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# Anthropometric - Hormonal Correlation: An Overview

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**ABSTRACT** Nearly all biological or physiological functions are in some way related to one or other aspects of morphology. The morphometric variables of human body can be measured by the fundamental techniques of anthropometry. To be more specific, biological anthropology is substantially enriched due to the contribution relating to application of anthropometry made by a number of scientific workers in the areas such as, anthropometry and growth, anthropometry and nutrition, anthropometry and ergonomics and anthropometry and sports. It is since the second half of this century that the importance of hormonal factors for growth processes and development of body shape has been reported. Body shape is determined by the nature of body fat distribution which, in turn, is significantly correlated with women's sex hormone profile, risk for disease, and reproductive capability. There is extensive evidence that sex hormones affect specific regional adiposity and regulate utilization and accumulation of fat. In the recent past, application of anthropometry revealed significant correlations between body measurements and sex hormone levels in male as well as in female subjects. It was found that gonadotropins, luteinizing hormone (LH), and follicle stimulating hormone (FSH) have significantly negative correlation with breadth measurements such as, biacromial breadth, chest breadth, waist breadth, pelvic breadth, bicondylar breadth and circumference measurements (as, upper arm circumference, hand circumference and thigh circumference). Studies show that estrogen levels have significantly positive correlation with breadth and circumference measures of trunk, thigh circumference and with body weight but, negatively with circumference of the extremities. Another hormone, progesterone was found to be correlated negatively with both breadth dimensions (biacromial breadth, chest breadth, pelvic breadth and bicondylar breadth) and with upper circumferences (upper arm circumference, hand circumference and chest girth). In postmenopausal women, sex- hormone concentrations in general were only found in connection with the appearance of individual symptoms; the climacteric syndrome. A study pointed out that there is a correlation between sex hormone concentrations and anthropometric breadth and circumference measurements in fertile and postmenopausal women. There are researches which reflect the role of hormones in various life processes (like, infertility and cancer) but, a few have investigated the relationship between anthropometric traits and hormonal changes. Moreover, research relating to the relationship between hormonal measures and anthropometric dimensions on Indian populations is almost unexplored.

## INTRODUCTION

Nearly all biological or physiological functions are in some way related to one or other aspects of morphology. The morphometric variables of human body can be measured by the fundamental techniques of anthropometry (Herron 2005). To be more specific, biological anthropology is substantially enriched due to contribution relating to application of anthropometry made by a number of scholars in the areas such as, anthropometry and growth (Tanner et al. 1976), anthropometry and nutrition (Jeliffee 1966; Mahapatra 1973; Waterlow 1977; Bar-Or et al. 1998; Bishnoi et al 2004; Kumari 2005; Baer et al. 2005), anthropometry and ergonomics (Forbes 1977; Shier 2006; Delisle 2008) and anthropometry and sports (Tanner et al. 1976; Lefebvre et al. 1997; Katzmarzyk et al. 1998; Eisenmann et al. 2001).

### Objectives of the Study

Enormous range of body dimensions have been measured by Biological Anthropologists and Human Biologists over a long period. These measurements provide information which is relevant to various physiological, genetic and other investigations. For quite a while now, studies have been carried out on various aspects of Anthropometry, including heritability of anthropometric traits (Devor et al. 1986a), determining genetic factors that contribute to the development obesity and concomitant traits (Livshits et al. 1998; Kartzmarzyk et al. 2000a), examining nutritional status (Martin-Prevel et al. 2000; Marins et al. 2002), observing overall distribution of subcutaneous fat related to risk factors of metabolic disorders and various adult diseases (Ghosh et al. 2004), providing discriminatory factors and characteristic feature of chromosomal anomalies (Cecil et al. 2005).

However, investigations in the relationships of Anthropometry and Hormones are relatively new and have been restricted in finding out the effect of hormones on various body dimensions (Knusmann 1988; Cabanes et al. 2004; Nagata

2008). There are a few authors who have investigated the relation between metric traits and hormonal changes in India (Mehrotra et al. 1997; Sehgal et al. 2000; Reddy et al. 2007).

This review work aims to bring forward some of the areas that are mostly studied within the domain of anthropometry and hormone and also identifies the areas which need to be researched intensively both at global level and in Indian perspective.

## ANTHROPOMETRY - HORMONE AND GROWTH

Growth refers to changes in magnitude, increment in size and change in size of an individual as a whole, whereas development refers to differentiation, change in proportion and complexity in organization (Dasgupta and Hauspie 2001).

A number of studies have reported the importance of hormonal factors for growth processes and development of body shape (Tanner 1969; Ganong 1979; Kulhman and Straub 1986). However, the influence of sex hormones on growth of bones, development of muscles and expression of extra genital sexual dimorphism was not documented until recently (Knusmann et al. 1986). Ahlgren et al. (2004) recently reported a weaker association of sex-hormones with BMI at age 14 years, based on a large Danish study with more accurate measures of early life anthropometry retrieved from school records.

## ANTHROPOMETRY - HORMONE, OBESITY AND CANCER

Indeed, although the worldwide evidence supports a protective role of childhood and adolescent body fatness on breast cancer risk, the decrease in risk does not appear to match the findings of Baer and co-workers in magnitude (Ahlgren et al. 2004; Okasha et al. 2003 and Berkey 1999). Baer and colleagues report a strong protective effect of childhood and adolescent body fatness on premenopausal breast cancer risk based on a large prospective study. There are strong associations between average childhood and adolescent body fatness and incidence of premenopausal breast cancer (Magnusson et al. 2005). Anthropometric measures appear to be fundamentally linked the risk factors to breast carcinogenesis. For example, the risk of postmenopausal breast cancer increases with body mass index (BMI), largely as a result of the related increase in endogenous oestrogen levels (Magnusson et al. 2005). Further findings fail to support a substantial role for progesterone-deficient menstrual cycles in the causal pathway between early life body size and breast cancer development. Childhood body fatness is inversely associated with adolescent peak height velocity, a factor that was recently demonstrated to be positively related to breast cancer risk (Berkey et al. 1999; Ahlgren et al. 2004). However, results from the Danish study imply that BMI at age 14 years confers an influence on risk over and above that of stature at ages between 8 and 14 years, as well as of high birth weight; but, interestingly not of age at menarche (Ahlgren et al. 2004). Finally, increased levels of bioavailable oestradiol, which may result from increased production of oestrogen by aromatase in adipose tissue and lowered sex hormone-binding globulin concentrations, have also been suggested to have a causal relation between early life obesity and breast carcinogenesis (Berkey et al. 1999).

Although the aetiology of breast cancer is closely linked to oestrogen (Cabanes et al. 2004), it has been hypothesized to have a dual impact on breast cancer risk, depending on the timing of exposure. Oestrogenicity may also up-regulate a tumor suppressor gene and thereby maintain genomic integrity and DNA repair. However, the literature does not provide firm evidence that childhood body fatness is clearly associated with oestrogen levels (De Aloysio 1988). Furthermore, the reduced risk for breast cancer is noted both with body fatness before menarche and in adolescence, although these effects are not easily separated. The association between adolescent obesity and breast carcinogenesis could not be accounted for by oestrogenicity if ovarian steroid production rather than adipose tissue is assumed to constitute the major source of oestrogen levels after menarche.

In conclusion, recent findings provide further support for a protective effect of childhood and adolescent obesity on breast cancer development, but the biological explanation for this association remains unclear. Epidemiologic studies are unlikely to unravel in great detail how adiposity at early ages of life influences breast cancer risk, because such measures are highly correlated and may be subjected to non-differential as well as differential measurement errors. Instead, further knowledge about the physiological correlates of obesity and their effects on the prepubertal and adolescent mammary gland could provide important keys to our understanding of breast cancer aetiology (Kêska et al. 2008).

Research indicates that anovulatory menstrual cycles in premenopausal females are characterized by elevated plasma leptin levels and the lack of the relationship between circulating leptin and estradiol and support the suggestion concerning a close relationship between leptin and reproductive function (Welt et al. 2004). Women with ovulatory and anovulatory menstrual cycles didn't differ with respect to age, anthropometric characteristics and cycle length. A study by Keska and others (2008) shows that in non-ovulating women, plasma leptin levels between 19$^{th}$ and 22$^{nd}$ day of the cycle was significantly higher and between 5$^{th}$ and 8$^{th}$ day tended to be higher than in ovulating ones. The same study also reveals that exclusively in ovulating women, plasma leptin to body fat ratio is significantly positively correlated with circulating estradiol levels.

## ANTHROPOMETRY AND SEX HORMONE

Body shape is determined by the nature of body fat distribution that, in turn, is significantly correlated with women's sex hormone profile, risk for disease, and reproductive capability (Singh et al. 1998b). There is extensive evidence that sex hormones affect specific regional adiposity and regulate utilization and accumulation of fat (Pond 1981). Sex dimorphism has been observed for many body parameters, and special attention has been paid to changes during puberty and menopause. In a study, among the women of La Alpujarra, of the western Mediterranean, a multivariate analysis was performed on several body fat parameters to obtain an overview of sex differences from the early reproductive period to the post reproductive period (Luna et al. 2007). Simply stated, estrogen inhibits fat deposition in the abdominal region and stimulates fat deposition in the gluteofemoral region more than in other body regions. In contrast, testosterone, stimulates fat deposition in the abdominal region and inhibits deposition in the gluteo-femoral region (Bjorntorp 1987).

It is important to note that women have greater amounts of body fat in lower parts of the body (gynoid,"pear-shaped" body fat), whereas men have greater amounts of fat in the upper body (android, "apple-shaped" body fat) induced by the circulating level of sex hormones between the two sexes. Furthermore, variation in the gynoid body shape should not only be correlated with variation in reproductive potential, but such variations should systematically affect the judged degree of female attractiveness. The nature of body fat distribution is largely determined by the gynoid body shape (Hefferman et al. 2002).

A widely-used anthropometric technique to ascertain the degree of gynoid and android fat distribution is to measure circumference of the waist (narrowest portion between the ribs and iliac crest) and hips (at the level of the greatest protrusion of the buttocks), and using these measurements to compute a waist-to-hip ratio (WHR). WHR is a stable and highly reliable measure and is significantly correlated with fat distribution measurement using computed tomography scanning (Despres et al. 1991). Before puberty, both sexes have similar WHRs. After puberty, females deposit more fat in the hips and buttocks; WHR therefore becomes significantly lower in females than in males. WHR has a bimodal distribution with relatively little overlap between the sexes. The typical range of WHR for healthy premenopausal women has been shown to be 0.67 to 0.80, whereas healthy men have WHRs in the range of 0.85 to 0.95. Women typically maintain a lower WHR than men throughout adulthood, although after menopause their WHR approaches the masculine range (Singh et al. 1998b). Thus, the size of WHR can be used as a reliable proxy determinant of women's general reproductive status. .

There is strong evidence indicating that WHR is an accurate somatic indicator of reproductive endocrinological status and long-term health risk (Davis and Cerullo 1996). WHR size provides reliable information about the reproductive age, fertility and health status of a woman at a glance (Singh 1994).

In the recent past, application of anthropometry revealed significant correlations between body measurements and sex hormone levels in male (Katz et al. 1985; Christiansen and Winkler 1990; Winkler and Christiansen 1991) as well as in female (Raschka 1988; Pasquali et al. 1997; Burger et al. 2002; Randolph et al. 2004) found that gonadotropins, luteinizing hormone (LH), and follicle stimulating hormone (FSH) were significantly negatively correlated with breadth measurements (such as, biacromial breadth, chest breadth, waist breadth, pelvic breadth, bicondylar breadth) and circumference measurements (such as, upper arm circumference, hand circumference and thigh circumference). Estrogen was known to be primarily related to the more feminine features of men but also leanness and slenderness of women (Raschka 1988). Studies show that estrogen levels correlate significantly positively with breadth and circumference measures of trunk, with thigh circumference and with body weight but, negatively with circumference of the extremities (Luna et al. 2007). Another hormone, progesterone was found to be correlated negatively with breadth dimensions (such as, biacromial breadth, chest breadth, pelvic breadth and bicondylar breadth) and with upper circumferences (such as, upper arm circumference, hand circumference and chest girth) (Kirchengast 1998). In postmenopausal women, sex- hormone concentrations in general were only found in connection with the appearance of individual symptoms; the climacteric syndrome (Barber et al. 2008). Kirchengast (1993, 1998) pointed out the directions of correlations between sex hormone concentrations and anthropometric breadth and circumference measurements in fertile and postmenopausal women.

## ANTHROPOMETRIC DIMENSIONS AND HORMONAL MEASURES: INDIAN STUDIES

At present, endocrinology appears to be emerging as a special field of interest to the biologists and medical scientists in India. Work has been done on various aspects like infertility, cancer and the role of different hormones in various life processes (Saxena et al. 1997). Earlier works on anthropometry and hormone in the Indian context were mostly focussed on the relation of growth hormone and thyroid hormone with the proper growth and development in children (Mehrotra et al. 1997; Sawhney et al.1991). Only a few authors have investigated the relationship between the metric traits and hormonal changes in any of the Indian population. A study was conducted among the Rajput, Gorkha, South Indian ethnicities of the Indian population employed in the Indian army, to study the effect of ethnicity on plasma concentration of the sex hormones (Sachidhanandam et al. 2010). The study revealed that the difference in plasma hormones was most prominent between north - (Rajputs and Gorkhas) and south Indians.

Another major area of study in India in this regard, is to unfold the menstrual health of women and to trace the hormonal background if there exists any. Although a woman's menstrual history can have significant implications for health outcomes, few studies have examined menstrual cycle variability in non-western, non-clinically based populations (Williams 2006). Menstrual cycles in a study, among the Bhutia women, in Sikkim, were highly variable, with most women experiencing more than one short or long menstrual cycle. The frequency of irregular menstrual cycles experienced by individuals also varied significantly by season. A body mass index (BMI) above or below the WHO (2004) defined normal range was associated with higher rates of irregular cycles. Although menstrual cycles in the Bhutia women were highly variable, median cycle length was still useful in predicting timing of the pre-ovulatory hormone surges of leutinizing (LH) and follicular stimulating hormone (FSH). It has been found that the frequency of irregular cycles affects the successful capture of the LH and FSH peak values (Santoro et al. 2003; Williams 2006). Some researches suggest that menstrual cycle reflects a woman's endocrine environment which plays an important role in determining long-term risk for developing chronic diseases like osteoporosis, cancer and cardiovascular disease (Harlow 2000). Some researches also advocate that women of low socio-economic group suffer more from the menstrual disorders than the others (Munster et al. 1992; Power and Matthews 1997). Results of a study conducted among the adolescent Bengalee girls from two different socioeconomic backgrounds show that significant differences exist in menstrual health conditions, in other gynecological problems and hygienic practices related to menstruation between the girls of the contrasting socio-economic groups (Basu et al. 2008).

Physical maturity and growth have a great bearing on the self-esteem of a young woman, especially in the overly critical social milieu that still exists in many parts of India. The effect of maternal determinants on birth weight was studied in a sample population of India (Bhatia and Tyagi 1984). Regular measurement of the gradual changes in body proportions was found to enhance the patients of eagerness to continue the treatment. Anthropometry thus constitutes a simple, inexpensive and useful methodology for assessing the therapeutic effect of HRT on the sexually infantile phenotype in Turner Syndrome (Sehgal et al. 2000).

## CONCLUDING REMARKS

The content of the foregoing literature indicates that a causal relation between hormonal alterations and somatic changes is plausible. Moreover, research work relating to the relationship between hormone and anthropometry on Indian population is almost unexplored. Further studies involving hormones and their gene polymorphisms as a possible basis for ethnic variation involving various age groups may help in understanding the prevalence and pattern of endocrine disorders in India. Comparative studies can also be carried out on Indians among different groups on the basis of age, sex and various economic groups. This might reveal information on the genetic and environmental factors responsible for the hormonal compositions and their variations. The emerging areas of research in relation to anthropometry and hormone in India can be the following: a) relationship of obesity and hormone, b) anthropometry, hormone and the metabolic syndrome, c) effect of HRT on health with the help of anthropometry, d) to find out the variations if any in different populations of India according to the different geological locations and e) anthropometric and hormonal correlation among the fertile, premenopausal and post-menopausal women.

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