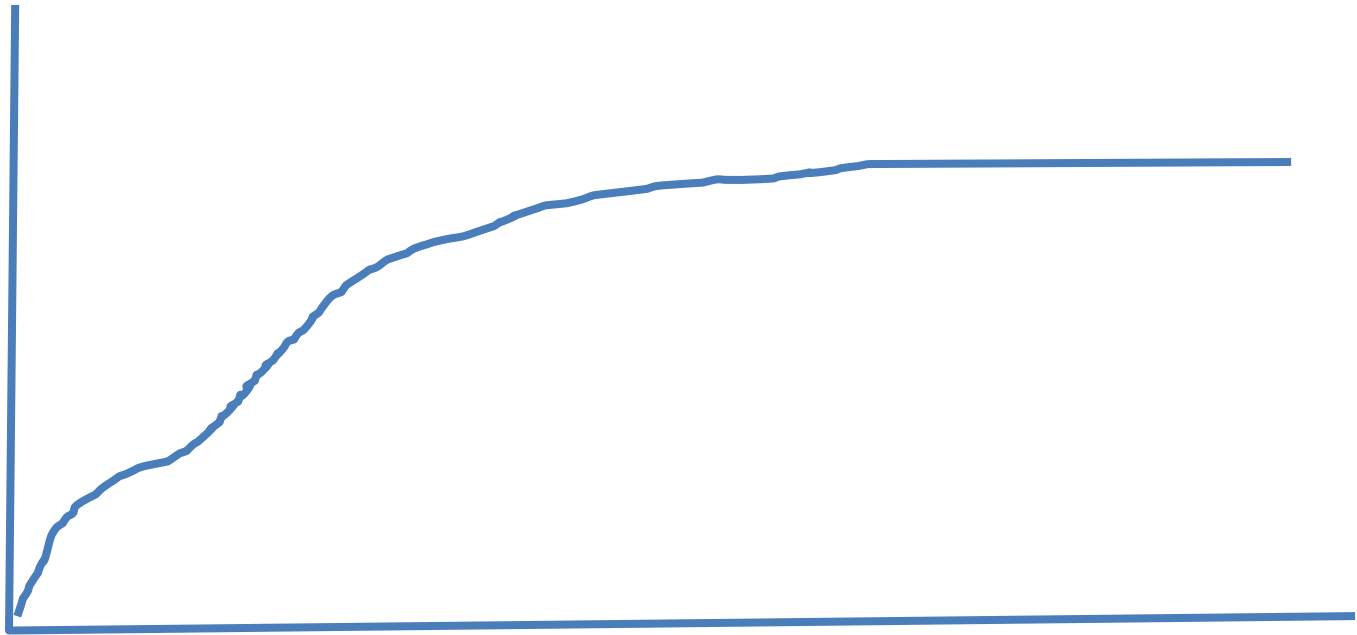
- the early 1980s

Growth pattern in 1983

Growth pattern in 2008

25 years





Telefol-speaking people (N=4500)

- 474 individuals were recruited in schools, clinics, and community centers.
- Height, weight, MUAC, armspan
- Reported age, verified by birth registries, hospital records or event calendar

Growth curves:

- US population (CDC), WHO
- Z scores

TABLE 1. Mt Ok study cohorts in 2008 and 1983

Age group (Years)	Male		Female	
	2008	1983	2008	1983
0-5	24	20	22	11
6-10	51	13	42	17
11-15	67	17	89	29
16-20	<u>36</u>	23	<u>45</u>	37
21-25	11	3	12	17
26-35	14	14	15	27
36-45	18	19	10	32
>46	9	38	9	25
Total	230	147	244	195

For the analysis of anthropometric data, subjects were grouped by age in intervals of 5 years to age 25, and intervals of 10 years above age 25. Total number of subjects were 474 in 2008 and 342 in 1983 cohort. Table shows numbers of subjects in age groups, by study year and gender.

Born	2008
'84-88	21-25
'89-93	16-20
'94-98	11-15

In 1983	2008
0-4	25-29
5-9	30-34
10-14	35-39
15-19	40-44

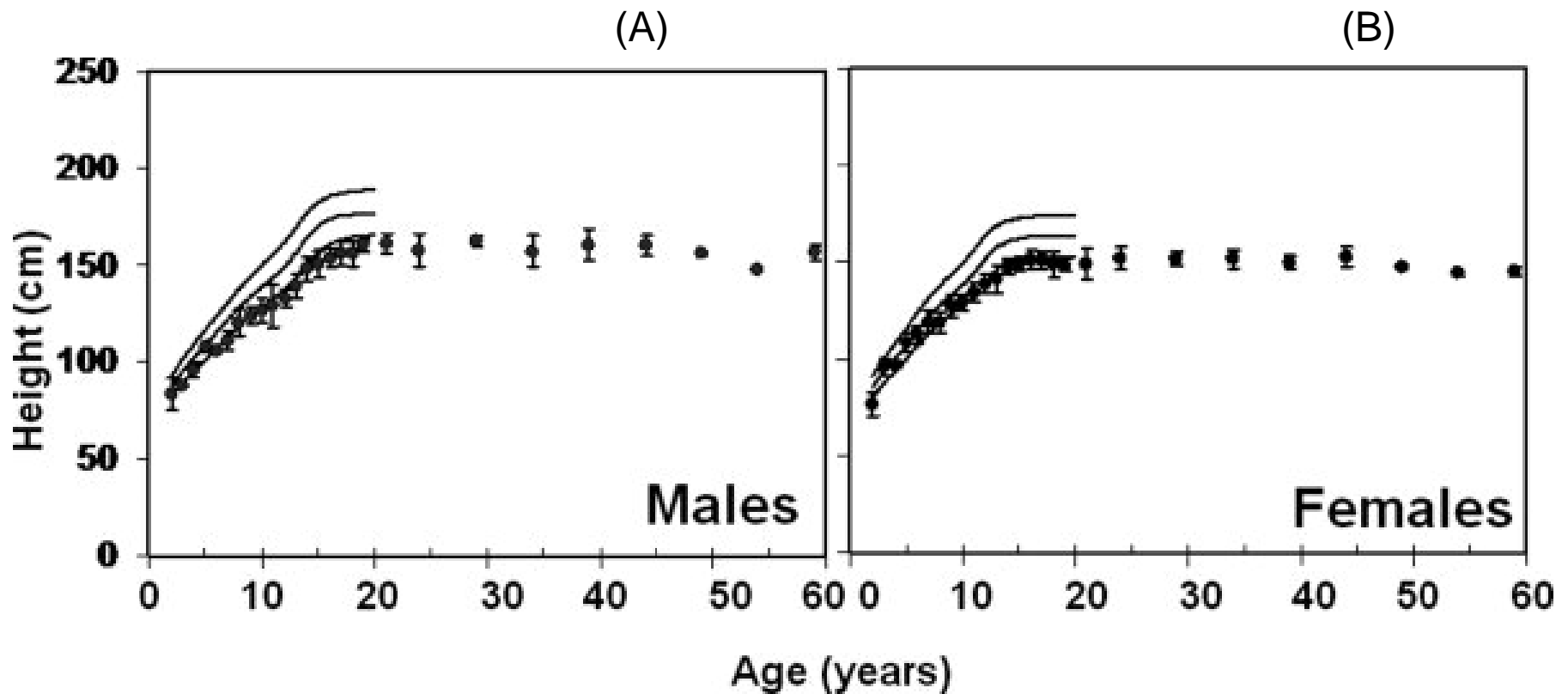


Figure 1. Height of Mt Ok people falls below fifth percentile in 2008. Growth curves for Telefolmin males (A) and females (B) are plotted as mean height (cm) for age (year) in comparison to US growth charts indicated by dotted lines for the 5th (lower), 50th (middle), and 95th (upper) percentiles. Points show Mean \pm SD for individual ages (below 20 years) or at the midpoint of 5-year age intervals above 20 years.

Fig 1: Comparison with US growth curves

- Hgt (>21y, 2008) = 158 (m), 151 (f); <5th %tile
- Hgt (11-20y, 2008) = <5th %tile
- Hgt (<10y, 2008) = 50th %tile (f)
- Hgt*Armspan: $r=0.96$

Figure 2. Height, weight, and BMI of Telefolmin are higher at peripubertal ages in 2008 than in 1983. Mean height (A), weight (B), and BMI (C) of Mt OK males and females are significantly greater at peripubertal ages ($P < 0.05$ shown by \blacklozenge) in 2008 (solid circles) versus 1983 (open circles). Weight and BMI are also significantly greater in some adult age groups in 2008 as indicated. Each point shows mean height (\pm SD) for age groups in Table [1](#).

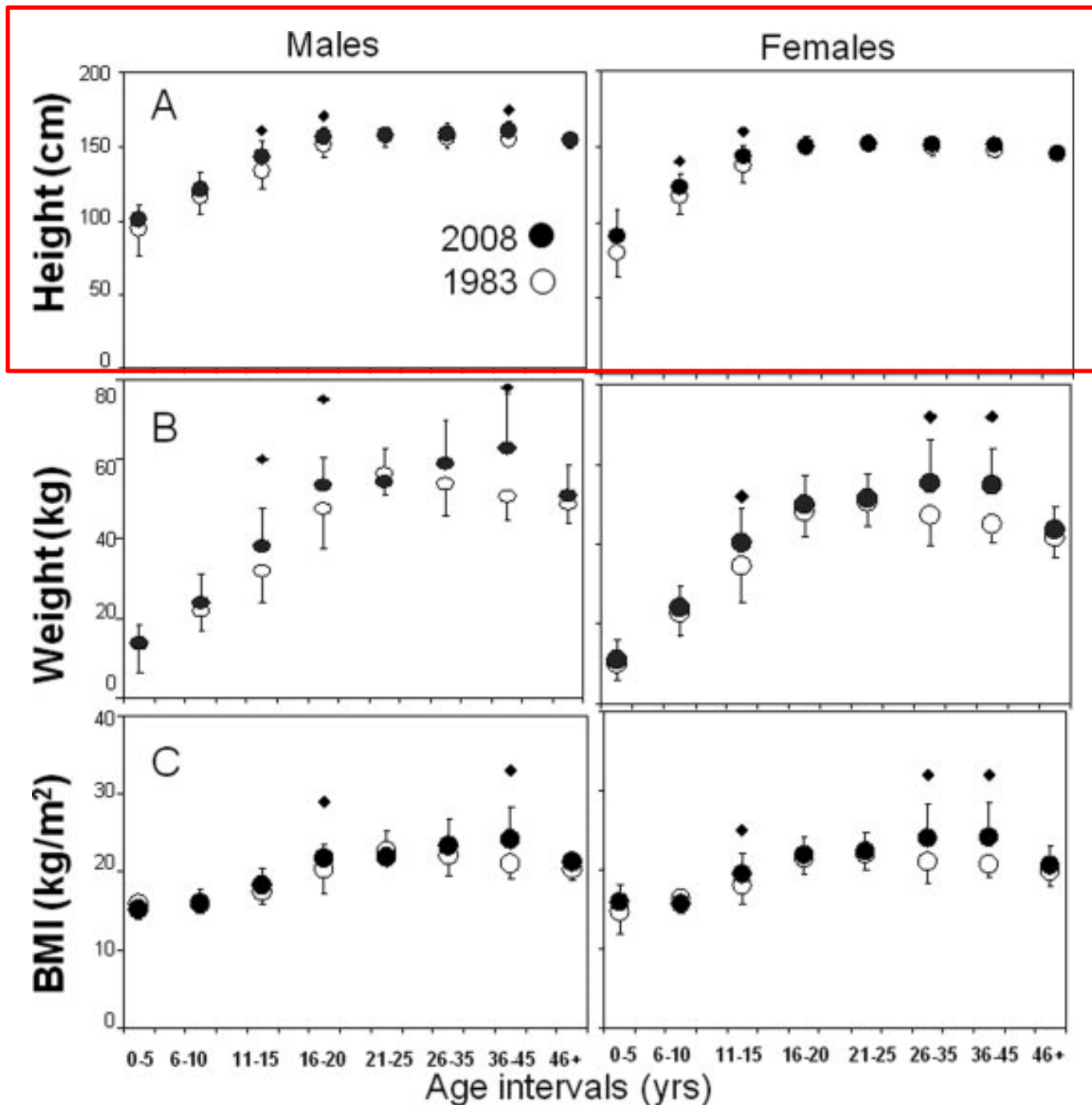


Figure 3. Z scores for height, weight, and BMI of Telefolmin are higher at peripubertal ages in 2008. Z scores normalizing Mt Ok data to US values (reference line = 0) are shown for subjects below 20 years, grouped as in Figure 2. Height, weight, and BMI were significantly greater in 2008 (gray box) versus 1983 (open box) for age groups indicated on x axis ($P < 0.05$ shown by *). Each box shows median (horizontal line) within 25th (bottom) and 75th (top) percentiles; error bars show 5th (bottom) to 95th (top) percentiles. Small open circles show outliers.

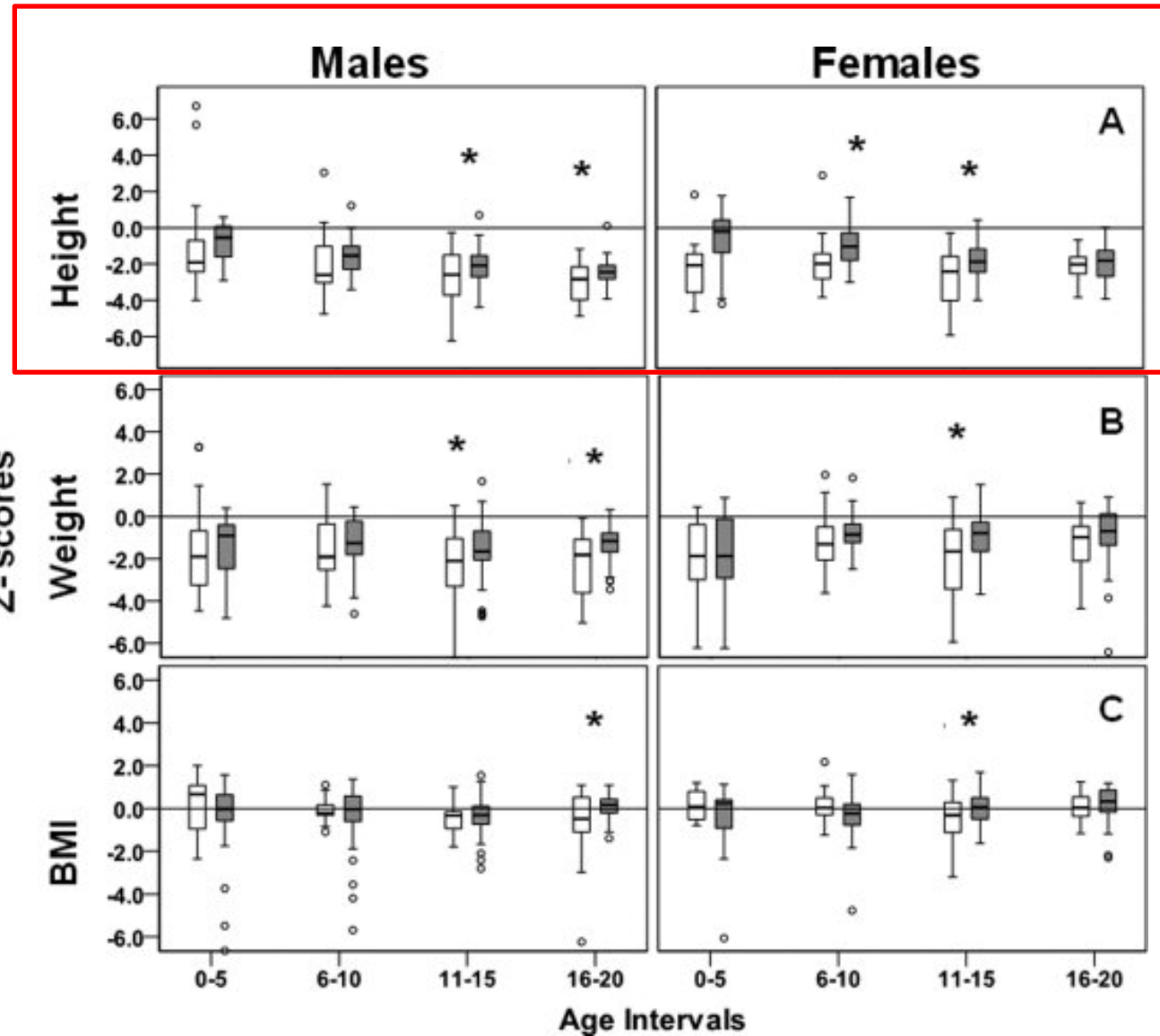


Fig 2A: Comparison of Hgt in 1983 and 2008

- Female: 2008>1983 (6-10y, 11-15y)
- Males: 2008>1983 (11-15y, 16-20y)
- Males: 2008>1983 (36-45y)

Born	2008
'84-88	21-25
'89-93	16-20
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In 1983	2008
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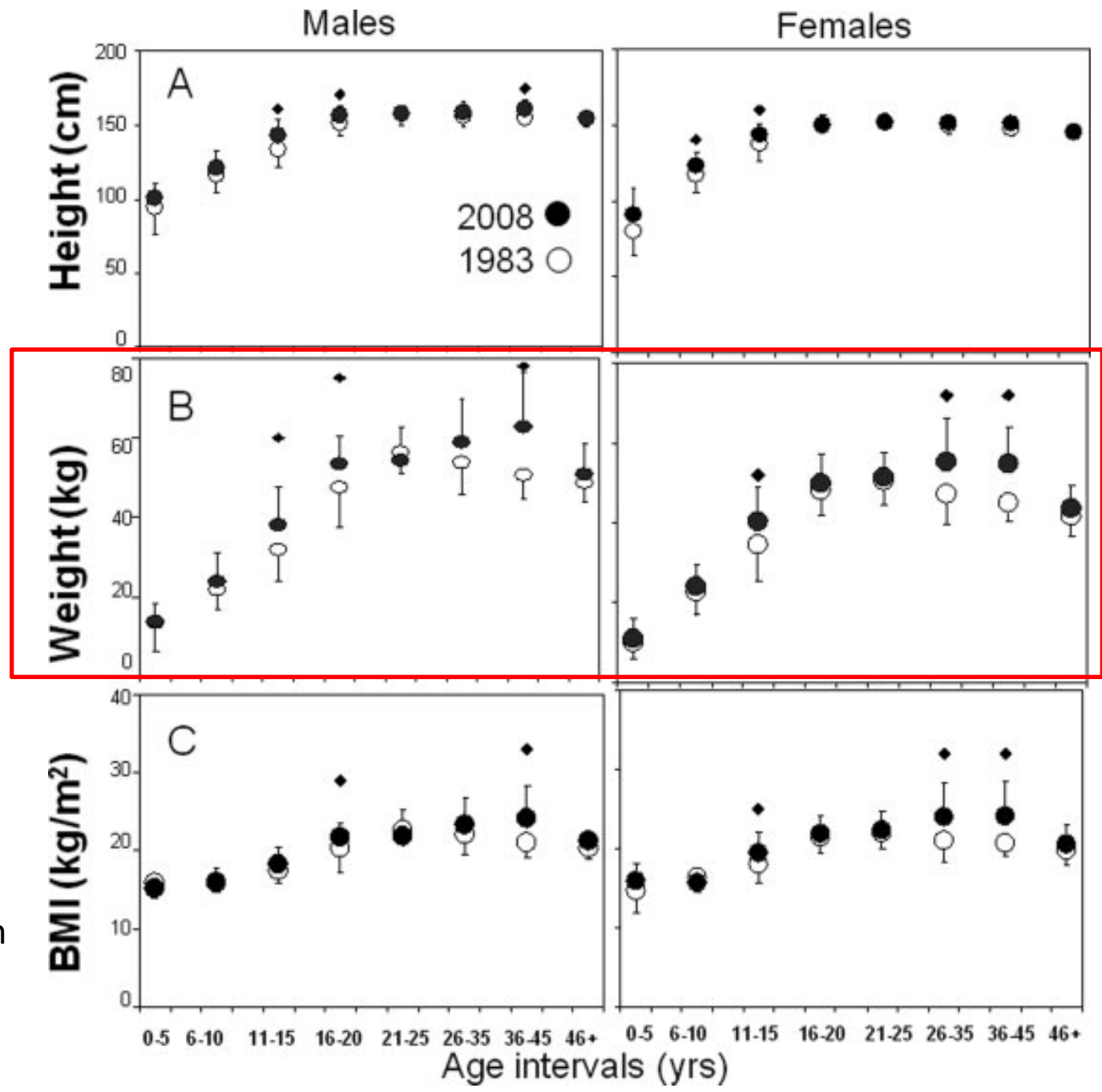


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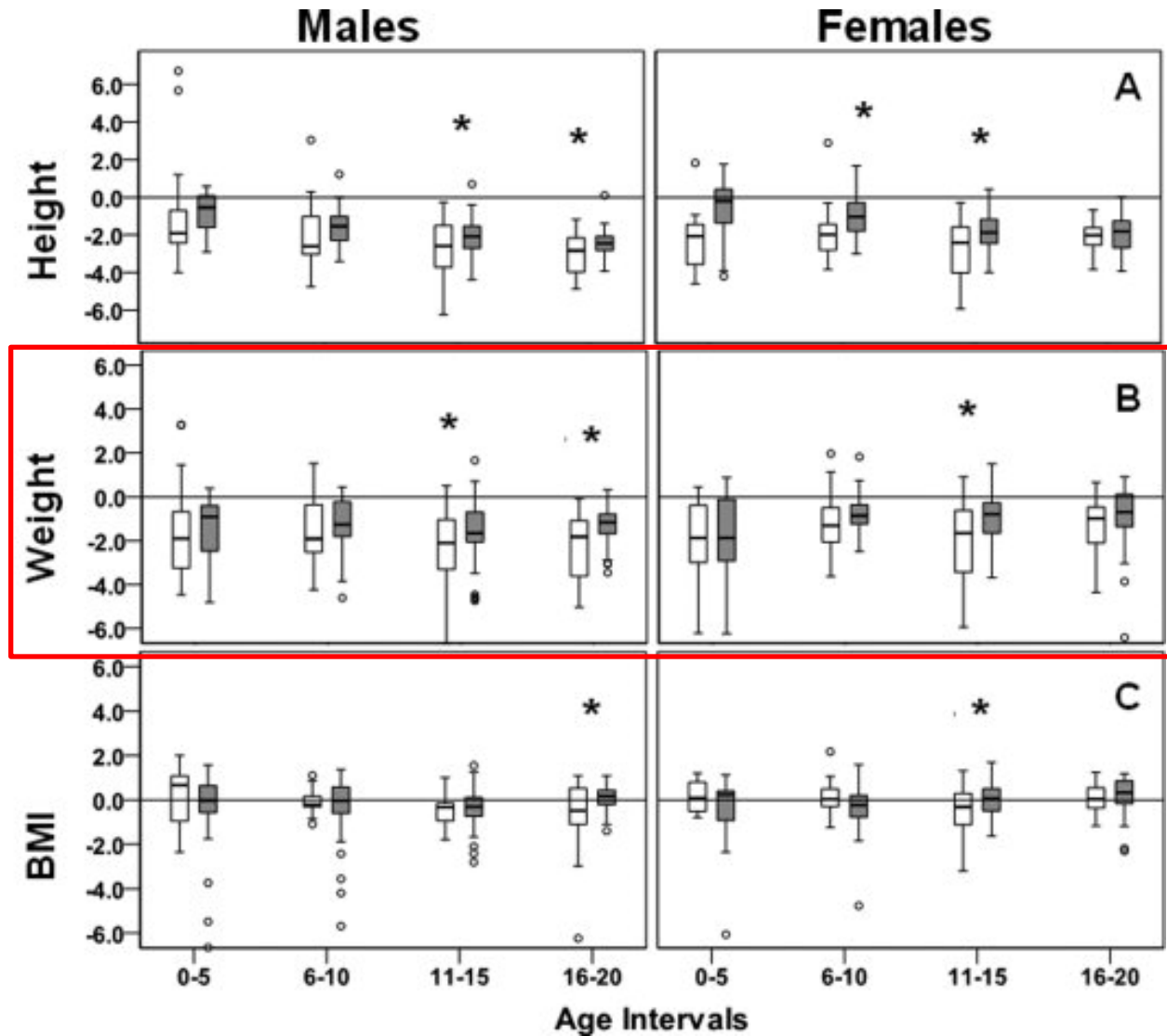


Fig 2B:

Comparison of Wgt in 1983 and 2008

- Female: 2008>1983 (11-15y)
- Female: 2008>1983 (26-35y, 36-45y)
- Males: 2008>1983 (11-15y, 16-20y)
- Males: 2008>1983 (36-45y)

Born	2008
'84-88	21-25
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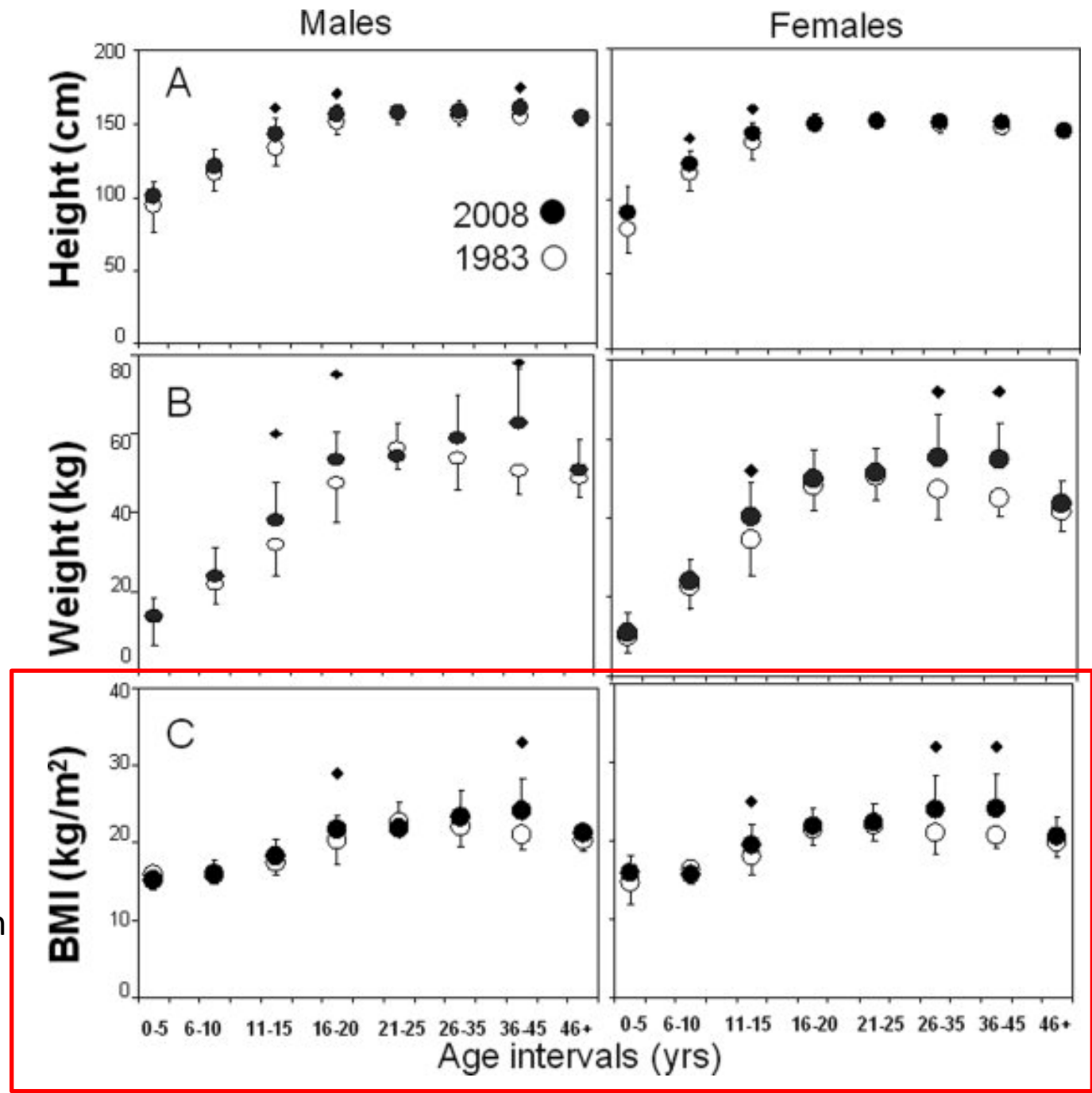


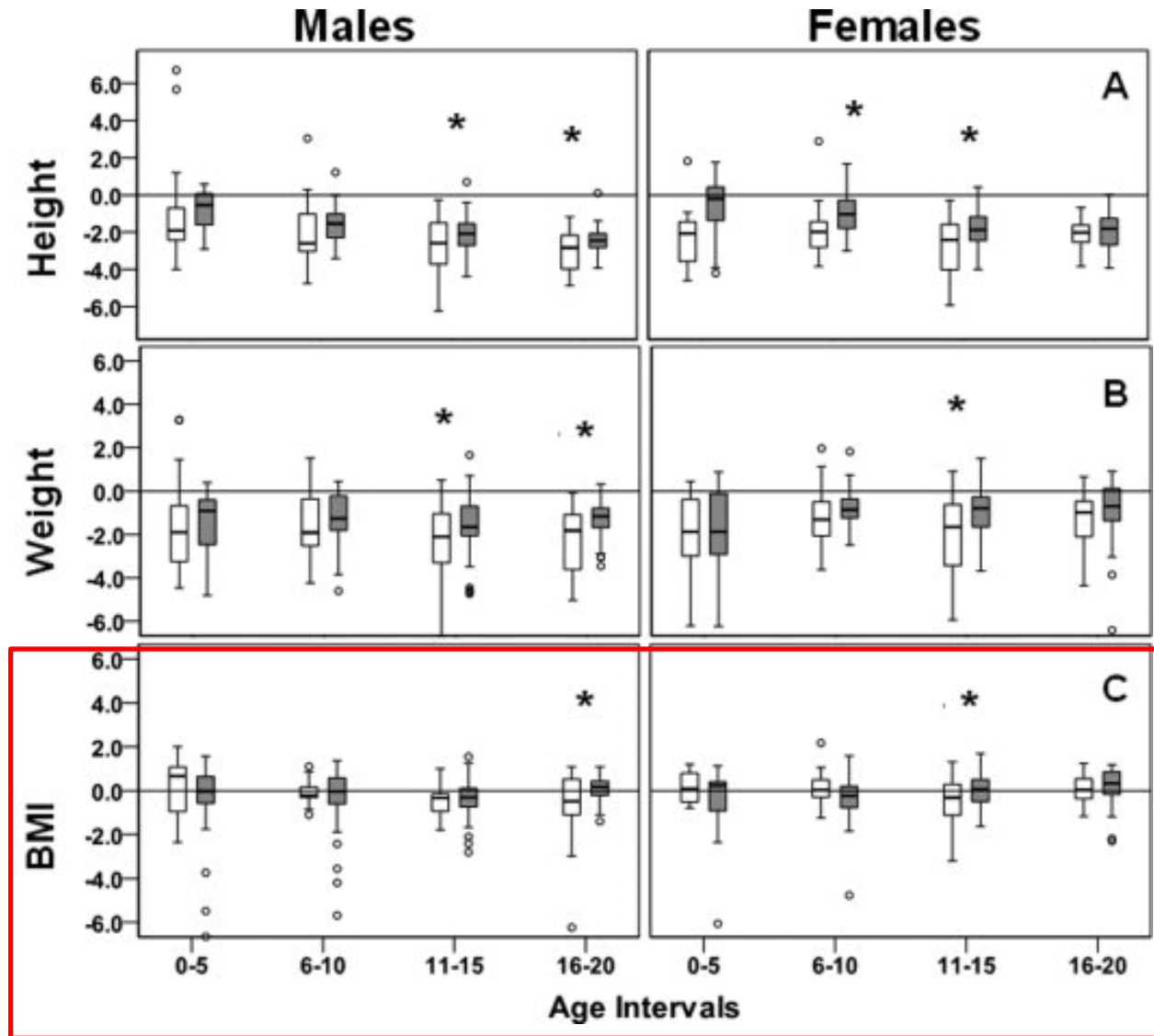
Fig 2C: Comparison of BMI in 1983 and 2008

- Female: 2008>1983 (11-15y)
- Female: 2008>1983 (26-35y, 36-45y)
- Males: 2008>1983 (16-20y)
- Males: 2008>1983 (36-45y)

Born	2008
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BMI = 50thtile of US standard

TABLE 2. Estimated changes in height, weight, and BMI by age group

Age group (Years)	Male	Female
A		
Height		
0-5	8.27 ± 1.0	9.44 ± 0.60
6-10	3.87 ± 0.42	4.4 ± 0.37
11-15	4.73 ± 0.35	4.06 ± 0.25
16-20	1.79 ± 0.38	0.56 ± 0.24
20-45	-0.02 ± 0.08	-0.11 ± 0.06
>46	-0.23 ± 0.11	-0.23 ± 0.1
B		
Log weight		
0-5	0.23 ± 0.02	0.24 ± 0.01
6-10	0.07 ± 0.01	0.08 ± 0.01
11-15	0.11 ± 0.01	0.11 ± 0.01
16-20	0.06 ± 0.01	0.02 ± 0.01
20-45	-0.002 ± 0.002	-0.004 ± 0.002
>46	-0.006 ± 0.003	-0.008 ± 0.003
Log BMI		
0-5	-0.01 ± 0.01	0.01 ± 0.01
6-10	0.01 ± 0.01	0.01 ± 0.01
11-15	0.04 ± 0.01	0.05 ± 0.01
16-20	0.03 ± 0.01	0.02 ± 0.01
20-45	-0.002 ± 0.001	-0.002 ± 0.001
>46	-0.003 ± 0.002	-0.005 ± 0.002

A: Estimated rate of change in height (cm/year) for each age group (year) are based on the regression coefficients shown ± standard errors. Peak change for males occurs at 11-15 years and for females at 6-10 years. B: Estimated rate of change in weight (percentage/year) and BMI (percentage/year) for age groups are based on the regression coefficients shown for log transformation of weight and BMI values ± standard errors. Peak changes in weight and BMI occur in 11-15 year group for males and females.

Piecewise linear structure regression(?), a special case of spline

Estimated change from 1983 to 2008

Regression to cancel the effect of different age in each age group?

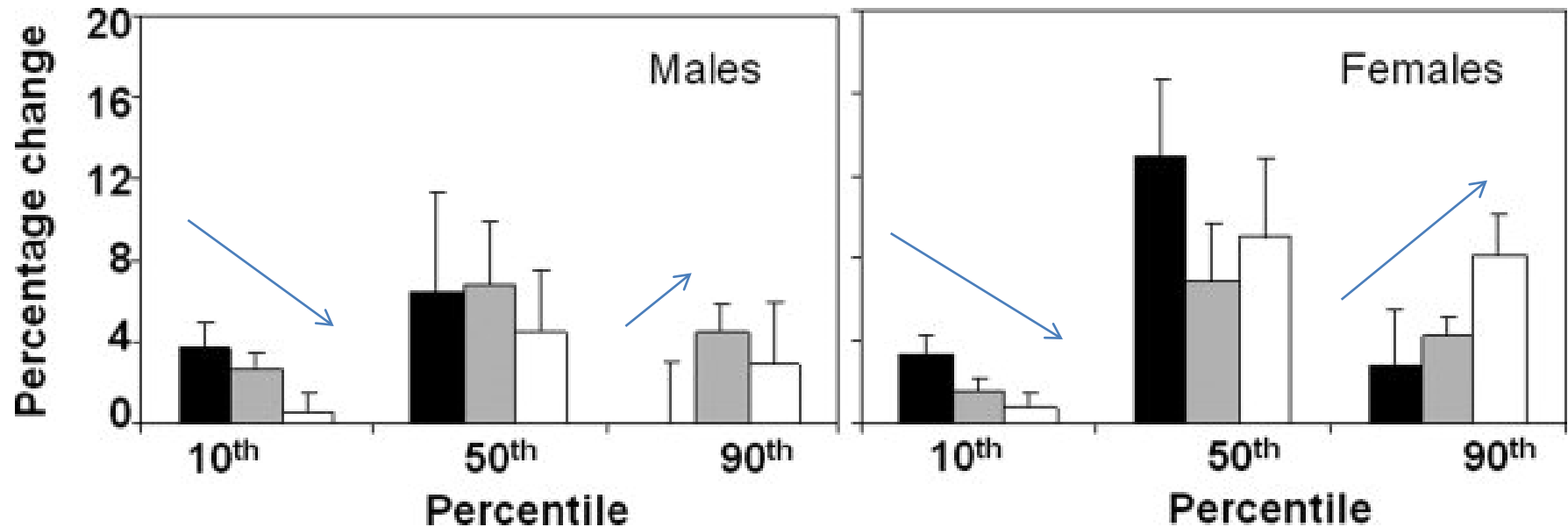


Figure 4. Percent changes in height are not parallel to changes in weight and BMI. The relationships among percent changes between 2008 and 1983, for height (black bar), weight (gray bar), and BMI (open bar), vary among the shortest (10th percentile) and tallest (90th percentile) subjects. Values are presented as Mean \pm SD, derived from quantile regression analysis.



Summary of the findings

- Height increased only in young generation
- Height did not increase in adult
- Weight and BMI increased in most age groups
- SE change contributed the above changes
- Unchanging adult stature may reflect the delay in impact or genes that limit growth

Stature of the Mountain Ok people

- Short stature (<5th%tile) in 1983 and 2008
 - Growth promoting hormones (GH and IGF1) were detectable in serum (Schwartz et al., 1987)
 - Reduced GHBP (Baumann et al., 1991)
 - “multiple factors impact regulation of stature”
 - “non-hormonal factors?”

Younger age groups show increased height over the 25-year-interval

- Height gain from 1983 to 2008: 11-15y (m) and 6-10 y (f)
- Originally characterized by “slow growth”
- Evidence of puberty spurt?
- Secular trend with changes in socioeconomic status?

Weight and BMI increase in young and adult age groups

- Height: high heritability
- Weight: Environmental effect
- Female of 26-25 years gained weight probably because of SE changes

Impact of interactions with ok Tedi mine

- No Height change in 21-35 males (2008), and adult females (2008) but in 36-45 y males (2008)
 - By chance? or onset of bone loss in 1983
 - Dietary change (e.g., energy dense)
 - Time lag: cf, birth weight: 2663g (1963-70) < 2854g (1995-2000)

Multiple factors influence stature of the Telefolmin

- Height increase in young generation
= future height increase in adults?
- Genetic factors limit the increase of final height? (see Fig 4)

Why their stature is short?

- (1) Biological adaptation?
- (2) Or Consequences of diet?

- The Shorter, the better: (1)
- Height increase due to dietary change (2)