Imperial Journal of Interdisciplinary Research (IJIR)
Vol-2, Issue-9, 2016
ISSN: 2454-1362, http://www.onlinejournal.in

Somatotype in Bipolar Disorder Revisited: Gender Differences, Neurodevelopment and Clinical Implications

Mladen Mantarkov[1*], Ferihan Ahmed-Popova[2], Valentin Akabaliev[1]
Stefan Sivkov[2]
[1]Department of Psychiatry and Medical Psychology, Medical University of Plovdiv, Bulgaria
[2]Department of Anatomy, Histology and Embryology, Medical University of Plovdiv, Bulgaria

Abstract: *Ninety-five years after Kretschmer's original publication the concept of somatotype in psychiatry remains controversial. The aim of the current study was to compare the somatotype of patients with bipolar I disorder and sex-matched mentally healthy controls using an objective method of somatotyping and predefined inclusion and exclusion criteria. 67 bipolar I patients (26 males, 41 females) and 119 mentally healthy controls (54 males, 65 females) were assessed using the Heath-Carter Anthropometric Method. Bipolar I males were significantly less endomorphic and more ectomorphic than sex-matched controls. Bipolar I females were significantly less ectomorphic than sex-matched controls. We found significant interaction effects between gender and group membership on all somatotype components. Bipolar I males had significantly lower, while bipolar I females had significantly higher BMIs than controls. Kretschmer's hypothesis may only apply to females. In an age of orexigenic mood stabilizers bipolar I females may be a particularly vulnerable treatment population. Our data suggest bipolar I disorder has neurodevelopmental underpinnings.*

Key words: *Bipolar disorder, Somatotype, Neurodevelopment, Gender differences, Sexual dimorphism, Body mass index, Central obesity, Mood stabilizers.*

1. Introduction

Ninety-five years ago, on the basis of direct *visual observation*, Ernst Kretschmer described three major body types: *asthenic*, *athletic* and *pyknic*, that could influence behavior and susceptibility to mental illness, particularly to manic-depressive disorder and schizophrenia [1,2]. Kretschmer believed that every single individual could be characterized as either asthenic, athletic, pyknic or dysplastic (a category, he recognized a little later). In Kretschmer's view, pyknic individuals were of cyclothymic temperament and more susceptible to bipolar disorder, while asthenic individuals were of schizoid temperament and more susceptible to schizophrenia [2-4]. Five different studies published in the 1920's and 1940's lent partial support to Kretschmer's observations [5,6]. The authors found a correlation between schizophrenia and the asthenic body build and between manic-depressive disorder and the pyknic body build. Although Kretschmer has been widely criticized for the purely observational nature of his studies and his small sample sizes, his influence on the constitutional approach in psychiatry over the last century remains undoubted [6].

Over a decade after Kretschmer's original publication, William Sheldon revolutionized the constitutional approach to the study of human physique and behavior in several different ways [6]. He was the first to use the term *somatotype* and to define its three main components: *endomorphy* (predominance of the width in relation to height, or relative obesity), *mesomorphy* (musculoskeletal predominance, including the internal fat mass, internal organs and total body fluids) and *ectomorphy* (overall linearity of the body): all irrespective of body size [3,6,7]. Sheldon presumed that the cells that contributed to the formation of the components of the somatotype derived from the respective germ layers (the endoderm, mesoderm and ectoderm), so in his view the somatotype was inborn and therefore immutable throughout life. Sheldon's perhaps most important contribution to the study of human physique was that he adopted a dimensional model in which every component of the somatotype could be evaluated on a 1 to 7 scale.

Sheldon used the *photoscopic* method for somatotyping, in which the somatotype components are calculated using various anthropometrical measurements in conjunction with standardized photos. Years later, his student

Barbara Heath together with JEL Carter developed the Heath-Carter Anthropometric Somatotype Method [8] which relies on direct objective measurements and has become the golden standard in the assessment of somatotype today.

Two Chinese studies published in the 1970s found greater linearity in the somatotype of patients with schizophrenia in comparison with healthy subjects and patients with "affective disorders" in both genders. These studies did not specifically address differences in somatotype between bipolar patients and healthy controls. However, the first study, which included 411 men with schizophrenia, 42 men with affective disorders and 180 healthy controls found "insufficient data" that males with affective disorders were more pyknic in comparison with healthy controls [9]. A later study of 317 females with schizophrenia, 44 females with affective disorders and 115 healthy controls established a pattern very similar to the one observed by Kretschmer [10].

In a study on 31 bipolar women in Hungary in 2003 Tóth et al. found evidence of balanced endo-mesomorphy [11]. The authors found no significant differences with two studies, carried out by their own group 10 and 20 years, respectively, i.e. before the age of atypical antipsychotics and other orexigenic mood stabilizers. According to the authors, Kretschmer's hypothesis remains valid today: the pyknic state of manic-depression is characteristic of the disease itself, rather than an artefact of its treatment. The authors did not specify the method of somatotyping that they used in the studies.

According to PUBMED since 2003 no one has explored the link between bipolar disorder and somatotype and only three study groups have studied somatotype in schizophrenia. Meanwhile, searches with the key words *somatotype, diabetes, hypertension* and *cancer* retrieved 23, 8 and 22 results, respectively. Evidently, somatotype, a concept, born 95 years ago, has in the last decade, been orphaned by psychiatry and adopted by general medicine instead.

The aim of our study was to investigate the somatotype of patients with bipolar I disorder (the very same patients Ernst Kretschmer called manic-depressive) versus mentally healthy controls using an *objective anthropometric method of somatotyping* [6]. We hypothesized that patients with bipolar I disorder may be more mesomorphic and endomorphic and less ectomorphic than sex-matched controls. Based on the results of the two Chinese studies we also hypothesized that there may be gender differences in the somatotype of bipolar I patients versus healthy controls.

2. Materials and methods

Study setting

The study was performed at UMHAT "Sveti Georgi". It was approved by the Local Ethics Committee and all subjects gave written informed consent to participate.

Participants

The study sample consisted of 67 consecutively hospitalized bipolar I patients (26 males, 41 males) with a mean age of 38.15 years (SD+/-14.81) and 119 mentally healthy controls (54 males, 65 females), recruited from the local community, with a mean age of 39.08 years (SD+/-10.33) and comparable socio-economic status. No significant differences in age were found in any of the between-group comparisons. All patients satisfied DSM-IV TR criteria for a diagnosis of bipolar I disorder on the basis of case records review, a semi-structured interview based on a checklist of items from DSM-IV TR and additional objective information to enhance the validity of the diagnosis. Potential subjects were excluded if there was evidence of mental retardation, a history of drug or alcohol abuse, an identifiable neurological disorder or a general medical condition with direct effects on the central nervous system. A clinically significant change in body weight (≥7% of original body weight) within the last 6 months was also exclusionary. Mental health (in controls) was defined as the absence of a major Axis I or Axis II disorder per DSM-IV TR criteria. Controls did not meet any of the exclusion criteria applicable to the patients. In addition, controls were excluded if they had a first-degree relative with a history of a psychotic disorder, major mood disorder or completed suicide. All patients and controls were of Bulgarian ethnicity in order to avoid the potential confounding effects of racial and ethnic variation on somatotype. Potential participants were excluded if their parental or grandparental ethnic origin was any other than Bulgarian.

Somatotyping: We used the Heath-Carter Anthropometric Somatotype Method to assess all subjects included in the study [6]. This method provides three-number ratings representing endomorphy, mesomorphy and ectomorphy. Values between 0.5 and 2.5 are considered low, between 3 and 5 - moderate, between 5.5 and 7 - high and above 7.5 - very high. The following anthropometric variables were assessed: height, weight, biepicondylar breadth of the humerus, biepicondylar breadth of the femur, upper arm girth with the biceps brachii muscle maximally contracted, calf girth, skin folds (Harpenden caliper - 10 g/mm2 pressure, 0.5 mm accuracy) – triceps

brachii, subscapular, suprailiac, medial calf. All measurements were taken on the right side. Ratings for the somatotype components (endomorphy, mesomorphy and ectomorphy) were calculated using Heath-Carter formulas [6]. The mean somatotypes of patients and sex-matched controls were plotted on somatocharts in two-dimensional space following the Heath-Carter Anthropometric Somatotype Method Instruction Manual [6]. Additionally, BMIs were calculated for all subjects based on the standard formulas.

Statistical analyses

All data were analyzed with IBM SPSS Statistics version 24 under Windows 10. We used independent samples t-tests to compare somatotype indices, components and BMIs between bipolar I patients and sex-matched controls. We used three separate ANOVAS with fixed factors group membership (either bipolar I or healthy control) and gender (either male or female) and the three somatotype components as the dependent variables to test our second hypothesis. Chi-squared tests were applied to determine if there were statistically significant differences in the distribution of bipolar I patients versus sex-matched controls across predefined BMI categories.

3. Results

Comparison of the somatotype of bipolar I males and sex-matched controls

All study findings in male participants are summarized in Table 1 and illustrated in Figure 1.

Bipolar I males had significantly thinner skin folds, which made them *significantly less endomorphic.*

They did not differ significantly from healthy controls in terms of biepicondylar breadth of either the humerus or the femur. However, they did have significantly smaller upper arm and calf girths. Overall, these differences did not result in significant differences in mesomorphy between the two groups, although bipolar I males were *less mesomorphic.*

Bipolar I males were slightly (and non-significantly) shorter but significantly lighter than their sex-matched controls, which made them *significantly more ectomorphic.*

The mean somatotype of bipolar I males was endomorphic mesomorph 3.92 - 4.85 - 1.92 with moderate values of the two leading components, while the mean somatotype of mentally healthy males was mesomorph-endomorph 4.98 - 5.32 - 1.28 with a moderate to high value for endomorphy and a high value for mesomorphy.

When we plotted our data on a standard somatochart, the mean somatopoint of bipolar I males fell close South to the center of the left mesomorphy segment (Figure 1). The mean somatopoint of mentally healthy males was in the same segment but near its border way to the West and slightly to the North from the mean somatopoint of bipolar I males.

Comparison of the somatotype of bipolar I females and sex-matched controls

All study findings in female participants are summarized in Table 2 and illustrated in Figure 1.
Bipolar I females had thicker skinfolds, but differences were only significant for the subscapular skinfold. Although the pre-set level of statistical significance was not reached, we found that in comparison with sex-matched controls, bipolar I females were *more endomorphic* (p=0.063).

Bipolar I females did not differ significantly from sex-matched controls in terms of biepicondylar breadths of the femur and humerus. They had significantly bigger upper arm girth (p=0.026) and non-significantly bigger calf girth than sex-matched controls. Although the pre-set level of statistical significance was not reached, we found that in comparison with sex-matched controls, bipolar I females were *more endomorphic* (p=0.094).

Bipolar I females did not differ in height from sex-matched controls but weighed 6.62 kg more, which made them *significantly less ectomorphic*.

The mean somatotype in both studied groups was mesomorphic endomorph. In bipolar I females it was 6.15 – 4.42 – 1.05, while in mentally healthy controls it was 5.45 – 3.97 – 1.92.

On the somatochart the mean somatopoints of both studied groups were in the upper endomorphy segment (Figure 1). However, the mean somatopoint of mentally healthy females was almost centrally located in that segment, while the mean somatopoint of bipolar I females was far to the West and slightly to the North near its border.

Group membership and gender as sources of variation for the three somatotype components

In the ANOVA model for endomorphy, gender was a significant source of variation and group membership was not (p=0.00, p=0.53). Their interaction was also statistically significant (F=1349.02, p=0.00).

Likewise, in the ANOVA model for mesomorphy, gender was significant source of variation (p=0.00), while group membership was not (p=0.98). Their interaction was also statistically significant (F=2051.51, p=0.00).

In the ANOVA model for ectomorphy, neither gender (p= 0.55), nor group membership (p=0.57) was a significant source of variation but their interaction was (F=205.17, p=0.00) (Table 3).

Prevalence of overweight and obesity

Fifty percent of bipolar I males were of normal weight and 50 percent were either overweight or obese. 27.7 % of mentally healthy males were of normal weight, while 72.3% were either overweight or obese.

Sixty-one percent of bipolar I females (vs 34.8 percent of sex-matched controls) in our sample were either overweight or obese (χ^2=7.096, p=0.029).

4. Discussion

To our knowledge, this is the first study to compare the somatotype of bipolar I males and females versus sex-matched mentally healthy controls using predefined inclusion and exclusion criteria and an objective method of somatotyping. Sexual dimorphism in the study of somatotype has been acknowledged for a long time. Males are significantly more mesomorphic and less endomorphic than females as has been proven in over 15 large samples of different ethnicities [6]. It is therefore unacceptable to study the somatotype in mental (or any other) disorders irrespective of gender.

Findings in bipolar I males

Our findings in bipolar I males are not consistent with Kretshmer's original observations and the studies that replicated his findings. However, these studies did not compare bipolar I males with mentally healthy males but rather heterogeneous groups of patients with heterogeneous groups of other patients. Our results confirm Singer's conclusion of "insufficient data" that men with affective disorders are more pyknic than controls.

In fact, in our sample, bipolar I males are less mesomorphic than mentally healthy males, although this was not statistically significant (p=0.163). We found that bipolar I males had smaller upper arm girth (p=0.000) and calf girth (p=0.000) than mentally healthy males, i.e. relative "underdevelopment" of the biceps and calf muscles. Skeletal muscle development is the result of a series of events that begins prenatally. The three processes that ultimately form the somatotype (myogenesis, adipogenesis and fibrogenesis) begin competitively from multipotent stem cells in the same environment under the regulation of numerous genetic and epigenetic mechanisms [12]. Myogenesis is divided into primary, which occurs during the embryonic period and secondary, which takes place during the fetal period. All muscle fibers in the human body are formed prenatally; new muscle cells can be formed after birth only in the event of muscle injury. So the fetal period is critical for the development of skeletal muscles. Any environmental factors (particularly maternal malnutrition) [12] that could disrupt the process of myogenesis could potentially lead to skeletal muscle underdevelopment. In a study of the Dutch Hunger Winter Birth Cohort Brown et al demonstrated that maternal malnutrition during the second and third trimester of pregnancy (which corresponds to the fetal period) increased the risk of later development of bipolar disorder [13]. A serological study has proven that maternal influenza during any trimester of pregnancy increases the risk of bipolar disorder four times [14]. It is possible that prenatal influenza could disturb myogenesis through malnutrition of the mother or other unknown mechanisms.

Postnatally, muscle development is largely due to the increase of muscle fibers through exercise and sport. It may be argued that our findings are due to decreased physical activity and lack of involvement of bipolar I males with sport. However, our own findings in bipolar I females show larger mean upper arm and calf girths than sex-matched controls. We find it highly unlikely, that only male patients with bipolar I disorder disengage from sport and physical activity in comparison with sex-matched controls, while bipolar I females on the other hand are more physically active and engaged with sport in comparison with mentally healthy females. We find it far more plausible that these differences are due to gender-specific patterns of prenatal myogenesis in bipolar I disorder.

In our sample bipolar I males had significantly thinner skinfolds than sex-matched controls. As a result, they were significantly less endomorphic. They weighed significantly less, which resulted in significantly higher ectomorphy and lower mean BMI. These findings are somewhat surprising, especially because the majority of the patients most likely had been on orexigenic mood stabilizing medications prior to the assessment of somatotype. Treatment non-adherence, however, is high in bipolar disorder and, perhaps, even higher in bipolar males [15]. Additionally, it must be acknowledged that the patients were assessed during an admission to a tertiary care psychiatry clinic for the acute treatment of a depressive, manic, hypomanic or mixed episode, which can all be associated with substantial weight loss.

Findings in bipolar I females

Our findings in bipolar I females replicate the results of earlier studies. Probably because of the relatively small sample size (n=41), we could not prove that bipolar I females were significantly more endomorphic than sex-matched controls (p=0.063). However, all skin-folds were thicker in patients, suggesting a greater propensity for central obesity in comparison with controls. It is important to note that the subscapular skinfold was significantly thicker in bipolar I females than sex-matched controls (p=0.034). A 14-year follow-up study of the predictive value of skinfold measurements for subsequent ischaemic heart disease in over 2500 men found that only the subscapular skinfold measure contributed independently to the risk of heart disease when BMI was included in the model [16]. Although findings in men should not be extrapolated to women, the INTERHEART study, including 27 098 participants from 52 countries, 6787 of whom were females, clearly demonstrated that central obesity (assessed by waist to hip ratio) is a risk factor for myocardial infarction with comparable effect sizes in males and females (odds ratios 2.24 and 2.26, respectively) [17]. Our findings of greater endomorphy in bipolar I females were corroborated by statistically significant differences in mean ectomorphy and BMI. We also found statistically significant differences in the distribution of female participants in the study across predefined BMI categories. Sixty-one of bipolar I females vs. 34.8% of sex-matched controls were either overweight or obese.

Our findings on skinfold measurements, endomorphy, ectomorphy and BMI suggest that bipolar I females are a particularly vulnerable treatment group. Mood stabilization is a long-term endeavor with potential metabolic adverse effects. In an age of orexigenic mood stabilizers, treatment decisions should definitely be informed by the patient's metabolic health. Although, skinfold measurements cannot be routinely implemented in patient assessment or safety monitoring, BMI or waist to hip ratios can help decision-making.

We did not find significantly greater mesomorphy in bipolar I females using the Heath-Carter Anthropometric Somatotype Method (p= 0.094). However, bipolar I females had significantly larger upper arm girths and non-significantly larger calf girths than sex-matched controls. With the same height and bone structure (as judged from the values of the breadths of the humerus and femur) (Table 2), on visual observation they would probably have been considered more pyknic than the controls by Kretschmer and his followers.

Impact of bipolar I disorder on the somatotype of male and female patients

Bipolar I males in our sample were more mesomorphic and less endomorphic than bipolar I females (Figure 1). This does not differ from the pattern we found in mentally healthy males and females (Figure 1) and the results from the 15 studies we already cited [6]. It is therefore not surprising that our ANOVA models for endomorphy and mesomorphy found that gender (and not diagnostic group membership) was the only significant source of variation for these two somatotype components. In our ANOVA model we found a significant interaction between group membership and diagnosis on ectomorphy. Generally, this means that at the time of evaluation bipolar I disorder makes the physique of male patients with the disorder more linear (irrespective of body size) and the physique of female patients less linear in comparison with their mentally healthy counterparts. This could be due to a variety of different factors that cannot be accounted for by our study: genetic differences, gender differences in prenatal development, differences in physical development and maturation before puberty, lifestyle differences, marital status, time spent in depression (or mania), gender differences in co-morbid medical condition with potential metabolic effects, etc.

We also found a significant underdevelopment of the biceps and calf muscles in bipolar I males and a significant overdevelopment of the biceps muscle in bipolar I females in comparison with sex-matched controls. As we have discussed, it is highly unlikely that these differences are due to dissimilar levels of physical activity or engagement with sport and most probably reflect gender-specific patterns of secondary myogenesis during the fetal period of life in bipolar I disorder. The inevitable question is why the pattern is different in males and females with the disorder. One possible answer is X-linked genetic inheritance. Although a recent genome-wide association study in bipolar disorder found no significant X-chromosome associations [18], a particular polymorphism of the X-linked SYBL1 gene has been shown to increase the risk of bipolar disorder in American males [19] and German females [20]. SYBL1 encodes a protein involved in synaptic vesicle docking, exocytosis, and membrane transport [20] that may very well be involved in the regulatory processes of secondary myogenesis. It may be that the "faulty" polymorphism produces a "wrong" protein that downregulates myogenesis in male fetuses and upregulates it in female fetuses. Other, unknown X-linked mechanisms are also possible.

Alternatively, prenatal adversities, such as maternal malnutrition or viral infections that

increase the risk for bipolar I disorder may exert dissimilar effects on secondary myogenesis in male and female fetuses. From the very start of gestation males adopt a *"dangerous growth strategy"* [21], in which they grow faster than females and invest more resources in the development of the central nervous system than that of the placenta. In the case of nutritional deficiency as a result of maternal malnutrition, viral infections or other prenatal adversities, this could lead to disturbances in prenatal myogenesis. These are only plausible mechanisms. The observed differences in mesomorphy are probably due to the much more complex interactions between genetic, epigenetic and environmental factors at play prenatally in bipolar I disorder.

Our findings on endomorphy in bipolar I males and bipolar I females are consistent with previous studies that have demonstrated both higher rates of central obesity and increased standardized mortality ratios from cardiovascular disease in women with bipolar disorder relative to men with the disorder [22]. Different explanations have been proposed, including time spent in depression, reproductive events, iatrogenic effects of mood stabilizing medications, comorbid conditions, such as hypothyroidism, etc. [22]. Another possibility is that bipolar I females are simply more endomorphic even before the index episode of illness. To our knowledge, there is only one study that explores the prevalence of overweight in first episode bipolar disorder. It included 76 drug-naïve bipolar patients and 65 drug-naïve patients obsessive-compulsive-disorder matched for age and sex [23]. The authors found that 40.8% of bipolar patients met criteria for overweight or obesity with significant difference in comparison with obsessive–compulsive patients (10.8%). The authors also found that 45.2% drug-naïve first-episode bipolar females were either overweight or obese [23]. Our findings cannot tip the argument either way as we did not assess drug-naïve first-episode bipolar I patients. However, we find it essential to reiterate that bipolar females are at high risk for central obesity and mortality from ischemic heart disease and this risk should be considered when implementing and monitoring a mood-stabilizing treatment.

5. Limitations

The study did not account for psychotropic or other medications, dietary habits and lifestyles. A similar study in drug-naïve first-episode patients would be more informative with regard to endomorphy and ectomorphy in particular.

6. Conclusions

There are significant gender-specific differences in the somatotype of bipolar I patients in comparison with sex-matched controls that may result from prenatal events, disease-related phenomena and mood stabilizing treatment. Although, bipolar disorder is highly genetic, our findings add support to the line of data that the disease also has a neurodevelopmental basis [24]. Apparently, Kretschmer's hypothesis of the pyknic manic-depressive patient is at least in Bulgarians true only for females. Bipolar I females are a very vulnerable treatment population in terms or the risk of central obesity and mortality from ischemic heart disease.

7. Funding sources

The study was supported by the Medical University of Plovdiv (Project № 11/2012: "Biomarker profile of patients with schizophrenia and bipolar I disorder. Dermatoglyphic and somatotype characteristics". Scientific competition "Young Scientists").

References

1. Ellis A, Abraham A, Abrams L. *Personality Theories: Critical Perspectives*. SAGE Publications, Inc, 2009.

2. Kretschmer E. *Körperbau und Charakter: Untersuchungen zum Konstitutionsproblem und zur Lehre von den Temperamenten*, 5. und 6. unveränderte aufl., mit 41 abbildungen. edn. J. Springer: Berlin, 1926.

3. Pailhez G, Rodriguez A, Ariza J, Palomo AL, Bulbena A. Somatotype and schizophrenia. A case-control study. *Actas espanolas de psiquiatria* 2009; **37**(5)**:** 258-266.

4. Pailhez G, Bulbena A. Body shape and psychiatric diagnosis revisited. *International Journal of Psychiatry in Clinical Practice* 2010; **14**(4)**:** 236-243.

5. Pinillos JL, López-Piñero JM, García Ballester L. *Constitución y personalidad: historia y teoría de un problema*. Consejo Superior De Investigaciones Científicas: Madrid, 1966.

6. Carter JEL, Heath BH. *Somatotyping - development and applications*. Cambridge University Press: Cambridge, 2005.

7. Sheldon WH, Stevens SS, Tucker WB. *The varieties of human physique; an introduction to constitutional psychology*. Harper & Brothers: New York, London, 1940.

8. Heath BH, Carter JEL. A modified somatotype method. *American Journal of Physical Anthropology* 1967; **27:** 57-74

9. Singer K, Chang PT, Hsu GL. Physique, personality and mental illness in the Southern Chinese. *Br J Psychiatry* 1972; **121**(5073784)**:** 315-319.

10. Singer K, Lieh-Mak F, Ng ML. Physique, personality and mental illness in southern Chinese women. *Br J Psychiatry* 1976; **129**(963360)**:** 243-247.

11. Tóth GA, Buda BL, Eiben OG. Contribution to the physique of women with manic-depressive disorder in Hungary. *Coll Antropol* 2003; **27**(2)**:** 581-586.

12. Yan X, Zhu M-J, Dodson MV, Du M. Developmental Programming of Fetal Skeletal Muscle and Adipose Tissue Development. *Journal of Genomics* 2013; **1:** 29-38.

13. Brown AS, van Os J, Driessens C, Hoek HW, Susser ES. Further Evidence of Relation Between Prenatal Famine and Major Affective Disorder. *American Journal of Psychiatry* 2000; **157**(2)**:** 190-195.

14. Parboosing R, Bao Y, Shen L, Schaefer CA, Brown AS. Gestational influenza and bipolar disorder in adult offspring. *JAMA psychiatry* 2013; **70**(7)**:** 677-685.

15. Leclerc E, Mansur RB, Brietzke E. Determinants of adherence to treatment in bipolar disorder: A comprehensive review. *Journal of Affective Disorders* 2013; **149**(1–3)**:** 247-252.

16. Yarnell JW, Patterson CC, Thomas HF, Sweetnam PM. Central obesity: predictive value of skinfold measurements for subsequent ischaemic heart disease at 14 years follow-up in the Caerphilly Study. *International journal of obesity and related metabolic disorders : Journal of the International Association for the Study of Obesity* 2001; **25**(10)**:** 1546-1549.

17. Anand SS, Islam S, Rosengren A, Franzosi MG, Steyn K, Yusufali AH *et al*. Risk factors for myocardial infarction in women and men: insights from the INTERHEART study. *European heart journal* 2008; **29**(7)**:** 932-940.

18. Hou L, Bergen SE, Akula N, Song J, Hultman CM, Landen M *et al*. Genome-wide association study of 40,000 individuals identifies two novel loci associated with bipolar disorder. *Hum Mol Genet* 2016.

19. Saito T, Parsia S, Papolos DF, Lachman HM. Analysis of the pseudoautosomal X-linked gene SYBL1in bipolar affective disorder: description of a new candidate allele for psychiatric disorders. *Am J Med Genet* 2000; **96**(3)**:** 317-323.

20. Muller DJ, Schulze TG, Jahnes E, Cichon S, Krauss H, Kesper K *et al*. Association between a polymorphism in the pseudoautosomal X-linked gene SYBL1 and bipolar affective disorder. *Am J Med Genet* 2002; **114**(1)**:** 74-78.

21. Eriksson JG, Kajantie E, Osmond C, Thornburg K, Barker DJ. Boys Live Dangerously in the Womb. *American journal of human biology : the official journal of the Human Biology Council* 2010; **22**(3)**:** 330-335.

22. Baskaran A, Cha DS, Powell AM, Jalil D, McIntyre RS. Sex differences in rates of obesity in bipolar disorder: postulated mechanisms. *Bipolar Disorders* 2014; **16**(1)**:** 83-92.

23. Maina G, Salvi V, Vitalucci A, D'Ambrosio V, Bogetto F. Prevalence and correlates of overweight in drug-naïve patients with bipolar disorder. *Journal of Affective Disorders* 2008; **110**(1–2)**:** 149-155.

24. Sanches M, Keshavan MS, Brambilla P, Soares JC. Neurodevelopmental basis of bipolar disorder: a critical appraisal. *Prog Neuropsychopharmacol Biol Psychiatry* 2008; **32**(7)**:** 1617-1627.

Table 1. Comparison of the somatotype of bipolar I males and sex-matched controls

Somatotype	Males (n=80)					
	Bipolar I (n=26)		Controls (n=54)		Statistical significance	
	Mean	SD	Mean	SD	t	p
Skin folds (mm):						
Triceps	11.45	4.79	15.81	6.35	3.414	**0.001**
Subscapular	16.39	7.46	20.47	7.97	2.241	**0.029**
Suprailiac	12.49	5.70	16.86	7.73	2.842	**0.006**
Sum of 3 skin folds	40.33	16.77	53.13	19.42	3.035	**0.004**
Medial calf	9.41	3.39	14.43	6.74	3.577	**0.001**
Endomorphy	3.92	1.61	4.98	1.58	2.757	**0.008**
Humerus breadth (cm)	6.92	0.34	6.84	0.36	-0.979	0.332
Femur breadth (cm)	9.72	0.49	9.78	0.50	0.467	0.643
Upper arm girth (cm)	31.47	2.97	34.37	3.10	4.017	**0.000**
Calf girth (cm)	36.09	3.11	38.81	2.92	3.743	**0.000**
Mesomorphy	4.85	1.48	5.32	1.17	1.420	0.163
Height (см)	173.97	7.39	176.36	6.29	1.420	0.163
Weight (kg)	74.94	9.69	84.27	11.66	3.768	**0.000**
Height-weight ratio	41.42	2.52	40.37	1.97	-1.855	0.071
Ectomorphy	1.92	1.63	1.28	1.12	-2.075	**0.041**
X-coordinate	-2.00	3.12	-3.70	2.45	-2.443	**0.019**
Y-coordinate	3.86	3.42	4.39	2.78	0.687	0.496
BMI	24.87	3.73	27.11	3.59	2.542	**0.014**

Table 2. Comparison of the somatotype of bipolar I females and sex-matched controls

Somatotype	Females (n=106)					
	Bipolar I (n=41)		Controls (n=65)		Statistical significance	
	Mean	SD	Mean	SD	t	p
Skin folds (mm):						
Triceps	24.49	8.61	21.74	7.86	1.656	0.102
Subscapular	22.75	10.28	18.48	9.41	2.151	**0.034**
Suprailiac	16.87	7.13	15.38	8.91	0.944	0.347
Sum of 3 skin folds	64.10	23.18	55.60	24.28	1.805	0.075
Medial calf	21.01	8.47	18.89	7.38	1.318	0.191
Endomorphy	6.15	1.84	5.45	1.95	1.883	0.063
Humerus breadth (cm)	5.99	0.42	5.96	0.33	0.312	0.756
Femur breadth (cm)	8.94	0.64	8.90	0.59	0.356	0.723
Upper arm girth (cm)	29.84	3.80	28.15	3.63	2.262	**0.026**
Calf girth (cm)	36.43	2.96	35.56	3.21	1.417	0.160
Mesomorphy	4.42	1.37	3.97	1.33	1.695	0.094
Height (см)	162.34	6.70	162.67	5.94	-.0257	0.798
Weight (kg)	69.50	12.91	62.88	12.49	2.613	**0.011**
Height-weight ratio	39.74	2.23	41.20	2.63	-3.067	**0.003**
Ectomorphy	1.05	1.13	1.92	1.43	-2.543	**0.012**
X-coordinate	-5.11	2.80	-3.55	3.22	-2.624	**0.010**
Y-coordinate	1.65	3.14	0.59	2.80	1.761	0.082
BMI	26.30	4.19	23.80	4.66	2.878	**0.005**

Table 3. Interaction between diagnosis and gender on ectomorphy

Source of variation	um of squares	df	Mean square	F	p
Fixed factors					
Diagnosis	0.57	1	0.57	0.33	0.57
Gender	0.61	1	0.61	0.35	0.55
Two factor interaction					
Diagnosis x gender	24.06	1	24.06	13.95	**0.00**

Figure 1. Mean somatopoints of bipolar I males, bipolar I females and sex-matched controls