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Does Urban Poverty Increase Body Fluctuating Asymmetry?

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A B S T R A C T

Perturbations during development leave enduring signs on the adult body. Fluctuating asymmetry (FA) is a good bio-indicator of stress during ontogeny. The aim of this study is to determine the effect of urban poverty on the fluctuating asymmetry of young Turkish males. Young males from a lower socioeconomic group (N=140, Mean age=18.17±0.61) were selected from slum areas of Ankara, the capital of Turkey, where urban poverty is intense. An upper socioeconomic group, on the other hand, consisted of students from two private colleges and included children from some of the richest families in Turkey (N=120, Mean age=18.08±0.54). Eight anthropometric traits of all subjects were measured. Considering the seven measurements demonstrate ideal FA, the individuals living in poor areas of the city displayed higher FA. The discrepancy between the two groups was even greater for a measure of composite FA. In conclusion, poor living conditions in Ankara, where urban poverty is intense, adversely impact the developmental stability of young Turkish males.

Key words: *fluctuating asymmetry, developmental instability, urban poverty, socioeconomic status*

Introduction

Fluctuating asymmetry (FA) refers to small random deviations from perfect symmetry in bilaterally paired structures, and it is thought to reflect an organism's ability to cope with genetic and environmental stress during development. FA has been used as an indicator of individual quality and developmental stability in studies of natural and sexual selection[1,2]. Thus, a high level of FA is assumed to reflect reduced developmental stability. Developmental stability is the ability of an individual to develop the same phenotype under identical genotypes and environments[1].

The other two main asymmetry types on the population level are directional asymmetry (DA) and antisymmetry (AS)[2]. DA is a pattern of bilateral variation in a sample of individuals, where a statistically significant difference exists between sides, but the larger side is generally the same, detected by statistical tests for departures of mean R – L from zero[2,3]. Another asymmetry type, AS is a pattern of bilateral variation in a sample of individuals, where a statistically significant difference exists between sides, but where the larger side varies at random among individuals. Graphically, the probability distribution of antisymmetry is either platykurtic or bimodal[2,4]. Some authors have claimed that antisymmetry and directional asymmetry may have a significant genetic basis, thereby rendering these forms of asymmetry useless for studies of developmental instability[2,5].

Research on different species reveals that many factors are responsible for deviation of bilateral traits. The key factors are high temperature, high living density, noise, nutritional or energetic stress, protein homozygosity and inbreeding, infections, parasites and some genetic diseases[6,7].

Foremost research demonstrates that the human phenotype is extremely plastic and the physical growth is particularly sensitive to the quality of its social and economic environments[8]. It is known that individuals from lower socioeconomic conditions suffer from malnutrition, have limited access to health services, and therefore, are more subject to infectious diseases[9,10]. Although it is known that there are significant differences between physical growth quality of individuals living under different socioeconomic conditions the number of studies that are directly focused on the relationship between socioeconomic conditions and FA is rather limited. Although

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several studies suggest that environmental pressures increase FA level via anthropometric measurements[11–13], others do not confirm this trend[14,15]. Yet it can be said that these studies did not focus directly on the effect of extreme socioeconomic conditions on FA. Therefore, it would be wrong to assess the correlation between socioeconomic conditions and FA on the basis of these studies.

Turkey is one of the countries in which urban poverty is extensively experienced in metropolitan areas. The capital city, Ankara has several districts that differ in terms of life conditions; hence, it provides the appropriate parameters in which to examine extreme socioeconomic conditions together[16]. This study seeks to observe FA degrees of young males coming from different socioeconomic environments in Ankara.

Material and Methods

Subjects

For this study, the individuals of lower socioeconomic group (LSG) were selected in two schools from slum areas located in the district Sentepe in Ankara, where urban poverty is intense (N=140, Mean age=18.17, sd=0.61). Second group included students with higher socioeconomic background (USG) and was composed of final year students from two different private schools located in Cankaya, a central district of Ankara, which is mainly inhabited by the rich (N=120, Mean age=18.08, sd=0.54). The students were examined in their respective schools. Primarily, students were asked to fill out a questionnaire that assessed socioeconomic status. Following completion of the questionnaire individuals were taken in groups of five in an empty classroom for the measurements. The ages of the individuals are recorded as day/month/year and later calculated by the decimal system. According to the results of one-way analysis of variance (ANOVA), there is no difference between the groups in terms of the mean average age ($p>0.05$). To minimize the effect of growth on developmental instability, we focused on the final year high school students, who have mostly completed their growth[17]. Participants were selected from sedentary students. They were not active in any type of sport or manual works.

Socioeconomic characteristics

Sentepe is an area where squatting is rather intense. Characterized by dense slum settlements within narrow streets, this area suffers from problems such as lack of infrastructure, high unemployment rate and basic health services[18]. The region houses the families that receive greatest coal and food aid from local municipalities. As a result of the coal aid of considerably poor quality in recent years, intense air pollution has posed a threat to human health in these areas. The area in which two private schools of the central district of Cankaya are located has no slum neighborhoods. The area is inhabited by families with higher-than-average incomes.

TABLE 1
SOCIOECONOMIC CHARACTERISTICS OF STUDY GROUPS

	LSG	USG
	N (%)	N (%)
Family size*		
≤3	16 (11.4)	63 (52.3)
4	40 (28.6)	48 (40.0)
≥5	84 (60.0)	9 (7.7)
Mother's education level*		
Illiterate	9 (6.1)	0 (0)
Primary school	116 (82.9)	3 (2.4)
High school	15 (11.0)	39 (32.8)
University	0 (0.0)	78 (64.8)
Father's education level*		
Illiterate	2 (1.4)	0 (0)
Primary school	72 (51.3)	3 (2.8)
High school	65 (46.3)	37 (30.8)
University	1 (1.0)	80 (66.4)
Father's occupation*		
Manual	140 (100.0)	2 (1.6)
Non-manual	0 (0.0)	118 (98.4)
Number of rooms *per* house*		
≤3	58 (41.2)	6 (5.3)
4	77 (55.0)	74 (61.3)
≥5	5 (3.8)	40 (33.4)

*$p<0.001$ (χ^2-test)

As shown in Table 1, subjects living in the city centre (USG) had better living conditions expressed by a higher educational level of both parents, smaller size of families and numbers of rooms *per* house.

Measurement procedure

The hand width, elbow width, wrist width, knee width, ankle width, foot width, ear height and ear width of the subjects were measured with a Vernier digital caliper of 0.01 mm sensitivity in accordance with the techniques proposed by the International Biological Programme[19]. Bilateral data was obtained using blind measurement technique[2] and all measurements were taken by the author. Right side of the body was measured in this exact order. The data on the left side of these traits were then collected. This procedure was repeated for the second measurements without reference to the prior data. There was about a 15 minute lag between the two measurements. Edinburgh Handedness Inventory was also applied to determine the handedness of the individuals[20]. According to the results of Kruskal-Wallis ANOVA, there is no difference between the groups in terms of the mean handedness value ($p>0.05$).

Asymmetry analysis

A mixed model ANOVA was used to estimate repeatability of the asymmetry. In this method the factors are Individuals (I) and Side (S; right or left). The ratio of the I-by-S mean square to the residual error provides an F-test of whether between-individual variation in estimated asymmetry is significantly greater than what can be accounted for by measurement error. In this test, interaction I × S is often used to estimate FA, and statistical significance of the FA estimate is determined by the F statistic[2]. Ideally, asymmetry studies necessitate taking repeated measurements from each individual. However, in studies that include large samples this is not likely. Therefore, it is suggested that repeated measurements be taken from a sub-group selected from the sample. In this study, 70 individuals were measured twice in order to determine measurement error. The side-by-individual interaction term was significant for each trait (Hand: $F_{[1,69]}=5.31$, $p<0.0001$; elbow: $F_{[1,69]}=8.17$, $p<0.0001$; wrist: $F_{[1,69]}=7.15$, $p<0.0001$; knee: $F_{[1,69]}=5.44$, $p<0.0001$; ankle: $F_{[1,69]}=6.02$, $p<0.0001$; foot: $F_{[1,69]}=4.39$, $p<0.0001$; ear length: $F_{[1,69]}=5.21$, $p<0.0001$; ear width: $F_{[1,69]}=3.92$, $p<0.0001$). When this test is separately performed for each group, the rate of the measurement error variance to between-side variation is less than 25% in all measurements (all $p<0.0001$).

Signed (SA), absolute (AA), and composite asymmetries (CA) were determined by the formulas; $R-L$, $|R-L|$, and $\Sigma\ (|R-L|)\ /\ n$, respectively[21]. To check for size dependence, absolute (i.e. unsigned) asymmetry values were regressed on trait size. There was no indication of size dependency for any of measures (all $p<0.05$). To determine the departures from normality, skewness and kurtosis[22] for signed right – left values were calculated for all traits. Ankle and elbow width in the LSG ($p<0.01$); hand width ($p<0.001$) and ankle width ($p<0.01$) in the USG were skewed. Outliers were identified visually from scatter plots as suggested by Palmer and Strobeck[2] and than these measures were tested and removed according to Grubbs' test[23]. Finally, 6 measures in LSG and 8 measures in USG were found to be outliers and therefore excluded from the sample. A normal distribution was attained once 14 measures were excluded from the data set.

In order to detect the existence of directional asymmetry within the groups, one-sample t-test was used as recommended by Palmer[21] and Swaddle et al.[24]. The null hypothesis for this test is that mean signed asymmetry equals zero. According to this test hand width ($p<0.01$) demonstrated directional asymmetry in two groups. For that reason, hand width was removed from the FA analysis, and further analyses were conducted using the seven measurements displaying FA. Fluctuating asymmetry values of the groups were compared using ANCOVA model. In all analysis, handedness and age were used as covariate factors. In all tests P value of <0.05 was considered statistically significant. The Statistical Package for Social Sciences (SPSS of version 12.0) was used for all statistical calculations and processes.

Results and Discussion

Mean values of the seven measurements displaying FA in the study are presented in Figure 1. All traits of the USG display significantly lower FA (handedness and age were controlled). According to CFA value, existing significance reaches a higher level ($p<0.001$).

Developmental stability is defined as the ability of an organism to buffer its development against genetic or environmental disturbances encountered during development to produce the genetically predetermined phenotype[25]. Fluctuating asymmetry is widely used as a measure of developmental stability. Individuals that are very stable developmentally build up a high level of resistance against destructive impacts during ontogeny and are affected from these factors at a minimum level. The results of this study support the assertion that adverse living conditions could cause developmental instability (DI). High school students from a slum area of Ankara were found to have significantly higher FA compared to students from a prosperous urban district. This result links to the observations of a previous study including students from the same schools in Sentepe, which found that physical development of final year students, was sig-

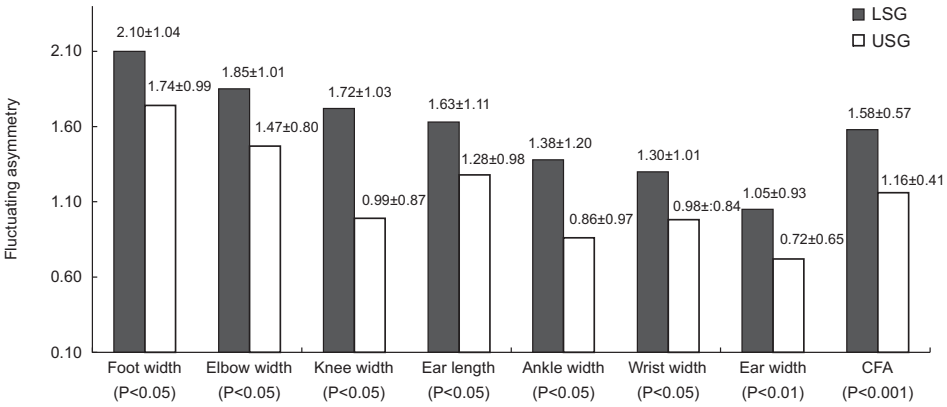

Fig. 1. FA and CFA values of study groups.

nificantly retarded when compared to their peers living in the prosperous urban area[26]. In this study, it was found that the average difference between the two groups was 9 kg in weight and 7 cm in height, with students from the urban areas being heavier and taller.

Information about the effect of environmental pressures on physical development is considerable for our species. However, the effect of socioeconomic conditions on body symmetry is a neglected subject. There are a few studies on groups with different development and nutritional status, in other words, with different socioeconomic status. Little et al.[15] conducted research on children with chronic malnutrition in South Mexico. At odds with the expectations, the researchers found that body asymmetry was higher among the well-nutritioned children. A similar observation could be found in another study in the villages on the East coast of The Dominican Republic. Flinn et al.[14] which compared the growth patterns of step children and children raised by biological parents in the same family. This study revealed that for all age groups between 0–20, biological children had better weight and height development. The results show that fluctuating asymmetry coefficient for both sexes is lower among step children[14]. Hume and Montgomerie[27] measured asymmetry of 22 traits (including facial, bodily and fingerprint traits) in addition to other anthropometric (i.e. body-mass-index) and health measures in a sample of males and females. It was found that the composite measure of FA accounted for a significant percentage of variation in facial attractiveness in both sexes, whilst socioeconomic status (SES) was not associated with facial symmetry. Also Schaefer et al.[13] found that FA in dental arches of individuals from an inbred Adriatic island population was higher than those of individuals from an outbred island group. These authors argued that the differences were caused by environmental as well as a genetic influence on dental arch asymmetry. As this research illustrates, the literature lacks studies establishing a direct link between extreme socioeconomic conditions and body bilateral asymmetry.

Though studies indicate that urbanization in developed countries has positive influences on living standards, they point out that this effect often cannot be observed in developing countries owing to the increasing urban poverty[28]. The slum settlements concentrating on the areas of Ankara »which are near the city centre and relatively less developed« are places where intense poverty is often experienced. A chronic problem, urban poverty has adverse effects not only on physical development levels but also on FA, which is the indicator of developmental stability, according to the findings of this study. When all traits are taken into consideration, the group from the students living in affluent areas of the city displays more symmetric structure. In FA studies, composite scores often show stronger relationship with fitness parameters than single trait FAs[29–31]. Therefore, CFA scores are a better indicator of the effect of living conditions on developmental stability. It is seen that the discrepancy between the two groups widens even more in terms of CFA.

Conclusion

This study sought to determine if the effects of urban poverty is one of the causes of increases developmental instability. According to the results, FA is higher in individuals who have lower socioeconomic status, and who, in turn, are subject to environmental stresses. It is clearly observed that the difference in living standards of the two groups plays a role in this discrepancy. In conclusion, it can be stated that in Ankara, the capital of Turkey, urban poverty has an adverse effect on developmental stability of young males.

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UTJECAJ GRADSKOG SIROMAŠTVA NA VARIRAJUĆU ASIMETRIJU: KOPARATIVNA STUDIJA NA MLADIM TURSKIM MUŠKARCIMA

S A Ž E T A K

Stres tijekom razvoja ostavljaju dugotrajne tragove na odraslom tijelu. Varirajuća asimetrija (FA) je dobar bio-indikator stresa tijekom ontogenije. Cilj ove studije je odrediti utjecaj gradskog siromaštva na varirajuću asimetriju mladih turskih muškaraca. Mladi muškarci iz niže socioekonomske grupe (N=140, $\overline{X}$=18,17±0,61) odabrani su iz siromašnih četvrti u Ankari, glavnom gradu Turske, gdje je gradsko siromaštvo intenzivno. S druge strane, višu socioekonomsku grupu sačinjavali su studenti iz dva privatna učilišta i koji su djeca jednih od najbogatijih obitelji u Turskoj (N=120, $\overline{X}$=18,05±0,54). Mjereno je osam antropometrijskih karakteristika za sve ispitanike. Podrazumijevajući da sedam mjera ukazuje na idealnu FA, osobe iz siromašnih gradskih četvrti pokazali su višu FA. Diskrepancija između dvije grupe bila je još veća za mjeru kombinirane FA. Zaključno, loši životni uvjeti u Ankari, gdje je gradsko siromaštvo intenzivno, negativno utječu na razvojnu stabilnost mladih turskih muškaraca.