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Effect of breath-hold diving (freediving) on serum androgen levels — a preliminary report

Wpływ nurkowania na wstrzymanym oddechu (*freediving*) na stężenia androgenów — doniesienie wstępne

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Abstract

Introduction: Breath-hold diving (freediving) is a discipline that makes considerable demands on sportsmen, which can amount to extreme distress. It is also known that psychological and physical strain affects hormonal milieus. We wanted to assess the impact of a stressful event (such as breath-hold diving) on the androgen status of men.

Material and methods: We evaluated serum gonadotropins and androgen concentrations in four divers before diving, immediately post, and 60 minutes after diving.

Results: We found that neither gonadotropins nor total testosterone, free testosterone, calculated free testosterone or bioavailable testosterone concentrations changed significantly during diving practice.

Conclusions: We conclude that the acute distress associated with breath-hold diving does not impact upon gonadotropins or androgen concentrations. **(Pol J Endocrinol 2012; 63 (5): 381–385)**

Key words: *breath-hold diving, freediving, distress, psychological distress, androgens, testosterone, gonadotropins*

Streszczenie

Wstęp: Nurkowanie na wstrzymanym oddechu (*freediving*) jest dyscypliną sportową, której towarzyszy znaczący stres. Jednocześnie wiadomo, że psychologiczny i fizyczny stres wpływa na stan hormonalny organizmu.

Materiał i metody: Oceniano wpływ stresującej sytuacji (*freediving*) na stężenia gonadotropin i androgenów u czterech nurków przed, bezpośrednio po oraz po 60 minutach od nurkowania.

Wyniki: Nie zaobserwowano znaczących zmian stężeń gonadotropin, testosteronu całkowitego, testosteronu wolnego, kalkulowanego wolnego testostosteronu ani stężenia testosteronu biodostępnego podczas treningu *freediving*.

Wnioski: Silny stres związany z nurkowaniem na wstrzymanym oddechu nie wpływa na stężenia gonadotropin i androgenów we krwi. **(Endokrynol Pol 2012; 63 (5): 381–385)**

Słowa kluczowe*: nurkowanie na wstrzymanym oddechu,* freediving*, stres, stres psychologiczny, androgeny, testosteron, gonadotropiny*

Introduction

Breath-hold diving has a very long tradition in certain parts of the world [1]. As a specific sport, it attracts the attention of scientists as well as athletes [2, 3].

Breath-hold divers are regularly exposed to extreme physiological and psychological distress. It has been reported that 10% of static apnoea competitors are disqualified from international events after encountering acute medical complications (e.g. complete loss of consciousness) [4].

Although it has been shown that distress associated with exercise influences the endocrine status of men [5, 6], the impact of breath-hold diving on the hypothalamo-pituitary-gonadal axis has not been studied until now.

Description of the hormonal background of the distress usually starts with corticotropin releasing hormone (CRH). CRH increases the production of neuropeptides such as: adrenocortioctropin (ACTH), antidiuretic hormone (ADH), vasoactive intestinal peptide (VIP) and beta-endorphins. CRH activates the sympathetic system and stimulates the hypothalamo-pituitary-adrenal axis. CRH and beta-endorphins inhibit GnRH (gonadotropin-releasing hormone) secretion and thus decrease the release of gonadotropins by the pituitary gland. ACTH increases production of cortisol, which has detrimental effects on the testes. Gonadal production of

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testosterone is influenced also by prolactin, interferon gamma, tumour necrosis factor-alpha and natural killers lymphocytes [7, 8]. Intratesticular catecholamines may reduce androgen production through auto- and paracrine interactions [9].

We were interested to see if freediving practices have an impact on blood androgen levels. The presence of such relations could for example affect the fertility of divers in the short or long terms [10].

We assessed serum gonadotropins, androgens, SHBG and albumin during the diving practices of four young freedivers.

Material and methods

The experimental protocol of the present study was approved by an Institutional Review Committee for the use of Human or Animal Subjects and was in compliance with the Declaration of Helsinki for human subjects and the European Communities Council Directive of 24 November 1986 (86/609/EEC).

Our study comprised four men (body mass: 89 ± 10.9 kg, height: 178.8 ± 5.0 cm, age: 31.3 ± 3.1 years) who had trained in breath-hold diving for 3–9 years. The small number of studied subjects is because there are few sportsmen engaged in this extreme discipline. All the participants were healthy and received no drugs prior to or during the experiment. None had participated in unaccustomed strength or endurance training in the previous month. Each of them was informed of the aim of the investigation, to which their written consent was given.

The experiment was conducted in one session and was composed of a deep freedive procedure and the collection of blood samples before, immediately after (three minutes post) and 60 minutes after the freedive. The freedive procedure had the following stages: preparation exercise performed by the divers (which included water habituation and relaxing breathing), maximal depth freedive, and return to the measurement station using a water scooter to avoid muscle work between the freedive and the collection of blood samples. Subject 1 reached a depth of 43 m and the dive lasted 80 s; for the other divers, it was, respectively: 2–28 m/85 s; 3–30 m/80 s; and 4–31 m/58 s.

Blood samples were obtained from the ulnar vein between 7.00 and 9.00 am. The material was transported to the Hormonal Laboratory at the Chair and Dept. of Endocrinology, Diabetology and Isotope Treatment at Wroclaw Medical University. Serum was stored at –20°C until use. Radioimmunoassay kits were used to measure total testosterone (TT) and free testosterone (FT) (Diagnostic Products Corporation, USA). The intra- and interassay coefficients of variation (CV) were 5.5% and 5.9% for total testosterone, and 3.2% and 8.5% for free testosterone. SHBG, FSH and LH were measured using immunoradiometric assay-IRMA kits (Immunotech, Czech Republic). The intra- and interassay CV were 3.8% and 7.0% for SHBG; 5.0% and 3.8% for FSH; 6.7% and 3.7% for LH. Concentrations of calculated free T and bioactive T were counted using a calculator developed at the Hormonology Department, University Hospital of Ghent, Belgium (http://www.issam.ch/freetesto.htm).

Data was gathered and presented using Excel 2007 (Microsoft, USA).

Results

Basal concentration of gonadotropins exceeded the normal range in one of the studied subjects (Subject 2). In this particular case, FSH and LH stayed elevated immediately after diving and after 60 minutes. In Subject 1, LH increased above the upper limit after diving, but was back to normal after 60 minutes. In Subjects 3 and 4, gonadotropins fluctuated within the physiological limits. Changes of gonadotropin concentrations during the protocol are presented in Figures 1–2.

The androgen status of the divers was assessed by four parameters (Fig. 3–6).

We did not find any evident differences when the procedure was screened with TT, FT, calc. FT or bioT.

Discussion

In our opinion, breath-hold diving can be compared to other acute, stressful situations such as combat sports or parachute-jumping [6, 11]. Typical diving practices include staying under water for several minutes, while world records go beyond ten minutes of apnoea at

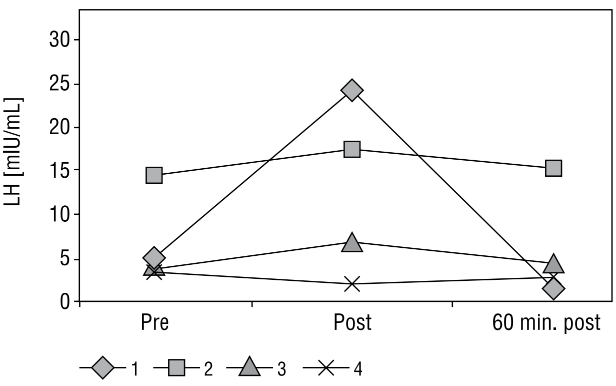

Figure 1. *LH before diving, immediately after diving, and after 60 minutes of rest (Subjects 1–4)*

Rycina 1. *Stężenie LH przed nurkowaniem, bezpośrednio po nurkowaniu i po 60 minutach odpoczynku (przypadki 1.–4.)*

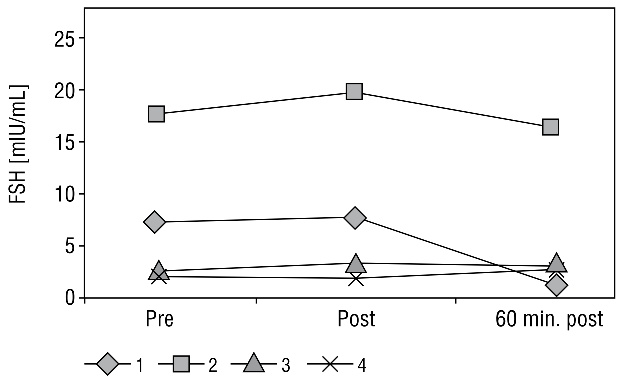

Figure 2. *FSH before diving, immediately after diving, and after 60 minutes of rest (Subjects 1–4)*

Rycina 2. *Stężenie FSH przed nurkowaniem, bezpośrednio po nurkowaniu i po 60 minutach odpoczynku (przypadki 1.–4.)*

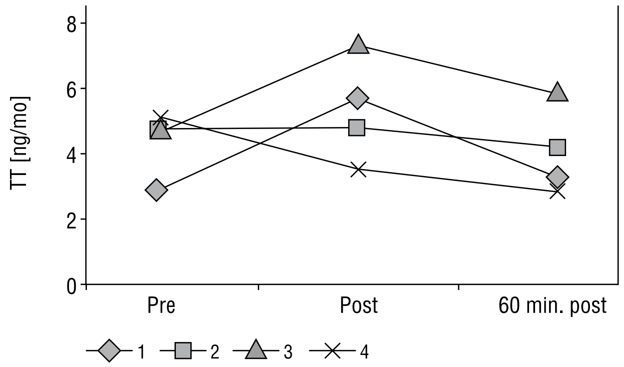

Figure 3. *Total testosterone (TT) before diving, immediately after diving, and after 60 minutes of rest (Subjects 1–4)*

Rycina 3. *Stężenie testosteronu całkowitego (TT) przed nurkowaniem, bezpośrednio po nurkowaniu i po 60 minutach odpoczynku (przypadki 1.–4.)*

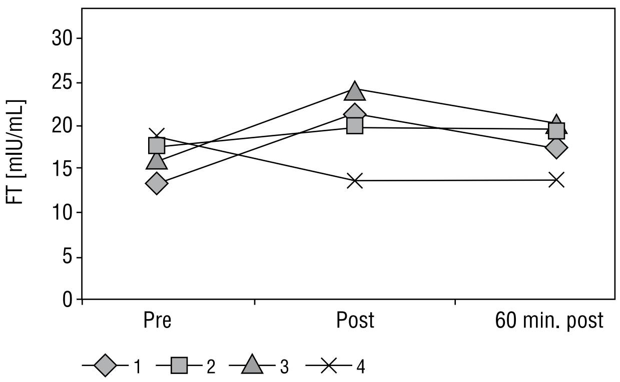

Figure 4. *Free testosterone (FT) before diving, immediately after diving, and after 60 minutes of rest (Subjects 1–4)*

Rycina 4. *Stężenie testosteronu wolnego (FT) przed nurkowaniem, bezpośrednio po nurkowaniu i po 60 minutach odpoczynku (przypadki 1.–4.)*

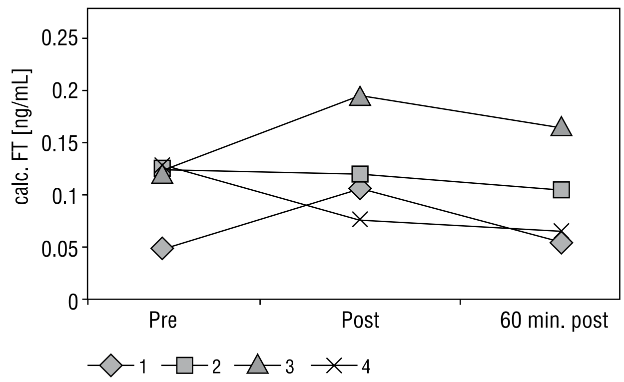

Figure 5. *Calculated free testosterone (calc. FT) before diving, immediately after diving, and after 60 minutes of rest (Subjects 1–4)*

Rycina 5. *Stężenie testosteronu wolnego kalkulowanego (calc. FT) przed nurkowaniem, bezpośrednio po nurkowaniu i po 60 minutach odpoczynku (przypadki 1.–4.)*

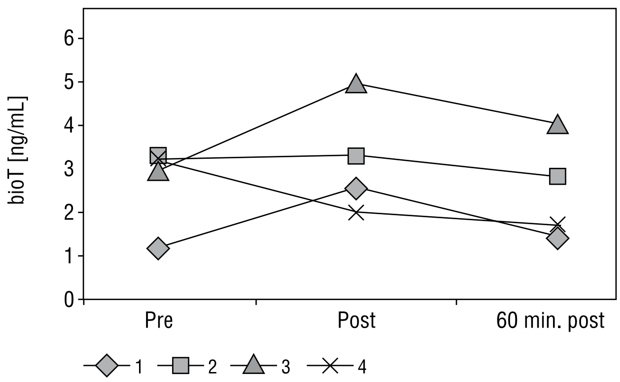

Figure 6. *Bioavailable testosterone (bioT) before diving, immediately after diving, and after 60 minutes of rest (Subjects 1–4)*

Rycina 6. *Stężenie testosteronu biodostępnego (bioT) przed nurkowaniem, bezpośrednio po nurkowaniu i po 60 minutach odpoczynku (przypadki 1.–4.)*

depths exceeding 200 m. The history of diving proves that fatalities and serious health complications in breath-hold divers are not so rare [12, 13].

There is no doubt that psychological and physiological distress impacts upon multiple functions of the human body. However, there is no accepted method of measuring the intensity of short-term distress. Widely used questionnaires enable epidemiological screening, but they are of little use in the evaluation of acute strain [14, 15]. We must agree that the intensity of distress varies depending on the subject and the situation; this makes controlling it difficult.

The assessment of androgen status typically relies on serum testosterone, though there are suggestions that salivary steroid measurements could be an alternative to serum measurements in athletes [16]. It seems that the day-to-day variability of testosterone concentration is negligible [17]. Up to 50% of circulating testosterone is inactive as it is bound to sex hormone-binding globulin (SHBG). Some assays measure free testosterone which makes up about 2–3% of total circulating testosterone. An accurate parameter of androgenocity is bioactive testosterone which measures the free fraction of testosterone and the fraction that is weakly bound to albumin [18]. We decided to evaluate four parameters: total, free, calculated free, and bioactive testosterone.

We have to underline that basal concentrations of androgens were normal in all the investigated divers.

The pattern of hormonal changes during the protocol was similar for TT, FT, calc. FT and bioT. Thus we see no reason to prefer any single parameter (TT, FT, calc. FT or bioT) while assessing the androgen status of divers.

Generally, changes of hormone concentrations in divers during the protocol were unclear and rather modest. In Subjects 1 and 3, we noted an increase of TT and FT immediately after diving and a deterioration of hormone concentrations 60 minutes after the end of the trial (to values above the basal ones). In Subject 2, we observed a very small increase of TT after diving compared to Subjects 1 and 3. Similarly to TT screening, the increase of FT in Subject 2 was small.

After an hour, TT declined in Subjects 1–3, but only in Subject 2 was it below the baseline. In Subject 2, calc. FT was reduced immediately after diving, unlike elevated TT and FT. In Subject 4, there was a clear reduction of TT, FT, calc. FT and bioT in the first phase, with a more prominent decrease 60 minutes post-dive.

After 60 minutes of recovery, levels of LH, FSH, TT, calc. FT, and bioT — but not FT — were lower than at baseline.

Some authors have evaluated hormonal response to psychological distress in men undertaking a jump with a parachute. Parachute-jumpers had decreased salivary testosterone throughout the day of the jump compared to non-jumping controls (from 8.00 am to 4.00 pm). However, serum testosterone level did not differ between jumpers and non-jumpers. It is intriguing that no changes of testosterone during the final four hours before the jump were observed [5].

We should also mention a report showing that staying submersed in thermoneutral water (average diving depth 2.5 m) for 41 h without sleeping caused a lowering of testosterone concentration from 3.5 ± 0.4 to 2.2 ± 0.6 ng/mL [19].

Our results are insufficient to support suggestions that acute psychological and physiological stress (such as during breath-hold diving) leads to reductions of gonadotropins and androgens. Such findings have been reported in previous studies regarding certain types of physical distress, although the change was relatively weak [20–22].

The small number of studied subjects is the major limitation of our observation. This is why we could not perform a structured statistical analysis. We are aware that future investigations must include stricter controls to exclude individual variations in hormonal responses. We also realise that using tools for quantifying acute distress would be valuable.

The inclusion of several different measures of androgen status is the strength of the present study. Thanks to the homogeneity of the studied group, we hypothesise that the diving-related distress was the only factor that influenced the concentration of androgens in the studied men.

It has been suggested that breath-hold divers have, for example, an increased risk of pulmonary hypertension [23]. It would be interesting to know if repeated apnoeas affect also the androgen status of breath-hold divers in a longer observation. In the literature, we have encountered a hypothesis that deep water divers have a low testosterone/gonadotropin ratio which may be associated with having subsequent daughters rather than sons [10].

Conclusion

Acute physiological and psychological distress associated with breath-hold diving does not have a significant effect on male androgenic function.

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