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CHANGE IN LIFESTYLE AND ITS EFFECT ON CARDIO-METABOLIC HEALTH: A LONGITUDINAL STUDY (2007-20) AMONG THE TOTO OF WEST BENGAL, INDIA

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***Abstract*:** Rapid change in lifestyle, particularly in the last two decades, mediated through less physical activity and dietary habits have had severely affected the cardio-metabolic health even among the indigenous peoples. The present longitudinal study (2007-20) was conducted in four phases (2007-08, 2011-12, 2016-17, and 2019-20) among the Toto tribal population with the a priori expectation that any changes in adiposity and body composition in this duration could be accounted for change in lifestyle since, genetic and environment factors are naturally under control among them. It was found that there was a significant increase in adiposity and body composition among both Toto males and females in the last fifteen years. Shift in physical activity level – from traditional activities to more sedentary activities, and shift in dietary habits- from traditional food to more modern and easily accessible fast foods etc., increased during the follow-up period. Easier access to food supply and sedentary activities have shown a significant rise and these changes affected possibly because of the founder effect/ genetic drift among the demographically small Toto resulting in genetic homogeneity for non-predisposing genes, and/or increase in sedentary work that is less physical activity level coupled with changes in dietary habits in recent years.

***Keywords*:** CVD, Metabolic syndrome, lifestyle, Toto, longitudinal study

INTRODUCTION

Rapid change in lifestyle perhaps mediated through less physical activity and dietary habits have had severely affected the cardio-metabolic health worldwide (WHO, 2000; 2015; 2017), particularly in the last two decades. The effect of modernisation vis-à-vis urbanisation in recent years could be seen even among the indigenous peoples across the world and even more among the millennial than their older counterpart. Initially, it occurs at the individual level with simultaneous development of two or more types of malnutrition (both undernutrition and overweight & obesity). Then it could occur at the household level with multiple family members affected by various forms of malnutrition. Finally, it is observed at the population level (WHO, 2017). Longitudinal study is therefore important to study the change over time. It is useful for evaluating the relationship between risk factors and the development of disease, and the outcomes of treatments over different lengths of time. It provides a more comprehensive approach to research. That allows an understanding of the degree and direction of change over time (Caruana et al., 2015).

Rapid change in lifestyle has been found to be the outcome of three major shifts or transitions in recent past viz., the nutrition transition, the epidemiological transition, and the demographic transition. The nutrition transition indicates the shift

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in dietary habits, consumption and energy expenditure associated with economic development over time, often in the context of globalisation and urbanisation. The change is associated with a shift from predominance of undernutrition in populations to higher rates of overweight, obesity, and non-communicable diseases (NCDs). The epidemiological transition describes the changes in the overall population disease burden associated with the increase in economic prosperity i.e., a shift from a predominance of infection and diseases related to undernutrition to rising rates of NCDs. Finally, the demographic transition describes the shift in population structure and lengthening lifespan. This seems to be a transformation from populations with high birth rates and death rates, with relatively high proportions of younger people, to populations with increasing proportions of younger populations, to populations with increasing proportions of older people (WHO, 2017).

In most of the countries with established market economy, these three transitions have occurred slowly and in a near-linear fashion in the last two centuries. The nutrition transition, accompanied by and linked to the epidemiological and demographic transitions, has resulted in intergenerational, incremental and controlled increases in population lifespan. The improved nutrition and higher caloric opportunity is associated with not only gradual increases in population health, but also a rise in overweight, obesity, and NCDs (Shrimpton and Rokx, 2012). In contrast, among the low-and particularly middle income countries, these processes have been accelerated over the last few decades rather than centuries. Hence people belonging to these countries are in a genetically disadvantageous stage since, it takes several generations to adapt genetically.

The present longitudinal study (2007-20) was therefore undertaken to study the change in cardio-metabolic health due to rapid change in lifestyle among the Toto of West Bengal, India. The purpose behind longitudinal study among the Toto tribal community lies in the fact that the Toto is a relatively genetically homogenous population and living in the same village for over the last 200 hundred years. Hence, the genetic homogeneity and same physical environment makes the design of the present study a unique one. The *a priori* expectation is that any changes in adiposity and body composition in the last two decades could be accounted for change in lifestyle since, genetic and environment factors are naturally/ by default under control.

MATERIALS AND METHOD

Study Population

The present population based longitudinal study (2007-20) was conducted on the Toto (a particularly vulnerable tribal group), living in the state of West Bengal, India. The Toto are a demographically small population and have passed through

demographic bottlenecks, but are now an expanding population. At present the total population of the Toto is 1682 which includes 858 males and 824 females, and at the beginning of the study (2007-08) it was 1286 (677 males and 609 females).The study was conducted in four phases: Phase I- 2007- 08, Phase II- 2011-12, Phase III- 2016-17, and Phase IV- 2019-20. The Toto are geographically localized in a single village (Totopara) of the district of Alipurduar (*erstwhile*, Jalpaiguri), West Bengal, India 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 four time points starting from the year 2007-08. As in case of any longitudinal study, on every next follow-up some study participants were not available and some new participants added. The present analyses were based on only those participants who were available in all the four visits. This includes 305 adult Toto aged 20 years and above comprising 158 males and 147 females.

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). The body mass index (BMI in kg/m^2) and weight hip ratio (WHR) were subsequently computed. Percentage body fat (PBF) 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) > 90 cm and (female) > 80 cm (WHO, 2000); BMI > 23 kg/m2 (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. (2005). 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 of all the four visits (2006- 07, 2011-12, 2016-17, and 2019-20). The prevalence (%) of adiposity was calculated using standard cut-off values. The $\chi 2$ -test was also applied to examine the differences in the nutritional status, physical activity level (PAL), and household clustering of double burden of malnutrition between males and females. Differences in adiposity and body composition over the last 15 years were calculated using analysis of variance (ANONA) with post-hoc *Scheffe* test. All statistical analyses were performed using SPSS (IBM version 25.0). A statistical significance (two tailed) was set at $p < 0.05$.

RESULTS

Differences in weight, adiposity and body composition of the Toto males and females over the period of 2007 to 2020 are given in Table I. It was found that among the Toto males there was a significant increase ($p<0.001$) in weight, WC, WHR, and PBF as well as BMI ($p=0.001$) in the last 15 years. Similarly, among the Toto females there was a significant increase ($p<0.001$) in weight, BMI, WC, WHR, and PBF. The increase in cardio-metabolic risks was more significant in females as compare to males. Changes in nutrition status of the males and females are shown in Table II. It was found that there was a significant increase in frequency of overweight among both males ($p<0.01$) and females ($p=0.011$) in the last 15 years (2007-20). Changes in physical activity status of the males and females are shown in Table III.

TABLE -1: DESCRIPTIVE STATISTICS OF THE TOTO MALES AND TOTO FEMALES (2007-20)

Variables	Males (N=158)					Females (N=147)				
	2007 - 08	2011 -12	2016 - 17	2019 -20	ANOVA (p)	2007 - 08	2011 -12	2016 - 17	2019 - 20	ANOVA (p)
Weight (kg)	61.28 (10.17)	61.80 (8.92)	64.70 (9.89)	65.72 (9.92)	7.847 (< 0.001)	51.80 (11.68)	53.34 (8.46)	57.28 (10.45)	59.28 (10.52)	16.395 (< 0.001)
BMI (kg/ m^2)	22.36 (2.74)	22.78 (2.78)	23.12 (3.93)	23.86 (3.62)	5.814 (0.001)	18.70 (2.90)	19.68 (2.52)	21.94 (3.75)	23.24 (3.45)	62.013 (< 0.001)
WC (cm)	90.75 (5.97)	91.70 (6.27)	92.80 (6.54)	94.20 (6.54)	8.672 (< 0.001)	81.89 (6.34)	84.58 (6.63)	85.90 (7.38)	87.90 (7.79)	18.735 (< 0.001)
WHR	0.92 (0.09)	0.94 (0.08)	0.95 (0.08)	0.97 (0.09)	9.444 (< 0.001)	0.83 (0.07)	0.88 (0.09)	0.91 (0.08)	0.93 (0.09)	40.447 (< 0.001)
PBF (%)	18.23 (6.33)	19.90 (5.83)	21.20 (5.98)	23.50 (5.98)	21.461 (< 0.001)	23.71 (5.91)	23.56 (6.45)	26.78 (6.99)	28.78 (5.98)	23.343 (< 0.001)

BMI- body mass index, WC- waist Circumference, WHR- waist : hip ratio, PBF- percentage body fat, ANOVA- analysis of variance showing the F-value, p- probability of significance

TABLE -2: CHANGES IN NUTRITIONAL STATUS AMONG THE TOTO (2007-20)

Nutritional status	Males (N=158)				Females (N=147)			
	2007-08	2011-12	2016-17	2019-20	2007-08	2011-12	2016-17	2019-20
Underweight	67	60	57	52	69	65	60	54
Normal	85	81	72	64	73	72	68	65
Overweight	6	17	29	42	5	10	19	28
χ^2-value	36.2 (df = 6; p < 0.001)				22.6 (df = 6; p = 0.001)			

χ^2 - chi-square, df- degree of freedom, p= probability of significance

TABLE -3: CHANGES IN PHYSICAL ACTIVITY STATUS AMONG THE TOTO (2007-20)

Nutritional status	Males (N=158)				Females (N=147)			
	2007-08	2011-12	2016-17	2019-20	2007-08	2011-12	2016-17	2019-20
Non-Sedentary	147	130	117	103	139	125	110	98
Sedentary	11	28	41	55	8	22	37	49
χ^2-value	39.7 (df = 3; p < 0.00001)				40.1 (df = 3; p < 0.00001)			

χ^2 - chi-square, df- degree of freedom, p= probability of significance

It was found that there was a significant increase in frequency of sedentary activity among both males ($p<0.01$) and females ($p=0.011$) since the initiation of the study to the last visit (2007-20). Household clustering of double burden of nutrition among the Toto was also studied and has been shown in Table IV. It was found that the intra-household clustering of double burden has increased significantly ($p<0.001$) over the last 15 years (2007-20) with a significant shift towards double burden of malnutrition within the family. Demographic transition of the Toto in Totopara over the last 100 years has been illustrated in Figure 1. It was found that in 1901 the Toto were the sole inhabitants in Totopara village whereas, at present, the Toto in Totopara constitute below 50% and non-Toto, predominantly the Nepalese, are the majority in the village. It clearly signifies a radical demographic transition of the Toto in Totopara over the last few decades.

TABLE -4: HOUSEHOLD CLUSTERING OF DOUBLE BURDEN OF NUTRITION AMONG THE TOTO (2007-20)

Year	No Double Burden	Double Burden	χ^2-value
2007-08	147	06	
2011-12	138	15	32.4 (df = 3)
2016-17	124	29	
2019-20	115	38	P < 0.001

χ^2 - chi-square, df- degree of freedom, p= probability of significance

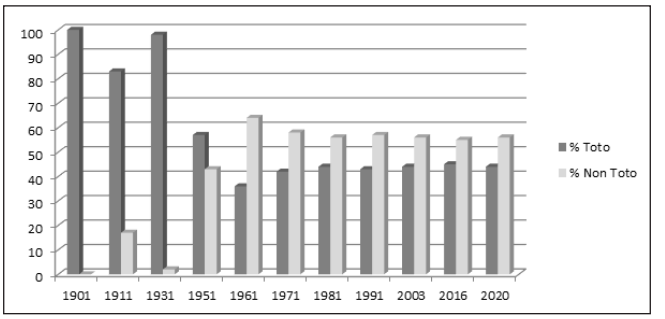

Figure 1. Demographic transition of theToto in Totopara since 1901

DISCUSSION

The present longitudinal study indicates that the increase in cardio-metabolic risk in the last two decades had primarily caused due to rapid changes in physical activity level and dietary habits. Even in traditional societies (as in the present study among the Toto) rapid changes in lifestyle in recent years have had significant effect on nutritional health. There are two possible reasons behind it: 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 physical activity level and/or radical changes in dietary habits in recent years (Das, 2017).

However, a trait that may be advantageous at one point in human history may be detrimental under different environmental conditions. Here comes the Neel's hypothesis or commonly known as '*thrifty genotype'* to explain cardio-metabolic risk (Neel, 1962). He hypothesized that people with diabetes often have allelic variations in certain genes that enable them to efficiently collect and utilize food. The human variations which were favourable in populations facing challenges of episodic undernutrition might be disadvantageous when food supplies became abundant. It provides a possible explanation for why the propensity to cardio-metabolic diseases varies greatly among populations. Carriers of these variations are therefore, at a high risk of developing obesity and diabetes when exposed to abundant and cheap supply of energy, and a dramatic reduction in energy expenditure. This thrifty

genotype would have been beneficial during periods of history characterized by food instability (Stoger, 2008). In the present study, the Toto are now enjoying food security from the Government and for the last one decade they have a surplus of food (both staple as well as fast foods). Hence, in spite of the long-term nature of the selective forces that are hypothesized to have positively selected the thrifty genotype, rapid change in food habit and physical activity had altered the metabolism of the studied population. There are various ways in which these changes increase the risk, perhaps in combination with evolutionary mediated phenotypes.

In contrast, the Baker's hypothesis also known as the *'thrifty phenotype'* opined that malnutrition acts not as a selection acting over many generations to alter the genetic make-up of the population, rather the early environmental (including prenatal environment) influences acting in an individual to increase the susceptibility of the disease (Hales & Barker, 2001). In Neel's hypothesis, the entire population have an increased predisposition to diabetes due to genetic selection. They are better adapted to different nutritional circumstances than those they experience today. In Baker's hypothesis, maladaptive responses occur as a result of environmentally induced alteration of physiology in the early life of the individual. Both hypotheses offer explanations of why the frequency of diabetes and obesity differ in different populations. For instance, people in the Indian subcontinent, have faced undernutrition for many generations, and Indian babies (new born) are among the smallest in the world (Yagnik, 2004). However, cardio-metabolic epidemic is of recent origin, and it is more common among the urban than rural Indians despite higher birth weight of urban babies. The two explanations (hypotheses) are therefore not necessarily exclusive and may complement each other. Then there is a third hypothesis called the '*common soil'* hypothesis as proposed by Lebovitz (2006) that diabetes and CVD might share underlying cause(s) – hence termed common soil. It was mentioned that insulin resistance is central to the progression from normal glucose tolerance to diabetes and to a constellation of CVD risk factors known as metabolic syndrome. Changes in adipose tissue and metabolism, as found in the present study, perhaps mediated through lifestyle/epigenetic changes) might link insulin resistance and visceral obesity – a condition that common to diabetes.

With the rapid socio-economic transition in India, accompanied by the demographic transition, health transition, change in food supply and consumption patterns, the burden of malnutrition has been clearly seen in national nutrition surveys in India (FAO, 2003). Secondly, the tribal families are mostly covered by below poverty line (BPL) schemes of the central and state governments. The regular supply of rice, wheat etc. at highly subsidized rates or for free under these schemes (GOI, 2012) has increased their dependency on the public food assistance program. This has restricted their earlier traditional practices of food collection from nearby natural resources because of various forest protection acts (Padhi & Panigrahi, 2011; Mohapatra, 2012), which led to forced diversity in their food habit.

The shift from a traditional food habit to a high dependency on supplied public food distribution systems among Indian tribal populations seems to be an important cause of undernutrition and obesity among them (Kshatriya and Acharya, 2016). Pima Amerindians, for example, who were confined to reservations by a growing dependence on food assistance for generations while undergoing a rapid transition from a nomadic to a settled lifestyle, showed high levels of type-2 diabetes and obesity during later condition (Hackenberg, 1983).

Emergence of obesity, CVD, and diabetes in developing countries is due to a number of factors: the most important are – *demographic transition* (shift to low fertility, low mortality, and higher life expectancy) and *epidemiologic transition* (from widely prevalent infectious diseases to a pattern of high prevalence of lifestyle-driven chronic diseases) have occurred in developing countries as they become economically more resourceful, socioeconomic transition (shift of people from low SES to high SES), causing shifts in dietary and physical activity patterns resulting into nutrition and lifestyle transitions. These changes cause significant effects on body composition and metabolism, often resulting in increase in BMI, excess generalized and abdominal adiposity. Each type of transition has an important bearing on occurrence of obesity and metabolic risk factors. However, urbanization and nutrition transition remains the most important determinants of such change in phenotype (Misra & Khurana, 2008).

The double burden of malnutrition confers a serious and negative economic impact on individuals and populations. As the burden of malnutrition continues to rise, so too does its economic toll. On one hand, it pose a significant public health challenge for all nutrition-related sectors and actors, but on the other hand, it also presents an important opportunity for integrated action (WHO, 2017). On the basis of large national surveys, the co-existence of underweight child and overweight non-elderly adult was found to be the most prevalent combination of underweight and overweight household type in Brazil (59%), China (39%), and Russia (62%) as mentioned by Doak et al. (2000). Garrett and Ruel (2003) by using the Health and Demographic Surveys (DHS) found that 3% of Asian, 4% of African, and 7% of Latin American households contained the stunted child-overweight mother pair. While undernutrition results not only poor growth, stunting and poor resistance to infection in children, it also causes low physical and mental performance in both children and adults as well. Overnutrition, on the other hand, results in obesity and its well-established co-morbidities.

Over the few decades, there has been a decline in prevalence of both moderate and severe malnutrition including stunting, although the prevalence of underweight and stunting among pre-school children is still unarguably high. In adults, there has also been a progressive decline in the prevalence of undernutrition and in overnutrition in both urban and rural areas. While significant differences in under- and overnutrition could be seen along with overnutrition and obesity which

are emerging as major problems (Florentino, 2011). High undernutrition is a consistent trend among Indian tribal children and adults (Chandramouli, 2011). Severe wasting and stunting has been reported among Indian tribal children and adolescents (Kshatriya and Ghosh, 2008; NIN-ICMR 2009; Bisai et al., 2010; Das and Bose, 2012; Das et al., 2013; Ghosh et al., 2014) whereas, 3-to 4-fold increase in overweight and a significant prevalence of obesity in different parts of India have also been reported by Kshatriya and Acharya (2016).

Moreover, it is known that whenever two cultures meet specially on different levels, there is a tendency on the part of the lesser culture to work in two directions. A part of it is attracted by the superior culture and imitates it. The other and more conservative part is repelled by the danger of absorption, draws its horn in, and makes every effort to preserve its identity intact by isolation, conservation and refused to have any track with the superior culture. Among the Toto, at present, it seems that the imitating part is in effect more than the conservative part.

The present study, in best of knowledge, is by far the first longitudinal study on a tribal population from India focusing double burden of malnutrition. It indicates that rapid changes in lifestyle (perhaps mediated through dietary changes and physical activity level) significantly causing double burden of nutrition both at the individual level as well as household clustering of malnutrition 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 and indigenous vs. non-indigenous cohorts will give better insight into the etiology behind this menace.

CONCLUSION

The rapid changes in lifestyle in recent years have significantly affected the nutritional health not only among the older but among the younger population as well. Change in lifestyle when coupled with genetic/ethnic predisposition, resulting in a much earlier predisposition to double the burden of malnutrition both at individual level as well as household and population level among the people of Indian origin (including indigenous communities, like the Toto). The present longitudinal study shows that rapid change in lifestyle due to modernisation vis-à-vis westernisation in the last two decades have significantly disrupted the nutritional status of the tribal peoples who are living in rural areas. The lifestyle-driven com-morbidities are not confined to peoples living in urban or peri-ruban areas but even among the traditional societies, like the Toto. This could lead to severe public health burden if necessary preventive strategies are not taken. The younger generation who are more prone to modern lifestyle are becoming more susceptible to lifestyle-driven diseases than their parental generation. This is causing more public health burden as younger people are becoming susceptible to such

co-morbidities at a much younger age than their parents leading to an increase of morbidity and mortality. It is therefore reasonable to argue that implementation strategies of the existing and future national policies should include double burden of malnutrition for timely and early preventive actions with special emphasis on indigenous populations. Access to improved health, quality diet and reduction in poverty would be the useful strategies to address the coexistence of double burden of malnutrition in this part of the world

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