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PROXIMATE AND ULTIMATE ASPECTS OF BODY COMPOSITION CHANGES DURING MENOPAUSAL TRANSITION

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Abstract: *Menopause, the irreversible termination of menstrual function and female reproductive capability is associated with various changes in body composition and body weight. In general, body weight increases, on average between 5 to 10 kg. This weight gain is predominantly caused by an increase of fat mass while in contrast fat free tissue mass, i.e. muscle mass as well as bone mass, decreases. Additionally the sex specific fat distribution patterns change from a more gynoid kind of fat patterning to the typical android fat distribution. Android fat patterning is not only associated with an increased risk of metabolic disturbances it is also in clear contradiction to the recent standards of female beauty ideals. Therefore menopausal weight gain and changes in fat distribution lead to a negative self perception in the affected women. All the somatic alterations mentioned above are caused by various factors such as the hormonal alterations, above all the decrease in estrogen levels, but also by numerous exogenous factors such as life style patterns, i.e. reduced physical exercise in combination with increased energy intake, individual life history patterns, such as menstrual and reproductive history or the form of menopause (natural menopause versus hysterectomy).*

Keywords: *Body composition; Weight gain; Menopause; Reproductive history; Hysterectomy.*

Introduction

Biological ageing in general and in both sexes is associated with adverse changes in body build and body composition. Body stature decreases due to increasing kyphosis, i.e. a narrowing of the intervertebral discs and sometimes a collapse of the vertebrae caused by bone loss and osteoporosis. In contrast body weight increases and body composition and body proportions change. Especially females in western industrialised societies interpret these somatic changes as visible signs of ageing and every sign of ageing is interpreted exclusively negatively in the youth-oriented culture of western societies. This may be one reason for the increased psychical distress associated with menopausal transition. Furthermore several health risk factors responsible for morbidity and mortality during this phase of life are known to be associated with these somatic alterations. Therefore the visible somatic changes accompanying menopause are important factors, making this phase of life an uncomfortable one for affected women in our society.

Changes in body weight, body composition and fat distribution during menopausal transition

At the onset of menopause a woman's body weight reaches its maximum (Astrup 1999). In general an increase of 5 to 10 kg is observable. Independent of general ageing

and weight changes, menopause has been associated with modifications in body composition. There is a rapid loss of bone mineral content that may lead to osteopenia or a manifest osteoporosis, a decline in body cell mass and lean soft tissue mass and an increase of total fat mass independent of ageing and height (Panotopoulos et al. 1996, Douchi et al. 1998, Tchernof and Poehlman 1998). In addition to the total increase of fat tissue mass, the sex specific fat distribution patterns change during menopausal transition (Ley te al. 1992, Tremollieres et al. 1996, Kirchengast et al. 1997a, Tchernof and Poehlman 1998, Toth et al. 2000). At the late phase of premenopause and during perimenopause the gynoid fat patterning changes independent of age and weight status to an intermediate stadium of fat distribution between the gynoid and the android type. The amounts of abdominal fat tissue and lower body fat tissue are more or less equal during perimenopause. During the postmenopausal phase of life the intermediate type of fat patterning changes into the typical android fat patterning in the majority of women. (Kirchengast et al. 1997, 1998). Both body composition changes and fat distribution alterations are strongly associated with menopausal status (Ley te al. 1992, Tremollieres et al. 1996, Kirchengast et al. 1997, Tchernof and Poehlman 1998, Toth et al. 2000).

Weight gain and changes in body composition and body fat distribution patterns as health risk factors

Weight gain during middle age and adverse changes in body proportions and fat distribution patterns lead not only to a negative self perception in the affected women because their body shape is no longer in accordance with our culture specific beauty ideals, preferring very slender females with a gynoid kind of fat patterning (Brown 1991). These body shape alterations are also associated with various health risk factors, also called the metabolic syndrome comprising symptoms such as cardiovascular disease, hypertension, arteriosclerosis, diabetes mellitus, hyperlipidemia, hypertrigliceridemia, (Björntorp 1997). This increased risk of cardiovascular and metabolic disease is caused partly by the adverse effects of estrogen deficiency on plasma lipid-lipoprotein profile and cardiovascular function but also mediated by increased body fat and intra-abdominal fat tissue accumulation (Tchernof and Poehlman 1998). Additionally, a marked association between weight gain, android fat patterning and the incidence of cancer affecting reproductive tissues such as breast or endometrium was found (Stoll 2000). Another important health risk factor associated with weight status and body composition during middle age and persisting into old age is bone loss and the development of osteoporosis which is a significant health problem and a main contributor to disability and premature mortality among postmenopausal women (Rougucka et al. 2000). The observed positive association between bone density as well as bone mass and weight has been explained by biomechanical forces or by increased aromatization rates of androgens to weak estrogens in the subcutaneous fat tissue (Holbrook and Barret-Connor 1993, Wahrhaftig et al. 1995). In body composition compartments the lean body mass seems to be the major contributor to increased bone mass and bone density (Chen et al. 1997). The positive associations between bone density and lean soft tissue mass reflect not only developmental and biomechanical relations but an increased lean mass is also an indicator for a more active lifestyle, especially increased physical exercise, which leads to increments in bone mass or may result in the enhancement of bone mineralization caused by additional electrical kinetic potential of greater lean body mass.

Body composition during menopause and climacteric complaints

Body composition characteristics and changes in body proportions have also an important impact on the course of climacteric or on the degree of severity of climacteric symptoms. With an increasing amount of fat tissue the degree of severity of paraesthesias, urogenital symptoms, pains in joints and muscles, general weakness, nervousness and sleeplessness increase significantly (Kirchengast 1993). Furthermore a significant decrease of sexual interest with increasing weight status and fat mass was observed. In contrast, no impact of somatic factors on the occurrence of hot flushes was stated (Kirchengast et al. 1996). The majority of symptoms mentioned above are explained as somatic reactions of the postmenopausal estrogen deficiency. However, during climacteric the subcutaneous fat tissue has a positive impact on the endogenous estrogen levels because the extraovarian estrogen synthesis by aromatisation of androgens to weak estrogens is taking place there. Therefore the increased climacteric symptomatology and the reduced sexual interest associated with increased fat mass may by explained by the adverse effects of psychosocial stress to which women are exposed in our society if their bodies do not correspond to our culture specific beauty ideal (Kirchengast 1993, Kirchengast et al. 1996)

But what are the reasons for these somatic changes? Analysing the causes and reasons for the somatic changes accompanying menopausal transition we have to distinguish between proximate or physiological causes and ultimate or evolutionary reasons.

Proximate factors responsible for somatic alterations during menopausal transition

Hormonal factors

First of all the hormonal alterations, including a decrease of estrogen levels, thyroid hormone levels, growth hormone level and the estrogen/androgen ratio, taking place during middle age and menopausal transition, are discussed as responsible factors for the typical somatic changes. The weight gain during middle age may be explained by the decrease of the lipolytic acting thyroid hormones and growth hormone indicating the decrease of the basal metabolic rate. The changes of the sex specific fat patterning typical for menopausal transition may be caused by the alterations of sex hormone levels, above all the decrease of estrogens and the estrogen/androgen ratio. During fertile phase in the lower body adipocytes at the gluteal-femoral region an increased lipoprotein lipase activity and a blunted lipolytic response can be observed in comparison with the upper body (abdominal) adipocytes. In the abdominal region the lipolysis is induced by estradiol. (Rebuffe-Scrive et al. 1985, 1986). The decrease of estrogen levels during the menopausal transition induces marked metabolic changes: the lower body adipocytes no longer show an increased lipoprotein lipase activity and a further increase of lower body fat mass does not take place. On the other hand the diminished estrogen levels reduce the lipolytic metabolism at the abdominal region and result in an increase of adipose tissue at this region. Therefore the menopausal hormonal transition with reduced estrogen secretion seems to be responsible for the typical menopause associated changes in fat patterning, the conversion from more gynoid to more android fat patterning.

Life style factors

Other proximate causes for body composition changes during menopausal transition are life style factors. The most important component of total daily energy expenditure, the resting metabolic rate, is reduced by ageing and also by menopause independent of the effects of the normal ageing process (Poehlman and Tchernof 1998). Unfortunately at the same time marked behavioural changes occur. The energy expenditure caused by intensive physical exercise decreases dramatically and a more sedentary life style is typical for middle age, while no changes in eating habits take place. One of the most important somatic consequences of these metabolic alterations and behavioural factors is the increase of body weight, especially an increase of adipose tissue, as a result of a long term positive energy balance.

Reproductive history patterns

Menstrual and reproductive history are considered to be of special importance in explaining somatic changes at the end of the reproductive phase of life (Ellison 1999). Several studies plead for significant associations between age at menarche and postmenopausal body composition (Ness 1991, Adams-Campbell et al. 1996, Parazzini et al. 1996). Other studies yielded significant associations between weight status, body composition as well as fat patterning and parameters of reproductive history, while no menstrual history factors were significantly related to somatic characteristics (Kirchengast et al. 1999). Of special importance appear to be the amount of weight gain during pregnancies and the number of births: Obese postmenopausal women reported the significantly highest average weight gain during their pregnancies while normal weight postmenopausal women reported the significantly lowest ($p < 0.001$) average pregnancy weight gain (Figure 1). Pregnancy weight gain can in retrospect be identified as the most important triggering life event for the development of obesity and a high amount of body weight. Furthermore postmenopausal weight status was significantly negatively associated with the age at first birth. Regarding fat distribution, only the number of births seems to be associated significantly with the fat distribution patterns. A gynoid fat patterning seems to be associated significantly positively with the number of births. (Kirchengast et al. 1999). Concerning body composition, a significant increase of lean soft tissue mass and fat mass during postmenopause with increasing pregnancy weight gain was described (Kirchengast 1999). Bone mineral content (BMC) and bone mineral density (BMD) increased significantly with increasing number of births.

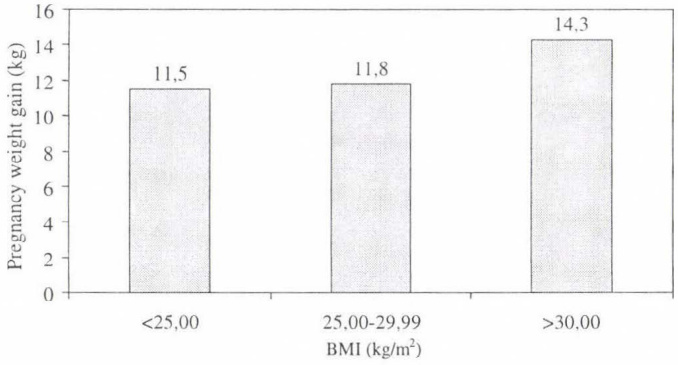

Figure 1: Postmenopausal weight status and pregnancy weight gain.

Natural menopause versus hysterectomy

The form of menopause (natural menopause versus artificial menopause as a result of hysterectomy or ovarectomy) is also considered relevant for the course of climacteric as well as for somatic alterations. Hysterectomy due to non-malignant cause is among the most common surgical procedures in women aged 40 to 60 years worldwide, although marked differences in the frequency of hysterectomies are observable between different countries and also within a population according to education, parity or ethnicity of the individual woman concerned (Meilahn et al. 1989). Hysterectomy carried out during pre- or perimenopause represents not only an artificial end of reproductive function, it also has several effects on women in later life such as an increase of postmenopausal symptomatology (Hartmann et al. 1995). Regarding the impact of hysterectomy on weight status and body composition Carlson et al. (1994) reported a significant weight gain in 12% of women after hysterectomy, according to Ravn et al. (1995) hysterectomized women exhibited 2% to 11% more body fat than women who experienced natural menopause. Kirchengast et al. 2000 documented a significantly higher weight gain after menopause in hysterectomized women than in those who had a spontaneous menopause (9.1 kg versus 6.0 kg). Furthermore the percentage of obese women (BMI < 30.00) was significantly higher among hysterectomized women (34.0% versus 17.7%). For a long time hysterectomy was assumed not to have any adverse effects upon the function of ovaries if conserved, however during the last two decades there has been a change in the awareness of the consequences of extirpation of the uterus per se. The removal of the uterus leads to a loss of ovarian hormone synthesis, even if the ovaries are conserved (Riedel et al. 1986). The ligation of both arteriae uternia as a result of hysterectomy reduces the arterial blood flow to the ovaries by about 50% (Riedel et al. 1986). The reduced blood supply to the ovaries may lead to a reduction in ovarian hormone synthesis and hence to an abrupt decrease of estrogen levels, which may be responsible for weight gain and the rapid development of an android fat patterning.

Ultimate reasons for body composition changes during menopausal transition

According to Theodosius Dobhansky "Nothing in biology makes sense except in the light of evolution". Several theories have been formulated to find an evolutionary explanation for the phenomenon of human menopause which is unique among mammals (Hawkes 2003). The most prominent theory seems to be the so called grandmother hypothesis, however we have not enough space to discuss all evolutionary theories concerning the existence of menopause. But what about the body composition alterations? As mentioned above the main characteristics of somatic changes during menopausal transition are the increase of body fat mass and the visible changes in fat distribution patterns. The typical fat distribution of fertile phase of life is the gynoid kind of fat patterning with a quantitatively higher amount of lower body fat, i.e. fat at the hips, buttocks and thighs, than at the upper body. Cross cultural analyses using the Human relation area files as data source reveal that in 90% of investigated cultures a gynoid fat distribution is associated with female attractiveness presumably because gynoid fat patterning is interpreted as an indicator for potential fertility and reproductive success of a female (Singh and Luis 1994, Kirchengast and Huber 1999, 2001a). Body fat at the lower body region is an excellent energy store for phases of increased energetic requirements

such as pregnancy or lactation. Lower body fat stores remain stable even during phases of starvation and malnutrition indicating the potential fertility of young women (Kirchengast and Huber 2001a). In contrast, an android fat patterning, typical for males throughout adult life, is found only in obese young females and in young females suffering from Polycystic Ovary Syndrome (PCOS), the most common endocrine cause of female infertility (Kirchengast and Huber 2001b). An android fat patterning or an android body silhouette is also found during pregnancy when a new conception is impossible. After menopausal transition nearly all postmenopausal women exhibit an android kind of fat patterning independent of their weight status. Android fat distribution patterns seem therefore to be excellent indicators of infertility or physiological sterility as in case of postmenopause. Therefore an ultimate or evolutionary explanation of the body composition and fat distribution changes taking place during menopausal transition may be that android fat patterning could serve as an indicator for the irreversible end of female reproductive capability.

Conclusions

We can conclude that weight status, body composition and fat distribution patterns underlie significant changes during middle age/menopausal transition. From a proximate perspective these somatic changes are mainly caused by hormonal changes taking place during menopausal transition and ageing in general but also by life style factors and individual life history patterns. Special risk factors for overweight, a high amount of body fat and a more android fat distribution, and therefore for the development of metabolic syndrome and an increased cancer risk are a late first birth, a low number of births, a higher pregnancy weight gain and hysterectomy. All these factors represent typical reproductive history patterns of industrialized countries, where the health risk factors mentioned above are common problems, while in contrast, they are rather unknown in traditional societies, where completely different reproductive history patterns prevail. On the other hand an evolutionary explanation of the body composition and fat distribution changes is possible.

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