Is Obesity as Measured by Body Mass Index and Waist Circumference in Adult Australian Women 2002 Just a Result of the Lifestyle?

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INTRODUCTION

It is well documented that in Australia, similar to many other countries, values of Body Mass Index, waist circumference and Waist-Hip Ratio indicate high levels of overweight and obesity (Swinburn, 2003; Cameron et al., 2003; Dalton et al., 2003; Cameron et al., 2004). Although the sedentary lifestyle coupled with readily available diet based on tradition of hard-working peasant and manual labourer British people are undoubtedly major contributors to the "obesity epidemic", other factors may be also involved. Specifically, in the last 100 years natural selection operating through differential mortality has been relaxed to a very large extent (Stephan and Henneberg, 2001). This occurred mostly through improved sanitation and efficiency of medical intervention. We have suggested earlier that changes in the operation of natural selection on humans result in changing hormonal/endocrine regulation of human physical growth and development (Henneberg and Steyn, 1995). We have also suggested that leptin levels, or sensitivity of human organism to leptin, may have undergone recent evolutionary change (Ruehli and Henneberg, 2001). This paper explores morphometric data of adult Australian women for associations of traditional mesaures of overweight/obesity with other morphological characteristics, both related and unrelated to energy balance.

MATERIAL AND METHODS

The National Body Size and Shape Survey of Australia was conducted in 2002. Through advertisement in media and in special publications of the Expertise Events Pty Ltd (a company organising craft fairs) adult women were asked to volunteer to undergo a series of anthropometric measurements during craft fairs in major cities. At the venues of those fairs anthropometric booths were staffed by academics and postgraduate students of the University of Adelaide, University of Western Australia, University of Western Sydney, University of Queensland, Australian National University, Royal Melbourne Institute of Technology University and a number of vocational training institutions. Staff members of SHARP Dummies Pty Ltd, who organised the logistics of the survey were also taking measurements. All measurers were trained in standard Martin's anthropometric technique and in taking garment-relevant measurements according to the International Standards Organisation document 8559 (1989). Approximately 200 female volunteers were measured at each of the fairs held in Perth, Adelaide, Canberra, Melbourne, Sydney and Brisbane, giving total of 1266 adult female volunteers with nearly complete sets of 65 anthropometric characters recorded for each person. Individuals measured at each location came not only from the capital city named, but also from an area of up to 500 km away from the city. Data used in this paper are derived from this set.

Body height was measured with the GPM anthropometer to the nearest millimetre, body mass (weight) was determined to the nearest kilogram in the majority of women by electronic scales, while the minority had it measured on spring scales daily calibrated against the electronic ones. Weight was taken barefoot in light clothing. Circumferences were measured with non-stretch tape calibrated to the nearest millimetre while linear trunk dimensions were measured with GPM spreading calipers. Skinfolds were measured using GPM calipers. Skinfold calipers are so constructed that their arms do not open much beyond 40 mm. Thus we have recorded precisely skinfold thicknesses of less than 41 mm. Thicker skinfolds were only recorded as "more" or >40. For this reason it is impossible to provide reliable estimates of standard deviations of skinfold thicknesses, while calculations of moment-product correlations of skinfold thicknesses with other characteristics are imprecise, and may be somewhat lower than the actual values. Skinfold thicknesses were subtracted from waist and arm circumferences to provide "lean" circumferences. This was done using a formula:

Slim circumfernce = actual circumference – skinfold * 3.14

Body Mass Index (BMI) was calculated as a ratio of body mass in kilograms to squared body height in metres. Linear and curvilinear regressions were run between the BMI and other characteristics to determine which of those explain significant portions of the BMI variance.

Recruitment of volunteers into the survey has resulted in random representation of Australian women since body heights and body weights did not differ substantially between the six locations (Table 1), with the exception of higher body weight in Adelaide. Body heights were also not different from those observed in 1995 by the Australian Bureau of Statistics (1998) when corrections for loss of height with age were made, though body weight averages were higher.

RESULTS

Table 1 presents arithmetic means of body heights, weights, BMI and waist circumference by location.

Table 1: Averages of body height, body mass (weight) and BMI of Australian adult women (18 100 years old, average 50 years) by capital city in which women from that city and its surroundings (radius of up to 500 km) were measured.

City	*N*	*Height (mm)*		*Weight (kg)*		*BMI (kg/m²)*	
		Avg	*std*	*Avg*	*std*	*Avg*	*std*
Adelaide	219	1624	68	77.2	16.6	29.3	6.2
Brisbane	208	1620	67	72.9	17.0	27.7	6.3
Canberra	183	1628	84	73.3	16.2	27.8	6.5
Melbourne	233	1629	70	74.0	16.2	27.9	5.9
Perth	190	1625	67	73.6	16.6	27.9	5.9
Sydney	233	1626	69	73.7	16.6	27.6	6.3

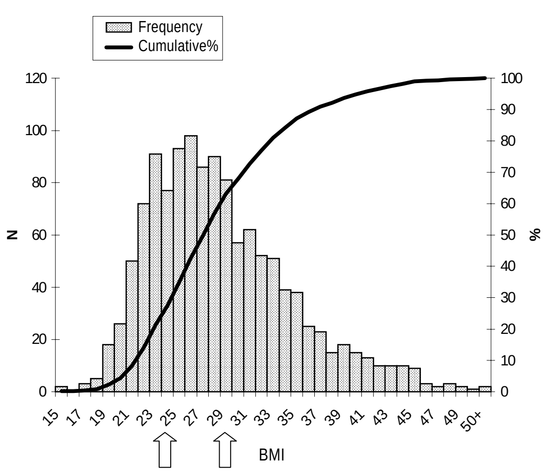

Fig. 1. Distribution of BMI among adult Australian women

Distribution of Body Mass Index (Fig. 1) indicates that about 1/3 of Australian women are obese (BMI>30), another 1/3 are overweight (BMI 25-29) thus leaving only 1/3 who have acceptable values of BMI. There are no clear changes in body weight and BMI with age (Fig. 2).

Distribution of waist circumference (Fig. 3) leads to conclusions similar to those based on BMI distribution, though proportion of obese women (waist circumference > 1020 mm) is somewhat lower than 20%.

Medians of skinfold thicknesses at the three sites are high (Table 2).

Table 2: Medians of skinfold thicknesses on three sites in adult Australian women (N~1250).

Site	*Median (mm)*	*Min.*	*Max.*
Triceps	24	8	>40
Subscapular	23	6	>40
Abdominal	29	6	>40

BMI correlates very strongly with body weight, while having no significant correlation with body height, as expected (Table 3). BMI also correlates positively with skinfold thicknesses, but the amount of BMI variance explained by skinfolds is about 50%, and not more than 65%. Nearly 75% of BMI variance is explained by the size of the intraabdominal contents, as indicated by high correlation with "lean waist cirumference" that is independent of abdominal skinfold thickness.

Interestingly, BMI also shows significant corre-lations with the width of trunk measured

Table 3: Coefficients of determination (r^2) of BMI and selected metric variables of Australian adult women.

Variable	r^2	*Type of regression*
Body height	0.007	linear
Body mass (weight)	0.856	linear
Waist circumference	0.803	linear
Lean waist circumference	0.732	linear
Abdominal skinfold	0.488	logarithmic
Subscapular skinfold	0.560	logarithmic
Triceps skinfold	0.535	logarithmic
Average skinfold	0.652	logarithmic
Bi-acromial diameter	0.157	linear
Bi-acromial diam./height	0.241	linear
Bi-iliocristal diameter	0.402	linear
Bi-iliocristal diam./height	0.441	linear
Lean arm circumference	0.436	linear

All coefficients, but for body height, significant at $p<0.01$ level. All correlations are positive.

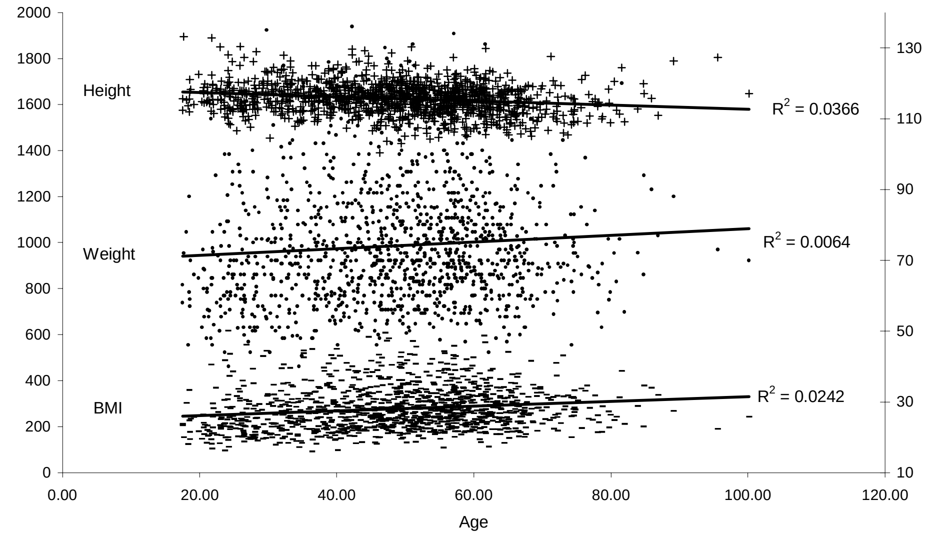

Fig. 2. Changes of adult Australian women's body height, body mass (weight) and Body Mass index with age

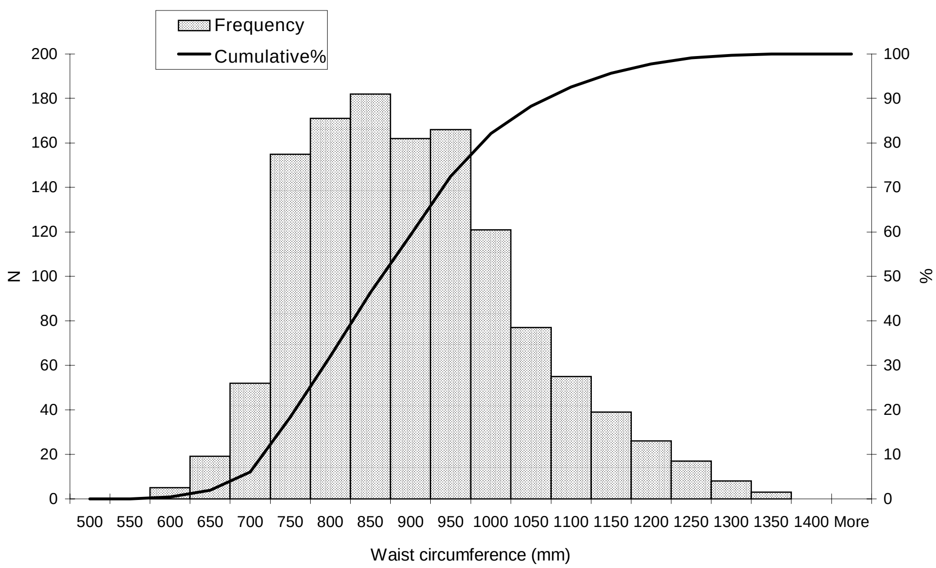

Fig. 3. Waist circumference distribution in adult Austrlian women

on bony points of shoulders and hips (acromion and iliocristale) which are not reflecting the amount of fat in the body, but inform about the robusticity of the skeleton. Their determination coefficients are even higher when the bony width of shoulders and hips are standardised on body height. Such standardised shoulder and hip widths are indicative of the shape of the skeletal frame of the body which can be described as gracile (lower values) or robust (higher values). Finally, there exists a significant positive correlation of BMI with the lean arm circumference which expresses mostly the size of muscles in the arm.

DISCUSSION

It follows that variance of the BMI is influenced not only by the amount of subcutaneous adipose tissue, but also by the size of the musculoskeletal system and, to a large extent by the size of intraabdominal contents. These latter comprise various viscera, mostly of the gastrointestinal system, peritoneum, blood vessels and intraabdominal fat. These components of intraabdominal contents cannot be separated based on external measurements of the body, but even when taken together they represent mostly the size of the gastrointestinal system.

Our findings on BMI and waist circumference distribution are similar to those of other recent surveys of Australian population (Swinburn, 2003; Cameron et al., 2003; Cameron et al., 2004) indicating the "obesity epidemics". In contrast to the conclusions of the other authors, however, we find that BMI is strongly influenced by components of lean body mass and thus its increases may not reflect solely increasing adiposity of the population, but also increases in its lean body mass. One can make an argument that obese people have more weight to carry and thus will develop greater muscle mass through exercise provided by normal daily activities. In the sedentary lifestyle, however, there seems to be not enough physical activity to substantially develop muscle mass by simply lifting one's own body weight. The lean arm circumference used in this study would not be influenced by the total body weight, anyway while moving upper limb with more fat on it during daily activities of sedentary lifestyle is probably inadequate to develop noticeably greater muscle mass. Therefore it seems that increased lean body mass of individuals in modern populations may be a result of robusticity of the musculoskeletal system changing largely independently of increased adiposity. Changes in head shape occurred during the historical times, at a scale of centuries, rather than millennia (Henneberg and Steyn, 1995), and it may be that some changes in proportions of postcranial skeleton may be occurring in recent generations. This, however, requires further, more thorough investigation.

Moreover, increased adiposity may not be entirely due to the positive energy balance resulting from the "lazy" lifestyle and excessive food intake, but may be, at least in part, related to changing metabolic properties of some individuals. After all, about 1/3 of the adult Australian women, despite the exposure to overabundant diet and to low-exercise lifestyle, still remain below BMI 25 value. Were the increase in BMI solely the result of abundant food intake and low energy expenditure, practically all people should have increased BMI values. This is not the case even in some individuals who are not excessively concerned about "weight watching". There are, of course, those members of modern societies who do not eat excessively and who maintain high levels of physical activity it, how-ever, remains to be ascertained what proportion of various populations they represent.

It may be that with the recent relaxation of the operation of natural selection, the Holocene trend towards gracilisation (Schwidetzky, 1962; Henneberg, 1988) of body build resulting from adaptations to poor diets as a consequence of unreliable and monotonous pre-industrial agricultural food production has been reversed and we are experiencing increases in the robusticity of musculoskeletal system, that, in addition to greater variation of endocrine/hormonal regulations of metabolic processes and the abundant diets coupled with low energy expenditure lifestyles produce greater body mass in relation to its height. Increase in average BMI values is a complex process that may not be easily reversed by simple changes in individual diets and lifestyles only.

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ABSTRACT Conducted in 2002 anthropometric survey of 1266 adult (18-100 years old) Australian women indicated high levels of overweight and obesity as assessed using formal classifications of the values of the Body Mass Index (BMI) and of waist circumference. Approximately 1/3 of Australian women have "normal" values of BMI (<25) while another 1/3 are obese (BMI>30), the remaining 1/3 being overweight. BMI, as expected, correlates strongly with body weight, but shows no significant correlation with body height. Triceps, subscapular and abdominal skinfold thicknesses explain each about 50% of BMI variance while the lean arm circumference (after removal of adipose tissue thickness by calculation) explains over 40% of BMI variance. The lean waist circumference (minus abdominal skinfold) explains about 75% BMI variance. Bony hip width (Bi-iliocristal diameter) explains over 40% BMI variance directly, and even more when expressed as a percentage of body height. These findings indicate that BMI is to a large extent influenced by components of lean body mass and suggest that recent epidemic increase in BMI may be partly due to microevolutionary change in body composition in addition to the increase in metabolic abnormalities and in the positive energy balance due to abundant diets and sedentary lifestyle.

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