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Ethnic Predisposition to Cardiovascular Disease Risk among the Toto of West Bengal, India: A Longitudinal Study

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ABSTRACT The South Asian population is home to the region with the highest public health burden of cardiovascular disease (CVD) in the world. The present population based longitudinal study was undertaken among the Toto of West Bengal, India, to investigate whether gradual changes in lifestyle affect the cardiovascular health and its associated risk factors among the adult Toto males and females. The prevalence of CVD risk factors was almost negligible, around 2-3 percent in 2002-03. In 2015-16, the prevalence increased to an alarming high of 26.3percent in males (n=108) and 18.2percent (n=97) in females. There was an adverse impact of globalization, perhaps primarily mediated through lifestyle changes on cardiovascular health, indicating a major public health problem even in traditional societies. The *in situ* urbanization even in rural settings seems to be an important factor among the people of South Asian origin.

INTRODUCTION

Several epidemiological studies have recorded a high prevalence of cardiovascular mortality (Mckeigue et al. 1993; Enas et al. 1996) among Indians, including those settled outside of India. Adverse body fat distribution, especially abdominal adiposity, seems to be an important determinant. The growing burden of CVD in India had been attributed to the increasing prevalence of CVD risk factors, especially hypertension, dyslipidemia, type 2 diabetes mellitus, visceral obesity, physical inactivity and tobacco use (Mckeigue et al. 1991).This effect has also been attributed to reduced levels of physical activity, and the dietary changes that occur with effective westernization (WHO 2000). As population becomes more and more westernized, habitual dietary changes to consume more saturated fat and less fiber with little or no physical activity is evident (WHO 2000; Venkatramana and Reddy 2002). In India, the urban prevalence of diabetes (one of most important CVD risk) in adults has risen from merely 5 percent in1984 to 15 percent in 2004 (Ramachandran et al. 2002; Misra and Vikram 2002; Mohan et al. 2006). Markedly lower rural levels of diabetes have been evident for decades, but more recently the prevalence of the same appears to have increased from 2 percent to 6 percent in rural South India (Ramachandran et al. 2004). Underlying these adverse trends in diabetes are the increases in the prevalence of obesity which affects the affecting urban areas much more than the rural areas of India. The rising rates of diabetes in both urban and rural India indicate that urbanization is an important but not a sufficient explanation (Ebrahim et al. 2010). Differences in physical activity level, mainly attributable to occupation, appear to be more important than residence, *per se*, in influencing the risk for CVDs (Gregory et al. 2007). Even though the prevalence of CVD risk factors are known to vary across defined ethnic groups (Cossrow et al. 2004), most epidemiological studies have been conducted in conglomerate populations without considering the ethnicity of the sampled individuals (Misra et al. 2002; Misra and Vikram 2004). Some longitudinal studies in recent times had shown various associations with cardiometabolic risk. For in-

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stance, increase in sedentary time was found to be highly associated with increased adiposity over 7-15 years of follow up (Mann et al. 2017); children and adolescent with normal body weight and high percentage body fat were found to be at increased risk of cardiometabolic morbidity in adulthood (Wiklund et al. 2017).

Keeping this view in mind, the present study was undertaken among the Toto of West Bengal, India with the hypothesis that adverse CVD risk factors are associated with increasing urbanization is not just due to differences in habitat but certain underlying factors like adoption of sedentary lifestyles (sedentary lifestyle is a medical term used to denote a type of lifestyle with no or irregular physical activity) even in rural settings.

METHODOLOGY

Study Population

The present population based longitudinal study (2007-16) was conducted on the Toto (a particularly vulnerable tribal group), living in the state of West Bengal, India. The Totos are a demographically small population and have passed through demographic bottlenecks, but are now an expanding population. As per 1901 census, their population size was 171 (Gait 1901). At present the total population of the Toto is 1546 which includes 796 males and 750 females, and at the beginning of the study (2007-08) it was 1286 (677 males and 609 females). The study was conducted in three phases: Phase I- 2007-08; Phase II- 2011-12 and Phase III- 2015-16. The Toto are geographically localized in a single village (Totopara) of the district of Alipurduar (erstwhile, Jalpaiguri), West Bengal bordering Bhutan. They are rural inhabitants, and are predominantly engaged in agri-horticultural activities and also work as agricultural labourers, and therefore undergo a lot of physical exercise, especially because of the lack of flat agricultural terrain (Sarkar et al. 2006). Toto possess Mongoloid morphological features and speak dialects that belong to the Tibeto-Burman linguistic family. The Toto practice inbreeding as marrying a first-cousin (cross-cousin, but not parallel-cousin) is the tradition (Sanyal 1971; Majumdar 1998). They prefer tea with salt and consume large amount of hand-made millet beer (*eu*) and red meat.

The longitudinal study was conducted at three time points starting from the year 2007-08. The study was first conducted during 2007-08 among 223 participants (120 males and 103 females). The second visit-first follow-up study was conducted during the year 2011-12 on 217 individuals (116 males and 101 females). The third visit-second follow up study was conducted during the year 2015-16 on 205 (108 males and 97 females). The reduction in the number of participants during the second and third visit was primarily due to the non-availability of the participants and because of pregnancy during the time of the studies. The final analyses were conducted on those 205 individuals who were available during all the three time periods of the study.

Anthropometric Measures

Anthropometric measures namely height (cm), weight (kg), circumferences of waist (WC) and hip (cm) were obtained using standard techniques (Lohman et al. 1988). Height and weight (in light clothing) was measured to the nearest 0.1 cm and 0.5 kg, respectively. Waist and hip circumferenceswere measured to the nearest 0.1 cm using an inelastic tape. The minimum WC was measured at the level of natural waist, which was the narrowest part of the torso. Maximum hip circumference was measured at the greatest protrusion of the buttock. The body massindex (BMI in kg/m^2) and weight hip ratio (Waist:Hip) were subsequently computed. Percentage body fat (%BF) was measured using portable body fat monitor (Omron, Omron Corporation, Tokyo, Japan).

To find out the prevalence of increased adiposity following standard cut-off values were used:

Increased Adiposity/Overweight (subjects with one or more of the followings):

WC (male) $\geq$ 90 cm and (female) $\geq$ 80 cm

BMI $\geq$ 23 kg/m^2(WHO 2000)

WHR (male)> 0.95 and (female) > 0.85 (JNC-V 1993)

PBF (male) > 25% and (female) > 30% (Dudeja et al. 2001).

Sedentary vs. Non-Sedentary work

The study participants were categorized into sedentary and non-sedentary work, following the criterion laid down by Mohan et al. (2005a). Individuals who had physically demanding occupation and/or performed regular exercise were grouped under non-sedentary work. On the other hand, individuals who neither had physically

demanding occupation nor did perform regular exercise were grouped under sedentary work. Physically demanding occupation includes works like day labour, industrial labour, agricultural labour etc., which requires high physical activity.

Statistical Analyses

Descriptive statistics such as mean and standard deviation (SD) were undertaken thrice (2006-07; 2011-12; 2016-17). The prevalence (%) of adiposity was calculated using standard cut-off values. The χ^2-test was also applied to examine the differencesin the physical activity level (PAL) between males and females. Differences in adiposity over the last 10 years were calculated using analysis of variance (ANONA) post hoc Scheffe test. All statistical analyses were performed using SPSS (PC + version 16.0). A statistical significance (two tailed) was set at $p < 0.05$.

RESULTS

The analytic sample comprised 205 participants which include 108 Toto males and 97 Toto females. The baseline characteristics of the studied participants (during first visit in 2007-08) are presented in Table 1. The physical activity levels (PAL) of the studied participants are presented in Table 2. It was found that males had significantly higher tendency of sedentary work as compare to their female counterparts (p = 0.007). The descriptive statistics (mean and standard deviation) for year 2007-08 followed by 2011-12 and 2015-16 over the same participants are presented in Table 3. The differences in risk variables associated with cardiovascular disease risk (like BMI, WC, waist : hip and percentage body fat) over the three phases of the study were analyzed by means of analysis of variance (ANOVA) post hoc Scheffe test as presented in Table 3. It was found that there was highly significant

Table 1: Baseline characteristics of the studied population (2007-08)

Variables	*Toto males (n=108)*		*Toto females (n=97)*		*Total (n=205)*	
	Mean	*± SD*	*Mean*	*±SD*	*Mean*	*± SD*
Age (yrs)	31.72	3.71	28.60	3.76	30.16	3.74
Height (m)	1.682	0.067	1.571	0.044	1.630	0.061
Weight (kg)	61.28	10.17	51.80	11.68	56.54	9.54
BMI (kg/m^2)	23.76	2.74	18.7	2.90	21.23	2.84
WC (cm)	90.75	5.97	81.89	6.34	86.32	6.13
Waist : Hip	0.97	0.09	0.83	0.07	0.90	0.08
%body fat	18.23	6.33	23.71	5.91	20.97	6.12

BMI = body mass index; WC = waist circumference; waist:hip = waist-hip ratio; %body fat = percentage body fat

Table 2: Differences in physical activity level (PAL) among the Toto males and females

PAL	*Males*	*Females*	*Marginal row Total*	*Chi-square**
Sedentary work	42	21	63	χ^2 = 7.1345
Non sedentary work	66	76	142	P = 0.007
Marginal Column Total	108	97	205	

*Chi-square (χ^2) at degree of freedom 1

Table 3: Differences in risk variables over the last 10 years (2007-16) among the studied participants (n=205)

Variables	*2007-08*		*2011-12*		*2015-16*		*ANOVA*P*
	Mean	±SD	Mean	±SD	Mean	± SD	
Weight (kg)	56.54	9.54	58.37	8.69	62.49	10.67	< 0.001
BMI (kg/m^2)	21.23	2.84	21.89	2.65	23.42	3.84	< 0.001
WC (cm)	86.32	6.13	88.14	6.45	89.85	6.96	< 0.001
Waist : Hip	0.90	0.08	0.93	0.09	0.96	0.09	< 0.001
%body fat	20.97	6.12	21.23	6.14	23.14	6.99	0.001

**post hoc Scheffe test*; BMI = body mass index; WC = waist circumference; waist:hip = waist-hip ratio; %body fat = percentage body fat

difference ($p < 0.001$) in weight gained; increased BMI; increased WC; increased waist:hip ($p < 0.001$) as well as significantly ($p = 0.001$) increased percentage body fat among the participants over the entire phase of the study (2007-16).

Change in prevalence of overweight with respect to WC and BMI among the Toto males and Toto females are presented in Table 4. It was found that among the males the prevalence of overweight (WC $\geq$ 90 cm) was 7.5 % in 2007-08 which later increased to 11.8% in 2011-12 (~4% rise) to 26.3% in 2015-16 (~15% rise). Among the females the prevalence of overweight (WC $\geq$ 80 cm) was 5% in 2007-08 which later increased to 7.2% in 2011-12 (~2% rise) and 18.2% in 2015-16 (~11% rise). It was also found that the prevalence of overweight (BMI $\geq$ 23kg/m^2) among the males was 8% in 2007-08 which later increased to ~13% in 2011-12 (~5% rise) little over 20% in 2015-16 (~7% rise). Among the females the prevalence of overweight was 5% in 2007-08 which later increased to 8% in 2011-12 (~3% rise) to 11.5% in 2015-16 (~3.5% rise).

DISCUSSION

The present longitudinal study indicates that among the people of South Asian origin the increase in CVD risk in the last 10 to 20 years primarily attributed to rapid change in physical activity level and dietary habits. Even in traditional societies (like the Toto) rapid changes in lifestyle in recent years have had significant effect on cardiovascular health. There are two possible reasons for the difference in prevalence of CVD risk factors among the Toto: i) founder effect/genetic drift among the demographically small Toto resulting in genetic homogeneity for non-predisposing genes, and ii) increase in sedentary work that is less PAL and/or radical changes in dietary habits in recent years. These differences among the Toto males and Toto females are already reflected in Table 2 as males had significantly higher sedentary work than females. It is however reasonable to mention that in the last 5 years as many as 7 young-adult Toto (aged between 30-40 years) died due to either cardiac arrest or stroke as compare to only 2 old-adult Toto (aged > 50 years). It further indicates that genetic factors that adversely affect the levels of such variables have long antiquities in different ethnic groups of India. An adverse impact of adoption of urban life styles (primarily mediated through dietary changes and sedentary work) was also apparent on cardiovascular disease risk factors (Sarkar et al. 2005, 2006). As young adults have adopted modern lifestyle significantly more than their older counterparts, this when coupled with genetic predisposition/ethnic susceptibility, are becoming more vulnerable to CVD risk as reflected in the present longitudinal study (observed in the last 10 years).The present study indicates that CVD risk factors can be a major health problem even in traditional societies, suggesting that this is not necessarily a result of modernization/ urbanization. It has been found that people living in rural habitat yet adopting urban lifestyle (primarily sedentary mode of occupation) were no more different in exhibiting the prevalence of CVD risk factors to their urban counterparts (Das et al. 2011). The sedentarization of occupation due to urbanization/modernization even in rural settings seems to be an important factor responsible for clustering of CVD in the people of Indian origin. Thus, sedentarization of rural occupations needs to be considered in future studies in addition to previously documented changes like rural to urban migration in order to get better picture to understand the CVD burden in this part of the world (Ebrahim et al. 2010).

It should be noted that CVD in Asian Indians occurs at an early age compared to sample

Table 4: Change in prevalence (%) of overweight among the Toto male (n=108) and Toto females (n=97) in the last 10 years (2007-16)

	2007-08		*2011-12*		*2015-16*	
	Male	*Female*	*Male*	*Female*	*Male*	*Female*
WC ($\geq$ 90 cm in males and $\geq$ 80 cm in females)	7.5	5.0	11.8	7.2	26.3	18.2
BMI ($\geq$ 23 kg/m^2)	8.0	5.0	12.8	8.0	20.2	11.5

Values in %; BMI = body mass index; WC = waist circumference

populations in America and Europe (WHO 2000). CVD is rising at an alarming speed, threatening to adversely affect India's growth and productivity as its youth is also most vulnerable to due to dietary and lifestylechanges for worse in the coming years causing a substantial loss of potentially productive years of life due to early onset of CVD. In a review study, it was found that lifestyle factors alone or modulated by inherited factors appear to play an important role, because obesity and dyslipidaemia become worse with urbanization and migration (Misra and Vikram 2004). Several studies have had hinted the influence of lifestyle interventions on cardio-metabolic risk factors in adult population. The China National Nutrition and Health Survey (2002) reported that individuals who were active or very active were 40% less likely to have CVD risk compared with those who were leading sedentary life (Ma et al. 2008). In the UK Whitehall II study, both vigorous and moderate leisure-time physical activities were associated with a reduced risk of having the CVD (Rennie et al. 2003). In a Finnish cohort study, baseline total leisure-time physical activity was found to be inversely associated with the risk of developing metabolic syndrome (MS) – metabolic clustering of CVD during a 4-year follow-up (Laaksonen et al. 2002). Total physical activity (measured as habitual energy expenditure) and fitness (measured as maximal oxygen consumption per kilogram) shown to have independent effects on the components of MS (Wareham et al. 1998). To prevent increasing morbidity and mortality due to obesity-related type 2 diabetes mellitus and CVD in developing countries, there seems to be an urgent need to initiate large scale community intervention programs focusing on increased physical activity and healthier food options (Misra and Khurana 2008). In the World Health Survey (2002– 2003), data of 212,021 adults from 51 countries, most of which were from developing countries showed that about 15% of men and 20% of women were at risk for chronic diseases due to physical inactivity (Guthold et al. 2008). Among the Asian Indian immigrants living in U.S (Misra et al. 2005) as well as those living in Indian (Mohan et al. 2005**b**) it was found that physical inactivity was highly associated with CVD risk phenotypes.

Several longitudinal studies in recent times had shown significant association of physical activity, lifestyle and dietary changes on cardiometabolic risk. In a recent study on a pooled data from 16 cohort studies from the USA and Europe it was found that risk of cardiometabolic multi-morbidity increased as BMI increased. The increase was double in overweight people to more than ten times in severely obese people as compared with individual with a healthy BMI (Kivimaki et al. 2017). In a Canadian longitudinal study adulthood overweight and obesity were found to be highly associated with childhood and life course determinants including childhood weight status (Barakat-Haddad et al. 2017).

The present study is by far the first longitudinal study on a tribal population from India focusing cardio-metabolic risks factors. It indicates that rapid changes in lifestyle significantly affect the cardiovascular health even in tribal populations like the Toto. However, the major limitation of the present investigation was that the study was performed on a small sample size and therefore it is imperative to study other ethnic groups to see if the trend observed also exists among them. Moreover, longitudinal studies involving rural-urban cohort would be more interesting to examine the stability of conventional CVD risk factors with the passage of time among the people of Indian origin.

CONCLUSION

The rapid change in lifestyle in recent years have had adversely affected the cardiovascular health not only among the older but the younger population as well. This when coupled with genetic/ethnic predisposition, resulting cardiometabolic disorder at a much earlier age among the people of Indian origin (including traditional societies, like the Toto).

RECOMMENDATIONS

Their seems to be an urgent need of a comprehensive risk stratification protocol at the national level (keeping in mind the cultural heterogeneity among the people of South Asian origins) for the successful management of cardiovascular disease risk in this part of the world.

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REFERENCES

Barakat-Haddad C, Saeed U, Elliot S 2017. A longitudinal cohort study examining determinants of overweight and obesity in adulthood. *Can J Public Health*, 108: e27-e35.

Cossrow N, Falkner B 2004. Race/ethnic issues in obesity and obesity-related comorbidities. *J Clin Endocrinol Metab,* 89: 2590-2594.

Das M, Pal S, Ghosh A 2011. Prevalence of cardiovascular disease risk factors by habitat: A study on adult Asian Indians in West Bengal, India. *Anthrop Anz,* 68: 253-264.

Dudeja V, Misra A, Pandey RM, Devina G, Kumar G,Vikram NK 2001. BMI does not accurately predict overweight in Asian Indians in northern India. *British J Nutr*, 86: 105–112.

Ebrahim S, Kinra S, Bowen L, Anderson E, Ben-Shlomo Y, Lyngdoh T, Ramakrishnan L, Ahuja RC, Joshi P, Das SM, Mohan M, Smith GD, Prabhakaran D, Reddy KS 2010. The effect of rural-to-urban migration on obesity and diabetes in India: A cross-sectional study. *PLoS Med*, 7: e1000268 doi:10.1371/journal.

Enas EA, Garg A, Davidson MA, Nair VM, Huet BA, Yusuf S 1996. Coronary heart disease and its risk factors in firstgeneration immigrant Asian Indians to the United States of America. *Indian Heart J,* 48: 343-353.

Gait EA 1901. *Census of Bengal*. Government of India, P. 171.

Gregory CO, Dai J, Ramirez-Zea M, Stein AD 2007. Occupation is more important than rural or urban residence in explaining the prevalence of metabolic and cardiovascular disease risk in Guatemalan adults. *J Nutr*, 137: 1314-1319.

Guthold R, Ono T, Strong KL, Chatterji S, Morabia A 2008. Worldwide variability in physical inactivity a 51-country survey. *Am J Prev Med,* 34: 486-494.

JNC V 1993. The Fifth Joint National Committee on detection, evaluation and treatment of high blood pressure (JNC V). *Arch Inter Med*, 153: 154–183.

Kivimaki M, Kuosma E, Ferrie JE, Luukkonen R, Nyberg ST, Alfredsson L, Batty GD, Brunner EJ, Fransson E,Goldberg M, Knutsson A, Koskenvuo M, Nordin M, Oksanen T, Pentti J, Rugulies R, Shipley MJ, Singh-Manoux A, Steptoe A, Suominen SB, Theorell T, Vahtera J, Virtanen M, Westerholm P,Westerlund H, Zins M, Hamer M, Bell JA, Tabak AG, Jokela M 2017. Overweight, obesity, and risk of cardiometabolic multimorbidity: Pooled analysis of individual-level data for 120813 adults from 16 cohort studies from the USA and Europe. *Lancet Public Health*, 2: e277-e285

Laaksonen DE, Lakka HM, Salonen JT, Niskanen LK, Rauramaa R, Lakka TA 2002. Low levels of leisure-time physical activity and cardio-respiratory fitness predictdevelopment of the metabolic syndrome. *Diabetes Care*, 25: 1612–1618.

Lohman TG, Roche AF, Martorell R 1988. *Anthropometric Standardization Reference Manual*. Champaign, Illinois: Human Kinetics Books.

Ma G, Luan D, Li Y 2008. Physical activity level and its association with metabolic syndrome among an employed population in China. *Obes Rev*, 9(suppl): 113-118.

Majumdar B 1998. *The Totos*. Calcutta: Academic Enterprise.

Mann KD, Howe LD, Basterfield L, Parkinson KN, Pearce MS, Reilly JK, Adamson AJ, Reilly JJ, Janssen X 2017. Longitudinal study of the associations between change in sedentary behavior and change in adiposity during childhood and adolescence: Gateshead Millenium Study. *International Journal of Obesity*, 1-6.

McKeigue PM, Shah B, Marmot MG 1991. Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. *Lancet,* 337: 382-386.

McKeigue PM, Ferrie JE, Pierpoint T, Marmot MG 1993. Association of early-onset coronary heart disease in South Asian men with glucose intolerance and hyperinsulinemia. *Circulation,* 87: 152-161.

Misra A, Vikram NK 2002. Insulin resistance syndrome (metabolic syndrome) and Asian Indians. *Curr Sci,* 83: 1483-1487.

Misra A, Pandey RM, Sharma R 2002. Non-communicable diseases (diabetes, obesity and hyperlipidemia) in urban slums. *Natl Med J India,*15: 242-248.

Misra A, Vikram NK 2004. Insulin resistance syndrome (Metabolic syndrome) and obesity in Asian Indians: Evidence and implications. *Nutrition,*20: 482-491.

Misra KB, Endemann SW, Ayer M 2005. Leisure time physical activity and metabolic syndrome in Asian Indian immigrants residing in northern California. *Ethn Dis*, 15(4):627-634.

Misra A, Khurana L 2008. Obesity and the metabolic syndrome in developing countries. *J Clin Endocrinol Metab*, 93: s9-s30.

Mohan V, Deepa R, Deepa M, Somannavar S, Datta M 2005a. A simplified Indian Diabetes Risk Score for screening for undiagnosed diabetic subjects. *J Assoc Physicians India*, 53: 759-763.

Mohan V, Gokulakrishnan K, Deepa R 2005b. Association of physical inactivity with components of metabolic syndrome and coronary artery disease—the Chennai Urban Population Study (CUPS No. 15). *Diabet Med*, 22: 1206-1211.

Mohan V, Deepa M, Deepa R, Shanthirani CS, Farooq S 2006. Secular trends in the prevalence of diabetes and impaired glucose tolerance in urban south India – the Chennai Urban Rural Epidemiology Study (CURES-17). *Diabetologia*, 49: 1175–1178.

Ramachandran A, Snehalatha C, Vijay V 2002. Temporal changes in prevalence of type 2 diabetes and impaired glucose tolerance in urban South India. *Diabetes Res Clin Pract,* 58: 55-60.

Ramachandran A, Snehalatha C, Baskar ADS, Mary S, Kumar CK, Selvam S, Catherine S, Vijay V 2004. Temporal changes in the prevalence of diabetes and impaired glucose tolerance associated with lifestyle transition occurring in the rural population in India. *Diabetologia,* 47: 860–865.

Rennie KL, McCarthy N, Yazdgerdi S 2003. Association of the metabolic syndrome with both vigorous

and moderate physical activity. *Int J Epidemiol*, 32: 600–606.

Sanyal CC 1971. *The Meches and the Totos: Two Sub-Himalayan Tribes of North Bengal.* 2nd Edition. Darjeeling: The University of North Bengal.

Sarkar S, Das M, Mukhopadhyay B, Chakrabarti CS, Majumder PP 2006. High prevalence of metabolic syndrome and its correlates in two tribal populations of India and the impact of urbanization. *Indian J Med Res*, 123: 679-686.

Sarkar S, Das M, Mukhopadhyay B, Chakrabarti CS, Majumder PP 2005. Prevalence of metabolic syndrome in two tribal populations of the sub-Himalayan region of India: Ethnic and rural-urban differences. *Am J Hum Biol*, 17: 814-817.

Venkatramana P, Reddy PC 2002. Association of overall and abdominal obesity with coronary heart disease risk factors: comparison between urban and rural Indian men. *Asia Pac J Clin Nutr*, 11: 66-71.

Wareham NJ, Hennings SJ, Byrne CD 1998. A quantitative analysis of the relationship between habitual energy expenditure, fitness and the metabolic cardiovascular syndrome. *Br J Nutr*, 80: 235–241.

WHO 2000. *The Asia-Pacific Perspective: Redefining Obesity and its Treatment.* WHO/IASO/IOTF. Health Communications Australia Pty Ltd.

Wiklund P, Tormakangas T, Shi Y, Wu N, Vainionpaa A, Alen M, Cheng S 2017. Normal-weight obesity and cardiometabolic risk: A 7-year longitudinal study in girls from pre-puberty to early adulthood. *Obesity (Silver Spring)*, 25: 1077-1082.

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