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Associations Between Physical Activity and the Androgenic/Estrogenic Status of Men

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Summary

Concentrations of numerous hormones decrease with age. Some authors imply that a syndrome of partial endocrine deficiency may occur in the aging men. Among many lifestyle factors that influence hormonal status is physical activity. Especially interesting are relations between physical activity and the androgenic/estrogenic status of men. The aim of this study was to evaluate age-related changes of serum androgens, estradiol and SHBG in men presenting different levels of physical activity. Hormonal parameters were measured in a cohort of 387 healthy Caucasian men (aged from 24 to 72 years) from one administrative region of Poland. Their level of physical activity was determined by means of the International Physical Activity Questionnaire (IPAQ). We have found that contrary to SHBG concentration, total testosterone, free testosterone, bioavailable testosterone, calculated free testosterone and estradiol were negatively associated with age in the investigated subjects. Apart from estradiol, physical activity did not influence concentrations of the studied parameters. In younger (24-48 years), physically active males estradiol was significantly higher than in subjects characterized by a low level of physical activity. The situation was opposite in older males (48-72 years). In this age group low level of physical activity was associated with lower concentration of estradiol. Undertaking physical effort increased the decline of estradiol level with age.

Key words

Hormones • Age • Motor activity • Lifestyle

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Introduction

Concentrations of numerous hormones decrease with age. This phenomenon has an individual dynamics and depends on genetic, psychical and social factors (stress, depressive states). It is also influenced by lifestyle: tobacco smoking, alcohol drinking and physical activity (Field *et al*. 1994, Svartberg and Jorde 2007, Shiels *et al.* 2009, Wolin *et al.* 2007, Muller *et al.* 2003).

The influence of repeated physical efforts on the androgenic status of aging men is not fully explored. Testosterone deficiency is supposed to be associated with vanishing of the muscle mass, increase of the visceral fat, insulin resistance, arterial hypertension, dyslipidemia as well as osteopenia (Denti *et al.* 2000, Vanderschueren and Vandenput 2000).

Estrogens warrant proper function of the reproductive, skeletal and nervous systems in men. Although it is assumed that male aging is accompanied by a gradual increase of estrogens, not all authors confirm this observation. The data on associations between estrogens and physical activity are scarce (Drafta *et al.* 1982, Shiels *et al.* 2009). We wanted to evaluate the impact of physical activity on age-related trends in hormonal status of men living in the Lower Silesia Region.

Materials and Methods

Our investigation is a part of a larger project named Health of Adults in Lower Silesia (HALS). The region of Lower Silesia is located in southern Poland and

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Table 1. Basic data of the study group.

Parameter	All (n = 387)	High activity (n = 191)	Low activity (n = 196)
Age (years)	48.3 ± 14.6	47.1 ± 14.3	49.5 ± 14.6
Weight (kg)	84.9 ± 13.4	85.3 ± 13.5	84.7 ± 13.4
Height (cm)	175.0 ± 6.9	176.0 ± 6.5	175.6 ± 6.8
Body mass index (kg/m^2)	27.5 ± 4.1	27.3 ± 4.1	27.6 ± 4.2

Data are mean ± SD.

Table 2. Basic of the study group.

Age (years)	24 - 30 n = 91	31 - 40 n = 68	41 - 50 n = 96	51 - 60 n = 98	61 - 72 n = 34
Weight (kg)]	81.8 ± 12.5	85.7 ± 13.1	87.0 ± 13.8	85.8 ± 15.1	81.9 ± 11.7
Height (cm)	179.2 ± 6.2	177.7 ± 5.7	175.9 ± 6.3	172.0 ± 7.0	172.5 ± 6.9
Body mass index (kg/m^2)	25.4 ± 3.4	27.1 ± 3.8	28.1 ± 4.0	28.9 ± 4.8	27.5 ± 3.3

Data are mean ± SD.

covers an area of 19 947 km^2. It has 2 880 000 inhabitants (100 % Caucasian). The project of the study was approved by the Bioethics Committee at the University School of Physical Education, Wroclaw, Poland.

We sent invitations to participate in the investigation to 900 adult men living in Lower Silesia. They were randomly selected by the Local Data Bank (Regional Statistical Office). As an operator the personal identification number was used. From the target group, 372 subjects (43 %) submitted their written consents and were enrolled for the study.

The subjects aged from 24 to 72 years. They underwent a standard medical interview and a full physical examination. About 43 % of subjects had university degree. According to the medical interviews 21 % had arterial hypertension, 19 % chronic low back pain, 5 % benign prostate hyperplasia and 4 % diabetes. The anthropological characteristics of the studied men are shown in Tables 1 and 2. Subjects distinguished upon the level of physical activity did not differ as to age, height, weight and body mass index (BMI).

Physical activity of the studied subjects was determined by means of the Polish version of the International Physical Activity Questionnaire (IPAQ, short form, last 7-day recall). IPAQ is commonly used as a comparable and standardized self-report measure of habitual physical activity of populations from different sociocultural contexts. It has been validated in healthy adults from 12 countries (Craig *et al.* 2003). The questionnaire was also compared against doubly labeled water what implicated that it may underestimate energy expenditure at higher levels of physical activity (Maddison *et al.* 2007). In the continuous scale the amount of physical exercise was counted as multiples of resting metabolic rate by minutes of performance during a week (METs-minute/week). In our study group we adapted the criteria presented by the IPAQ scientific committee [http://www.ipaq.ki.se/]. According to above classification persons who moved at least 12 500 steps a day or the equivalent in moderate or vigorous activities were highly active. They had at least an hour more moderate-intensity activity over and above the basal level of activity or half an hour of vigorous-intensity activity over and above basal levels daily (basal is 5 000 steps/day). Subjects who did not fulfill above criteria were assigned to the subgroup of low physical activity.

Hormone measurements

Radioimmunoassay kits were used for measurements of total testosterone (TT), free testosterone and estradiol (Diagnostic Products Corporation, USA). The intra- and interassay coefficients of variation (CV) were 5.5 % and 5.9 % for total testosterone, 3.2 % and 8.5 % for free testosterone, 3.1 % and 4.5 % for estradiol.

Table 3. Multiple regression models for estradiol, total testosterone, bioavailabe testosterone, SHBG, free testosterone and calculated free testosterone with statistically significant regresses.

Parameters	**Estradiol**			**Total testosterone**			**Bioavailable testosterone**		
Independent variables	B	SE	P<	B	SE	P<	B	SE	P<
Intercept	83.36	5.68	**0.0001**	21.80	1.13	**0.0001**	12.66	0.95	**0.0001**
Age	–0.52	0.12	**0.001**	–0.10	0.023	**0.001**	–0.093	0.019	**0.001**
Low physical activity and age	–0.5	0.16	**0.0002**	NS	NS	NS	NS	NS	NS
Adjusted R^2		0.21			0.28			0.23	
P<		**0.0001**			**0.0001**			**0.001**	

Parameters	**SHBG**			**Free Testosterone**			**Calculated Free Testosterone**		
Independent variables	B	SE	P<	B	SE	P<	B	SE	P<
Intercept	25.16	3.02	**0.0001**	73.51	4.37	**0.001**	0.54	0.04	**0.0001**
Age	0.25	0.19	**0.001**	–0.62	0.06	**0.001**	–0.004	0.0082	**0.0001**
Low physical activity and age	NS	NS	NS	NS	NS	NS	NS	NS	NS
Adjusted R^2		0.19			0.16			0.23	
P<		**0.001**			**0.001**			**0.001**	

B – regression coefficient, SE – standard error

SHBG was measured using immunoradiometric assay-IRMA kits (Immunotech, Czech Republic). The intra- and interassay CV were 3.8 and 7.0 %.

The concentrations of bioavailable testosterone and calculated free testosterone were assessed with a calculator developed at the Hormonology Department, University Hospital of Ghent, Belgium (details on the calculation are available on the website: http://www.issam.ch/freetesto.htm).

Statistical methods

Models evaluating concentrations of hormones in groups of different physical activity levels and age were built using least squares multiple linear ridge stepwise regression. The statistical significance of models was tested by F-test from one-way ANOVA. The statistical significance of variables was tested using Student t-test. Non-significant variables in the models were eliminated by forward selection. All calculations were performed using statistical package *Statistica* v.6 (Statsoft Inc.).

Results

The multiple regression models for hormonal levels with statistically significant regresses are shown in Table 3. Diagrams of spread and the regression straight line of the concentrations of investigated hormones with age are shown in Figures 1-6.

We have found that concentrations of total testosterone, free testosterone, bioavailable testosterone, calculated free testosterone, SHBG and estradiol were significantly influenced by age. Physical activity did not modify concentrations of androgens in the investigated men. The mean estradiol level in men aged 24-48 years was higher in the subgroup declaring high level of physical activity. Contrary to above, in men >48 years. estradiol was lower in those who were physically active. It is worth to notice that estradiol decreased by approximately 5.2 nmol/l per 10 years in highly active men. In subjects, who declared low level of physical activity, this decrease was insignificant (0.2 nmol/l per 10 years).

Discussion

Previous studies of the Polish population suggested a rather high incidence of sedentary lifestyle and a relatively low level of occupational physical activity (Kaleta *et al.* 2007). In contrast, in our study about 50 % of men declared high level of daily physical activity. Similar outcomes were reported by authors who showed that the amount of physical activity was higher when IPAQ questionnaires were filled by subjects themselves rather than by experienced interviewers (Biernat *et al.* 2008). We have to mention a suggestion that IPAQ may overestimate the level of physical activity (Rzewnicki *et al.* 2003). On the other hand, it is probable that the investigated men were more health-conscious than the average.

Our results are consistent with observations pointing to a decreased production of androgens and increased serum concentration of sex hormone binding globulin in aging men (Gray *et al.* 1991, Kaufman and Vermeulen 2005, Van den Beld *et al.* 1999).

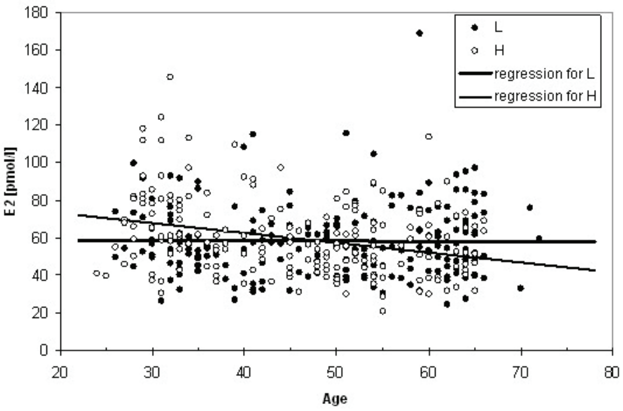

Fig. 1. Concentration of estradiol by age for men with low (L) and high (H) physical activity.

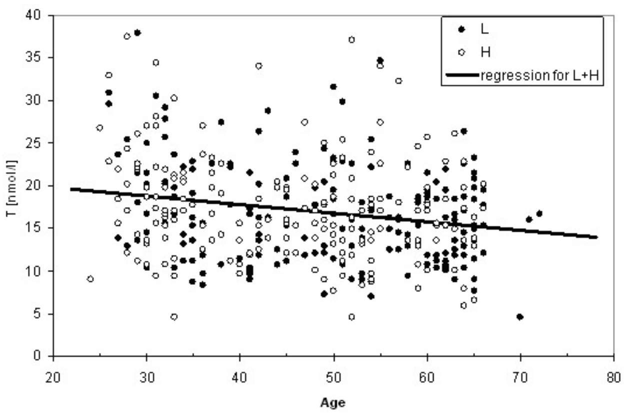

Fig. 2. Concentration of total testosterone by age for men with low (L) and high (H) physical activity.

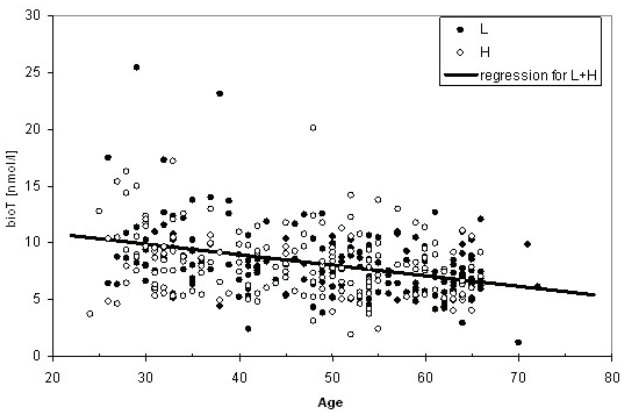

Fig. 3. Concentration of bioavailable testosterone by age for men with low (L) and high (H) physical activity.

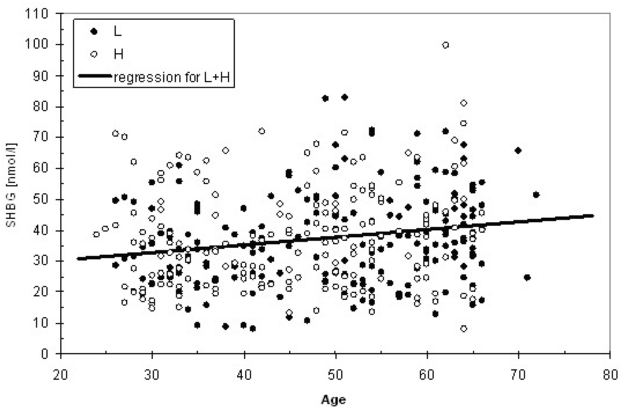

Fig. 4. Concentration of SHBG by age for men with low (L) and high (H) physical activity.

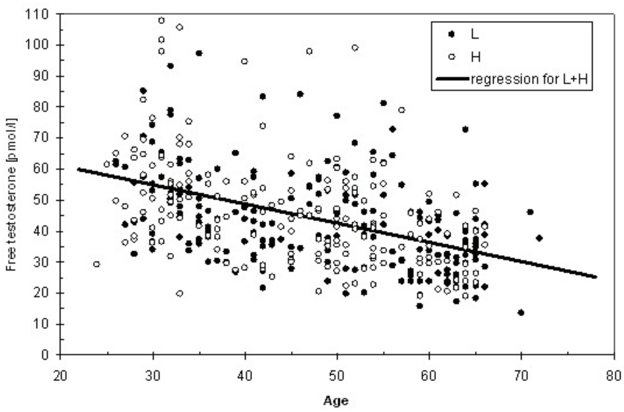

Fig. 5. Concentration of free testosterone by age for men with low (L) and high (H) physical activity.

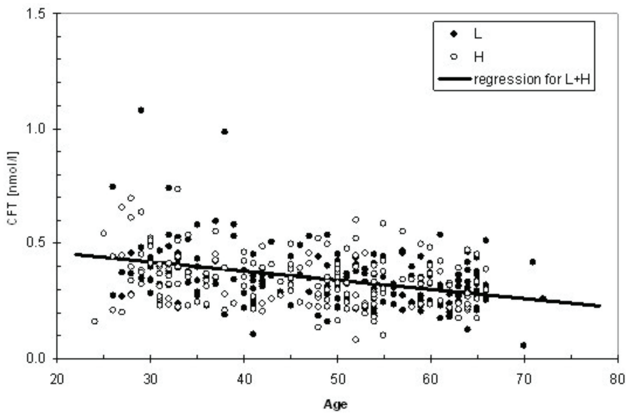

Fig. 6. Concentration of calculated free testosterone by age for men with low (L) and high (H) physical activity.

Influence of age on estradiol concentration is not so clear. Several studies found that the level of total estradiol does not change with age in men (Ferrini and Barret-Connor 1998, Muller *et al.* 2003). Others observed a decrease of estradiol only in the old age (Van den Beld *et al.* 2000). However, in a cross-sectional study of men aged 25-85 years, bioavailable estradiol decreased significantly with age (Khosla *et al.* 1998). Associations between estradiol levels and ERα polymorphisms were suggestive for estrogen-related processes, possibly related to changes in the neuroendocrine regulation of testosterone production in elderly men (Lapauw *et al.* 2008).

In our investigation estradiol was negatively associated with age and its concentration was influenced by physical activity. We have noticed that in men between 24-48 years the estradiol concentration was higher in physically active rather than inactive subjects. At 48 years the mean estradiol concentration was similar in both groups. In men older than 48 years physically active subjects had lower concentration of estradiol.

The age-dependent decline of estradiol was apparent in physically active men. The decrease of estradiol in inactive subjects was statistically insignificant. One may suspect that exercise exacerbates estradiol reduction with age.

It was noticed previously that vigorous physical activity undertaken more than four times per week increased total estradiol concentration more than less frequent vigorous exercise. According to Shiels *et al.* (2009) such results question the opinion that those, who engage in vigorous physical activity, tend to have lower body fat, and thus should have lower estradiol production by adipocytes given the same testosterone level.

We have no explanation for a steeper estradiol decline with age in active subjects and a higher concentration of estradiol in young, physically active men. We underline the fact that there were no differences in body weight and BMI between subgroups distinguished upon physical activity level. This finding can be a result of differences in the aromatase activity, as the physiological balance between sex steroid hormones is largely controlled by the aromatase cytochrome P-450 (Conley and Hinshelwood 2001).

Studies performed in rats proved that single-time physical effort evokes an increase of the skeletal muscle aromatase cytochrome P-450 activity in male animals. On the contrary, a decrease of the aromatase activity was observed in female rats subjected to the same stimulation. After an intensive effort, the estradiol concentration increased in tissues obtained from the male rats, whereas the testosterone concentration increased in the female subjects (Aizawa *et al.* 2008).

Associations between physical activity and concentrations of androgens are not fully elucidated. In our sample physical activity did not modify age-dependent changes of total testosterone, free testosterone, bioavailable testosterone, calculated free testosterone and SHBG in men aged 24-72 years.

Some authors reported positive associations between physical activity and androgen levels. An exercise-induced testosterone increase was found to be smaller in the elderly (Swerdloff and Wang 1993). Allen *et al.* (2002) reported that vigorous exercise lasting three or more hours per week was positively associated with testosterone and SHBG, but not with free testosterone. Muller *et al.* (2003) suggested that an increase in total testosterone, bioavailable testosterone and SHBG appears in the highly active group.

On the other hand, several studies did not reveal any associations between physical activity and androgens (Ponholzer *et al.* 2005, Svartberg *et al.* 2003, Ukkola *et al.* 2001, Shiels *et al.* 2009). We also reported a lack of association between androgen status and physical activity in men aged 45-58 years. There were no significant differences of total testosterone, free testosterone, dehydroepiandrosterone sulphate and estradiol concentrations between physically active (1.0-1.5 h of exercise twice a week, for about 10 years prior to the examination) and physically inactive middle-aged men (Medras *et al.* 2005).

It has also been suggested that low testosterone concentration reduces the level of physical activity (Van den Beld *et al.* 2000). An individually defined low level of androgens may be the cause of decreased physical activity.

Conclusions

Total testosterone, free testosterone, bioavailable testosterone, calculated free testosterone and estradiol decreases with age, inversely to the concentration of SHBG. The level of physical activity did not influence concentrations of androgens or SHBG. In younger, physically active males (24-48 years) serum estradiol was higher than in less active ones. On the contrary, older males (48-72 years) with higher level of physical activity had lower estradiol levels. Physical effort augmented estradiol decline with age.

Conflict of Interest

There is no conflict of interest.

Acknowledgements

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