Seven-year stability of indicators of obesity and adipose tissue distribution in the Canadian population[1–3]

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ABSTRACT

Background: The prevention of obesity appears to be a better approach than treatment; thus, the prediction of future obesity from current status is important.

Objective: The aim of the study was to examine the stability of adiposity and adipose tissue distribution (ATD) in the Canadian population.

Design: The sample included 1048 males and 1063 females aged 7–69 y at baseline from the Campbell's Survey, a 7-y follow-up of the Canada Fitness Survey. Indicators of adiposity included body mass index (BMI), sum of 5 skinfold thicknesses (SF5), and waist circumference (Waist), whereas indicators of ATD included the ratio of trunk to extremity skinfold thicknesses adjusted for SF5 (TER_{adj}), and Waist adjusted for BMI ($Waist_{adj}$).

Results: Interage correlations ranged from 0.53 to 0.91 for BMI, from −0.09 to 0.72 for SF5, from 0.24 to 0.89 for Waist, from 0.23 to 0.73 for TER_{adj}, and from 0.18 to 0.77 for $Waist_{adj}$. Correlations for BMI were higher than for SF5, suggesting that fat-free mass may contribute to the stability of BMI. Although lower than those for BMI, correlations for indicators of ATD were significant, indicating a propensity to retain an android or gynoid pattern. Furthermore, the average percentage of participants remaining in the lower or upper quintiles for the various indicators ranged from 37.8% to 66.7% in males and from 47.0% to 65.3% in females, indicating that those in the lower and upper portions of the distribution tend to remain there.

Conclusion: Obesity and ATD showed significant stability over 7 y in the Canadian population. *Am J Clin Nutr* 1999;69:1123–9.

KEY WORDS Fatness, tracking, fat distribution, skinfold thicknesses, subcutaneous tissue, body mass index, Canada Fitness Survey, Campbell's Survey

INTRODUCTION

Obesity is a multifactorial disease with dietary, physical activity, genetic, and social factors (and their interactions) contributing to its etiology. Given the morbidity and mortality associated with overweight and obesity, particularly extreme or morbid obesity, it is important to identify those who are at increased risk of becoming obese. People can become obese at any age and, in general, long-term weight loss is rarely achieved once obese. Thus, prevention appears to be the most promising way to deal with the currently observed increase in the prevalence of overweight and obesity.

The prediction of adult obesity from childhood weight status is currently of major interest. Targeting prevention programs at children at high risk of adult obesity is a potential starting point in our efforts to reverse the current epidemic of obesity. Two recent reviews indicate that the risk of adult obesity is increased if one is obese as a child (1, 2). In addition, the risk of adult obesity is increased if one or both parents are obese (3). Although there is considerable variability in changes in fatness from childhood to adulthood, risk of adult obesity is associated with both childhood obesity and the obesity status of the parents (3, 4).

In addition to the degree of overall fatness, the distribution of adipose tissue within the body is an important predictor of disease risk. Three types of adipose tissue distribution are of particular interest: excess subcutaneous truncal abdominal fat (android obesity), excess abdominal visceral fat, and excess gluteofemoral fat (gynoid obesity). These 3 types of obesity have been identified from both anatomic and health perspectives (5, 6). Given the differential health risks associated with these types of obesity, an indication of the stability of adipose tissue distribution is an important concern. The present study focused on the stability of anthropometric indicators of adipose tissue distribution over time because precise measures of abdominal visceral fatness were not available for the present sample.

The most commonly used indicator of obesity is body mass index (BMI; kg/m^2) because of its ease of measurement and reasonable relation to body fatness in the general population (6). Recently, waist circumference has been advocated as a good indicator of body fatness (7) because it is highly correlated with BMI (8), visceral fatness (9), and total body fat (10). The stability of BMI as an index has been well documented (11–20). The constancy of more direct

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TABLE 1
Initial values and 7-y changes in indicators of obesity and adipose tissue distribution in the general Canadian population[1]

Age (y)	BMI	SF5	Waist circumference	TER
	kg/m²	*mm*	*mm*	
Males				
7–8 (*n* = 55–61)	16.4 ± 1.8 (4.7 ± 2.3)	34.3 ± 11.8 (12.4 ± 14.4)	572 ± 47 (161 ± 63)	0.54 ± 0.11 (0.28 ± 0.19)
9–10 (*n* = 43–48)	17.3 ± 2.8 (5.2 ± 2.5)	38.5 ± 24.1 (5.9 ± 28.5)	614 ± 74 (156 ± 70)	0.54 ± 0.11 (0.43 ± 0.20)
11–12 (*n* = 50–57)	18.2 ± 2.3 (4.4 ± 2.3)	44.9 ± 19.6 (3.4 ± 22.1)	647 ± 64 (138 ± 69)	0.63 ± 0.25 (0.45 ± 0.31)
13–14 (*n* = 37–41)	19.6 ± 3.1 (4.2 ± 2.7)	38.3 ± 15.3 (13.4 ± 26.6)	702 ± 61 (103 ± 74)	0.73 ± 0.21 (0.39 ± 0.28)
15–16 (*n* = 39–47)	20.6 ± 2.2 (3.7 ± 2.9)	36.5 ± 10.2 (17.8 ± 18.3)	721 ± 53 (90 ± 77)	0.78 ± 0.18 (0.47 ± 0.33)
17–18 (*n* = 46–55)	21.7 ± 2.1 (2.7 ± 2.3)	42.5 ± 17.5 (12.7 ± 16.0)	758 ± 52 (73 ± 68)	0.92 ± 0.22 (0.32 ± 0.31)
19–29 (*n* = 205–245)	23.3 ± 3.0 (1.4 ± 1.6)	47.4 ± 20.2 (9.7 ± 14.0)	809 ± 69 (43 ± 48)	1.16 ± 0.29 (0.15 ± 0.32)
30–39 (*n* = 218–243)	25.0 ± 3.5 (1.3 ± 1.8)	56.6 ± 21.5 (8.8 ± 17.9)	866 ± 92 (39 ± 54)	1.31 ± 0.35 (0.10 ± 0.39)
40–49 (*n* = 111–128)	26.0 ± 3.3 (0.9 ± 1.9)	58.7 ± 17.8 (6.1 ± 15.9)	905 ± 92 (39 ± 112)	1.41 ± 0.36 (0.02 ± 0.42)
50–59 (*n* = 77–90)	25.8 ± 3.3 (0.6 ± 1.8)	55.3 ± 16.7 (6.3 ± 17.6)	916 ± 88 (22 ± 57)	1.39 ± 0.37 (0.02 ± 0.42)
60–69 (*n* = 20–33)	26.0 ± 4.4 (0.7 ± 1.8)	58.3 ± 16.1 (17.6 ± 20.4)	941 ± 107 (47 ± 56)	1.30 ± 0.32 (0.25 ± 0.46)
Females				
7–8 (*n* = 45–54)	16.6 ± 1.8 (4.7 ± 1.9)	44.9 ± 15.7 (22.7 ± 17.0)	556 ± 38 (129 ± 54)	0.52 ± 0.13 (0.14 ± 0.15)
9–10 (*n* = 50–58)	17.7 ± 3.1 (4.7 ± 1.8)	51.7 ± 25.4 (19.8 ± 18.0)	596 ± 77 (103 ± 47)	0.56 ± 0.24 (0.13 ± 0.24)
11–12 (*n* = 36–44)	18.1 ± 2.7 (3.9 ± 2.2)	48.8 ± 16.3 (26.2 ± 21.0)	605 ± 61 (87 ± 65)	0.60 ± 0.14 (0.11 ± 0.16)
13–14 (*n* = 36–46)	20.0 ± 2.3 (2.2 ± 2.5)	54.7 ± 16.1 (20.2 ± 27.6)	659 ± 58 (39 ± 49)	0.56 ± 0.11 (0.08 ± 0.12)
15–16 (*n* = 28–32)	20.8 ± 2.5 (1.5 ± 2.0)	54.4 ± 17.6 (9.4 ± 18.0)	667 ± 53 (34 ± 62)	0.61 ± 0.14 (0.06 ± 0.16)
17–18 (*n* = 35–43)	21.4 ± 3.1 (1.5 ± 2.2)	66.5 ± 25.5 (8.6 ± 27.4)	687 ± 80 (36 ± 86)	0.65 ± 0.18 (0.01 ± 0.17)
19–29 (*n* = 198–242)	21.6 ± 2.9 (1.4 ± 2.7)	61.7 ± 20.4 (9.7 ± 17.9)	697 ± 66 (24 ± 56)	0.66 ± 0.20 (0.00 ± 0.14)
30–39 (*n* = 212–254)	23.5 ± 4.2 (1.5 ± 2.7)	72.1 ± 25.6 (12.6 ± 19.9)	744 ± 102 (35 ± 50)	0.66 ± 0.20 (0.02 ± 0.17)
40–49 (*n* = 118–142)	24.1 ± 3.8 (1.4 ± 2.6)	76.7 ± 28.9 (14.0 ± 25.1)	758 ± 86 (37 ± 71)	0.66 ± 0.19 (0.03 ± 0.18)
50–59 (*n* = 75–95)	24.8 ± 3.5 (0.9 ± 2.6)	83.5 ± 23.7 (11.0 ± 23.9)	779 ± 78 (38 ± 56)	0.69 ± 0.20 (0.02 ± 0.21)
60–69 (*n* = 35–53)	24.1 ± 4.2 (0.5 ± 2.8)	73.7 ± 23.9 (9.4 ± 19.2)	784 ± 96 (38 ± 57)	0.69 ± 0.28 (−0.01 ± 0.25)

[1] $\bar{x}$ ± SD; change ± SD in parentheses. SF5, sum of 5 skinfold thicknesses; TER, ratio of 2 trunk to 3 extremity skinfold thicknesses (in mm).

measures of fatness such as skinfold thicknesses (11, 12, 15, 21–26) and percentage body fat from underwater weighing (27, 28) have also been addressed. On the other hand, the stability of adipose tissue distribution phenotypes from childhood into adulthood and throughout adulthood has been less studied (29–32).

The purpose of this study was to estimate the stability of indicators of obesity and adipose tissue distribution in the Canadian population over 7 y (1981–1988). Such longitudinal studies are often concerned with predicting adulthood obesity from childhood values; however, few studies have examined the stability of indicators of obesity throughout the adult age range. The degree to which adults maintain their fatness or pattern of adipose tissue distribution as they progress through middle age is also of interest. Thus, 7-y changes were assessed at different ages throughout the life span.

SUBJECTS AND METHODS

Sample

The Campbell's Survey database includes information on 4345 individuals from urban and rural areas of every province who were initially part of the Canada Fitness Survey in 1981, and were subsequently revisited in 1988 (33). The Canada Fitness Survey sample is representative of the entire population (34). The present analysis is based on a subsample of 1048 males and 1063 females, 7–69 y of age at baseline, for whom anthropometric dimensions were available in 1981 and 1988.

Measures

Anthropometric dimensions were taken according to the standardized procedures of the Canada Fitness Survey (35). Stature was measured to the nearest 0.1 cm by using a Harpenden tape; body mass was measured to the nearest 0.1 kg by using a standing beam-balance scale (Seca Corporation, Columbia, MD); and waist circumference (Waist) was measured to the nearest 1.0 mm by using an anthropometric tape. Skinfold thicknesses at the triceps, biceps, medial calf, subscapular, and suprailiac sites were measured to the nearest 0.2 mm by using a Harpenden skinfold caliper (British Indicators, Ltd, London). All skinfold thicknesses were taken on the right side of the body.

Several indexes were derived from the anthropometric dimensions. BMI was calculated and the 5 skinfold thicknesses were summed to provide a measure of subcutaneous adiposity (SF5). The ratio of the 2 trunk to the 3 extremity skinfold thicknesses (TER) was calculated to provide an index of subcutaneous adipose tissue distribution. The sample sizes, means, and SDs of the indicators of obesity and adipose tissue distribution and 7-y changes are provided in **Table 1**.

TER and Waist were adjusted for SF5 and BMI, respectively, by using regression procedures, and the adjusted values were used as indicators of adipose tissue distribution. TER was adjusted by applying the following regression: TER = SF5 + $SF5^2$ + $SF5^3$ in a forward stepwise manner, retaining terms significant at the 5% level. The residuals (TER_{adj}) were retained for further analysis to represent TER adjusted for overall subcutaneous fatness. Similarly, Waist was adjusted for BMI ($Waist_{adj}$). Given that the relation between fatness and adipose tissue distribution may vary by sex and age, the TER and Waist adjustments were made separately in males and females 7–19 and 20–69 y of age. Briefly, SF5, $SF5^2$, and $SF5^3$ accounted for between 4.2% and 10.6% of the variability in TER, whereas BMI, BMI^2, and BMI^3 accounted for between 71.9% and 84.8% of the variability

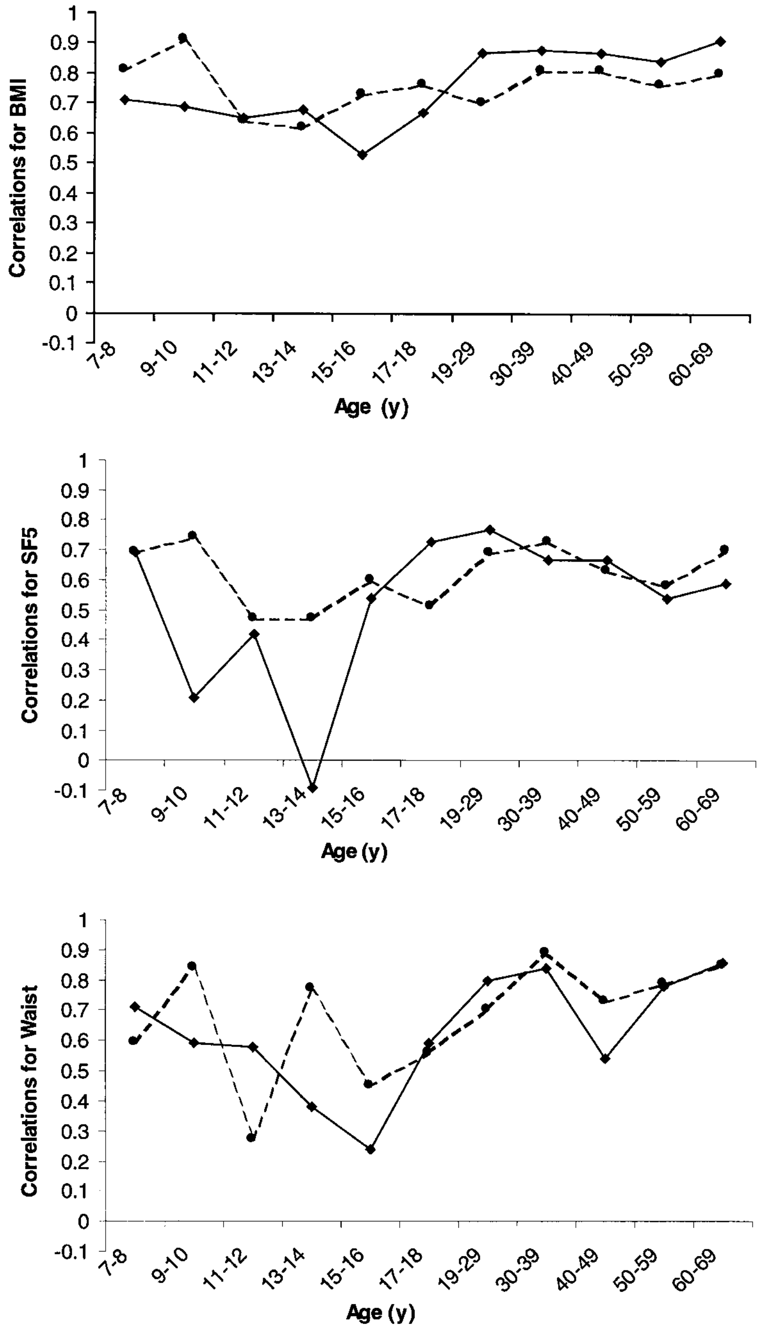

FIGURE 1. Pearson 7-y interage correlations for BMI, the sum of 5 skinfold thicknesses (SF5), and waist circumference (Waist) in males (——■) and females (---●). All correlations are significant, $P \leq 0.05$, except for SF5 in 9–10- and 13–14-y-old males and Waist in 15–16-y-old males and 11–12-y-old females.

in Waist. Thus, 3 indicators of fatness (BMI, SF5, and Waist) and 2 indicators of fat distribution (TER_{adj} and $Waist_{adj}$) were considered in the present study.

Statistical analysis

For the purpose of analysis and to preserve sample sizes, the sample was divided into 2-y age groups from the ages of 7 to 18 y and into decades from the ages of 19 to 69 y (Table 1). Pearson interage correlations were computed between the first (1981) and second (1988) measurements for each variable. Stability in the upper and lower portions of the distribution was examined by calculating the percentage of participants who remained in the upper and lower quintiles (20%) over 7 y.

RESULTS

Seven-year interage correlations for the indicators of obesity and adipose tissue distribution are presented in **Figures 1** and **2**. With few exceptions, the correlations were significant. BMI remained relatively constant across the age range and there were

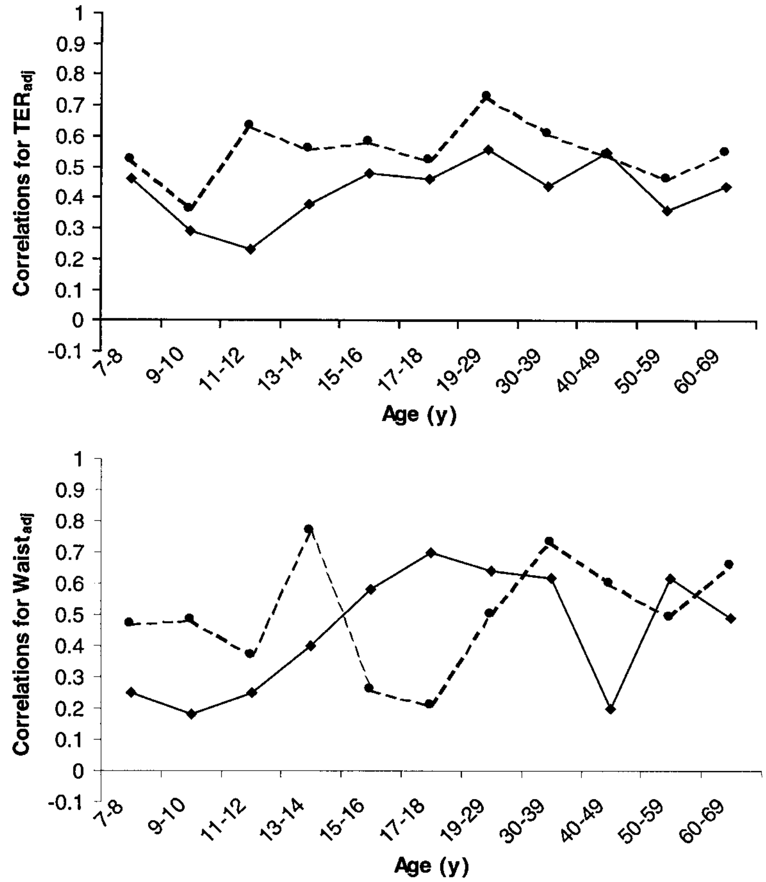

FIGURE 2. Pearson interage correlations for the ratio of trunk to extremity skinfold thicknesses adjusted for the sum of 5 skinfold thicknesses (TER_{adj}) and waist circumference adjusted for BMI ($Waist_{adj}$) in males (——■) and females (- - -●). All correlations are significant, $P \leq 0.05$, except for TER_{adj} in 11–12-y-old males and $Waist_{adj}$ in 7–8- and 9–10-y-old males and 15–16- and 17–18-y-old females.

no marked sex differences (Figure 1). Similarly, SF5 showed significant stability, except in boys 13–14 y of age, in whom the correlations approached zero. Correlations for TER_{adj} were consistently higher in females than in males (Figure 2), and the strength of the correlations was generally lower than for BMI, although they followed a similar pattern. There was more variability in the pattern of interage correlations for $Waist_{adj}$ than for TER_{adj} (Figure 2).

The percentages of participants who remained in the upper and lower quintiles (20%) of the distribution over 7 y are presented in **Table 2**. On average, the percentages of males remaining were 66.7%, 47.0%, 60.6%, 49.6%, and 52.0% for the lower quintile and 62.4%, 47.8%, 58.8%, 37.8%, and 46.3% for the upper quintile for BMI, SF5, Waist, TER_{adj}, and $Waist_{adj}$, respectively. The corresponding average percentages for females were 55.8%, 58.3%, 56.2%, 49.1%, and 47.0% for the lower quintile and 65.3%, 48.1%, 56.2%, 53.0%, and 49.0% for the upper quintile for BMI, SF5, Waist, TER_{adj}, and $Waist_{adj}$, respectively.

DISCUSSION

Results of the present study indicate significant 7-y stability of indicators of obesity and adipose tissue distribution. In addition, obesity and adipose tissue distribution phenotypes also correlate well throughout the age range of adulthood, with correlations similar to those in childhood. On the basis of these data, it is difficult to pinpoint a given age at which prevention strategies may be most effective.

BMI is a commonly used indicator in the study of changes in fatness. The interage correlations for BMI in the present study range from 0.53 to 0.91 in males and from 0.62 to 0.91 in females and the strength of the correlations was fairly stable across the entire age range (Figure 1). These results are consistent with other studies. In a review, Power et al (1) indicated that the correlations between childhood and adulthood BMI ranged from 0.25 to 0.91 in males and from 0.05 to 0.77 in females; however, the initial age of the children and the length of follow-up varied from study to study. The correlations in the present study are slightly higher than those reported from childhood to adulthood; however, the present study did not address the changes in BMI from childhood to adulthood per se, but rather 7-y stability throughout the life span.

Results of the present study suggest that the stability of BMI is better than for other indicators of obesity and adipose tissue distribution. Caution must be used in interpreting the results, however, because BMI is a composite measure that cannot distinguish between fat and lean tissue. In a sample of 41 boys followed from 11 to 18 y of age, interage correlations for densitometric estimates of fat mass ($r = 0.25$) were lower than those for fat-free mass ($r = 0.60$) (27). Similarly, Guo et al (28) reported

TABLE 2
Percentages of participants remaining in the lower or upper quintile (20%) over 7 y[1]

Age (y)	BMI Lower	BMI Upper	SF5 Lower	SF5 Upper	Waist Lower	Waist Upper	TER_{adj} Lower	TER_{adj} Upper	$Waist_{adj}$ Lower	$Waist_{adj}$ Upper
	%									
Males										
7–8	53.9	50.0	45.5	63.6	63.6	63.6	45.5	45.5	27.3	45.5
9–10	50.0	66.7	33.3	44.4	55.6	44.4	33.3	37.5	44.4	33.3
11–12	54.6	63.6	60.0	50.0	60.0	50.0	40.0	30.0	70.0	40.0
13–14	62.5	37.5	28.6	14.3	57.1	28.6	42.9	28.6	14.3	42.9
15–16	70.0	27.3	50.0	50.0	50.0	37.5	37.5	50.0	50.0	42.9
17–18	66.7	63.6	22.2	55.6	50.0	66.7	55.6	44.4	60.0	55.6
19–29	80.4	75.5	62.8	68.3	68.9	76.2	53.5	46.3	58.1	53.7
30–39	76.5	75.5	60.0	53.5	63.8	80.0	35.6	46.5	53.2	61.4
40–49	70.4	76.9	47.8	54.6	70.8	68.2	52.2	50.0	66.7	65.2
50–59	77.8	66.7	56.3	43.8	76.5	56.3	50.0	37.5	52.9	43.8
60–69	71.4	83.3	50.0	25.0	50.0	75.0	100.0	0.0	75.0	25.0
Average	66.7	62.4	47.0	47.8	60.6	58.8	49.6	37.8	52.0	46.3
Females										
7–8	45.5	70.0	44.4	55.6	60.0	50.0	44.4	44.4	40.0	50.0
9–10	50.0	90.9	40.0	70.0	40.0	90.0	50.0	50.0	40.0	40.0
11–12	42.9	44.4	85.7	42.9	25.0	25.0	71.4	42.9	50.0	50.0
13–14	77.8	44.4	71.4	28.6	57.1	57.1	28.6	71.4	57.1	57.1
15–16	28.6	66.7	33.3	20.0	50.0	50.0	33.3	80.0	33.3	20.0
17–18	66.7	50.0	42.9	42.9	62.5	42.9	57.1	28.6	37.5	42.9
19–29	55.6	62.5	65.9	59.0	60.5	56.1	65.9	64.1	53.5	61.0
30–39	63.5	62.8	50.0	57.1	66.0	73.3	50.0	50.0	55.3	64.4
40–49	79.3	67.9	62.5	56.5	70.4	53.9	50.0	47.8	51.9	46.2
50–59	57.9	68.4	73.3	53.3	64.7	62.5	46.7	46.7	41.2	50.0
60–69	45.5	90.0	71.4	42.9	62.5	57.1	42.9	57.1	57.1	57.1
Average	55.8	65.3	58.3	48.1	56.2	56.2	49.1	53.0	47.0	49.0

[1] SF5, sum of 5 skinfold thicknesses; Waist, waist circumference; TER_{adj}, ratio of 2 trunk to 3 extremity skinfold thicknesses adjusted for SF5; $Waist_{adj}$, waist circumference adjusted for BMI.

better stability of fat-free mass than of fat mass in both males and females over intervals of 5–10 y in the Fels Longitudinal Study. Thus, the available evidence suggests that the stability of fat-free mass appears to be better than that of fat mass and studies that rely on BMI as an index of obesity may overestimate the stability of fatness per se.

The stability of subcutaneous fatness (SF5) is generally lower than that of BMI, which may reflect to some extent the stability of fat-free mass, as discussed above. Nevertheless, the stability of fatness in the present study is significant. The results are consistent with those of other studies that have used either single skinfold thicknesses or the sum of several skinfold thicknesses. In general, skinfold thicknesses correlate moderately well during childhood and adolescence (15, 23, 24, 36) and between adolescence and adulthood (12, 37, 38). In the present study, the correlation coefficients were low and not significant for SF5 in 13–14-y-old boys. This is the age range when boys have their growth spurt in stature, and correlations between measurements are typically lower when one of the time points falls in this age range (39). In females, the correlations in the age group 11–12 y were also somewhat lower, but were still significant.

Several studies have shown that interage correlations increase with age in childhood and that the shorter the time period between measurements the higher the correlation (15–17, 25). The present study could not address the latter issue because the time between measurements was fixed at 7 y; however, there was no pattern of increasing correlations with age (Figures 1 and 2). Significant 15-y stability of various skinfold thicknesses was reported by Hawk and Brook (23), and, similar to the current study, the correlations did not increase with increasing age of the children. On the other hand, interage correlations for skinfold thicknesses increased with age in a French study of changes between 1 and 16 y of age, and young adulthood (mean age: 21 y) (15). The increasing trend in the French study may have been due to the decreasing time spans between child and adult measurements in that study, in contrast with the study of Hawk and Brook (23) (15 y) and the present study (7 y) in which the follow-up periods were fixed.

The present study extends the findings for indicators of fatness to those of adipose tissue distribution. Significant correlations were observed throughout the age range for TER_{adj} and $Waist_{adj}$. The tracking of subcutaneous adipose tissue distribution across childhood and adolescence is moderate at best. Among British (32), Australian (29), and Belgian (G Beunen, A Claessens, M Ostyn, et al, unpublished observations, 1986) youth, interage correlations between values at younger ages and several adolescent ages are variable and range from 0.2 to 0.6. The correlations tend to be slightly higher in girls (32). Correlations in youth 7–18 y of age in the present study ranged from 0.23 to 0.63 for TER_{adj} and from 0.21 to 0.77 for $Waist_{adj}$. With the exception of correlations for 15–18-y olds for $Waist_{adj}$, the correlations are consistently higher in females than in males for each age group (Figure 2).

The instability of the TER during adolescence is related to individual differences in the timing of the adolescent growth spurt and to variation in changes in individual skinfold thicknesses during adolescence, particularly in males (40).

There is limited information on the stability of adipose tissue distribution from childhood into adulthood. One study reported that the stability of the waist-to-hip diameter ratio taken from somatotype photographs was significant from 6 to 30 y of age (r = 0.47 in males and r = 0.40 in females) and correlations were particularly strong from 18 to 30 y of age (r = 0.65 in males and r = 0.79 in females) (30). These results are interesting; however, the waist-to-hip ratio (diameters or girths) is a complex measure that includes bone, muscle, and adipose tissue, particularly the hip measurement.

Information on the stability of adipose tissue distribution in adulthood is limited. Correlations from one study are generally similar to those observed in children and adolescents (31). Interage correlations for the TER [(subscapular + abdominal)/(triceps + biceps)] were 0.32 and 0.36 across 23 y in men seen initially at 42–50 and 51–62 y of age, respectively (31). The results are similar to those of the present study in which correlations ranged from 0.44 to 0.73 for TER_{adj} and from 0.20 to 0.73 for $Waist_{adj}$ for adults 19–69 y of age. Thus, the available evidence indicates that the stability of an android or gynoid distribution of adipose tissue is moderate in adulthood, but more work is required to better characterize the stability of adipose tissue distribution throughout the life span.

The quintile analysis indicated that, on average, 37.8–66.7% of males and 47.0–65.3% of females in the lower and upper portions of the distributions of the various indicators tended to remain there. Using a similar approach, Lefevre et al (38) indicated that between 25% and 31% of males remained within the lower or upper decile (10%) of the distribution between the ages of 18 and 30 y for calf, subscapular, and suprailiac skinfold thicknesses. Slightly higher percentages, 47% and 50%, of the sample remained in the lower and upper deciles, respectively, of the distribution for body weight (38). The present sample, particularly at younger ages, was too small to be divided into deciles; however, the results reported for quintiles are similar to those reported for deciles.

The results of the present study are important in view of the related health effects of obesity. Given that obesity and adipose tissue distribution are remarkably stable throughout the life span (7–69 y), so to is the significant risk for disease that is associated with obesity. In particular, if someone has severe android obesity, one can be confident that that individual will probably remain at elevated risk for cardiovascular diseases or diabetes throughout his or her life, unless appropriate weight-loss and weight-management measures are taken.

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