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Studies on the relationship between thyroid hormones and some trace elements in the blood serum of Iranian fat-tailed sheep

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ABSTRACT

This research was conducted to determine the correlation between selenium, copper, zinc, manganese, and triiodothyronine (T_3), thyroxine (T_4), free triiodothyronine (fT_3) and free thyroxine (fT_4). Blood samples were collected from 56 clinically healthy, non-pregnant ewes in 3 different times over 45 days. Serum T_4, T_3, fT_4 and fT_3 were measured by the RIA method and selenium, copper, zinc and manganese by atomic absorption spectrophotometer. Comparing the values of the trace elements and thyroid hormones from 3 samplings showed that there was no significant difference in any of the above mentioned parameters. There were significant positive correlations between fT_3 and zinc ($P<0.05$, $r = 0.41$), fT_3 and manganese ($P<0.05$, $r = 0.49$) and copper and T_3 ($P<0.01$, $r = 0.27$). There was a significant negative correlation between manganese and T_3 ($P<0.01$, $r = -0.30$). There were no significant correlations between other biochemical parameters.

Key words: thyroid hormones, copper, zinc, selenium, manganese, Iranian fat-tailed sheep

Introduction

Among the domestic animals, thyroid function and its diseases are well known in companion animals but less so in livestock. Advances in thyroid physiology and the pathogenesis of its disease, as well as continued development and refinement of methods of testing thyroid function, have added impetus to the study of thyroid diseases in all animals (KANEKO, 1989). Normal thyroid status is dependent on the presence of many trace elements for both the synthesis and metabolism of thyroid hormones. Iodine is most important as a component of the hormones, thyroxine and 3, 5, 3'-triiodothyronine

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(T_3). Selenium is another trace element that is essential for normal thyroid hormone metabolism (AURTHOR et al., 1992). Selenium is required for conversion of thyroxine (T_4) into the more active triiodothyronine (T_3) via the enzyme type 4 deiodinase (AWADEH et al., 1998). Additionally, selenoperoxidases and thioredoxin reductase protect the thyroid gland from peroxides produced during the synthesis of hormones (AURTHOR and BECKETT 1999; AURTHOR et al., 1992). However there are some other trace elements such as iron, zinc and copper, though their role in the thyroid are less well defined but sub-or super optimal dietary intake of all these elements can adversely affect thyroid hormone metabolism (AURTHOR and BECKETT, 1999). Interrelationships among copper and iodine and thyroid hormones were studied in rats by AURTHOR OLIVER (1975), ESIPENKO and MARSAKOVA (1990) and AURTHOR et al. (1996). PFEIFFER and BRAVERMAN (1982) revealed a significant negative correlation between zinc concentration of erythrocytes and serum thyroid hormones. Similar results were achieved by KECECI and KESKIN (2002) in healthy male Merino lambs and Angora goats. Iranian fat-tailed sheep are reared under the climatic conditions of Iran. The physiological importance of the fat tail is to provide energy during drought seasons and conditions of feed deprivation, which are not uncommon under the climatic conditions in Iran. The aim of the present study is to determine whether there is any correlation between selenium, copper, zinc, manganese and thyroid hormones (T_3, T_4, fT_3 and fT_4) in Iranian fat-tailed sheep.

Materials and methods

Blood samples were collected from the jugular vein of 56 non-pregnant Iranian fat-tailed ewes at three different times over 45 days. All the animals were clinically healthy and free from internal and external parasites.

For the analysis of serum copper, zinc, manganese and selenium, blood samples were collected into plain vacutainers and the serum was separated following centrifugation for 15 min at 750 g. Any haemolysed samples were discarded. Serum samples were stored at -20 ºC until analyzed for copper, zinc, manganese and selenium by atomic absorption spectrophotometry (Shimadzo AA-670, Kyoto, Japan). Serum T_4, T_3, fT_3 and fT_4 was measured by radioimmunoassay kits at the Namazi Research Center, Shiraz, Iran. The areas of validation for T3, T4, fT3 and fT4 assays included limits of detection, and precision in the standard curve following sample dilution, inter- and intra- assay coefficients of variation results were considered.

The data were expressed in SI units and analyzed by one-way ANOVA and Pearson correlation analysis using SPSS/PC software, and Duncan's multiple range tests was used to detect significant differences between the means. All values were expressed as mean and standard error (SE), and ($P<0.05$) were seen as statistically significant.

Results

The mean and standard error (SE) of some trace elements and thyroid hormones of non-pregnant Iranian fat-tailed sheep are presented in Table 1 and 2. Comparing the values of the trace elements and thyroid hormones from the 3 samplings showed that there was no significant difference in any of the above mentioned parameters.

Table 1. The mean ± SE of some trace elements of non-pregnant Iranian fat-tailed sheep

Parameter, times of sampling	N° of sheep	Copper (µmol/L)	Zinc (µmol/L)	Selenium (µmol/L)	Manganese (µmol/L)
1	56	21.50 ± 1.88	17.28 ± 1.53	0.12 ± 0.01	2.73 ± 0.18
2	56	19.93 ± 1.09	26.62 ± 2.98	0.17 ± 0.02	4.91 ± 0.03
3	56	17.89 ± 0.94	17.44 ± 1.53	0.14 ± 0.01	3.45 ± 0.03
Total	168	19.78 ± 0.78	20.50 ± 1.07	0.14 ± 0.01	3.82 ± 0.18

Table 2. The mean ± SE of some thyroid hormones of non-pregnant Iranian fat-tailed sheep

Parameter, times of sampling	N° of sheep	Thyroxine (T_4) (nmol/L)	Triiodothyroxine (T_3) (nmol/L)	fT_4 (pmol/L)	fT_3 (pmol/L)
1	56	91.60 ± 2.95	2.58 ± 0.09	19.53 ± 0.90	4.89 ± 0.21
2	56	87.08 ± 3.17	1.84 ± 0.08	20.58 ± 0.99	4.46 ± 0.24
3	56	86.07 ± 2.90	1.98 ± 0.09	20.62 ± 0.56	4.68 ± 0.24
Total	168	88.25 ± 1.74	2.13 ± 0.07	20.24 ± 0.47	4.68 ± 0.14

The results of the present study revealed a significant positive correlation between fT_3 and zinc ($P<0.05$, $r = 0.41$), fT_3 and manganese ($P<0.05$, $r = 0.49$), copper and T_3 ($P<0.01$, $r = 0.27$). A positive correlation was determined between manganese and zinc ($P<0.01$, $r = 0.32$). In contrast, a negative correlation was established between manganese and T_3 ($P<0.01$, $r =-0.30$). There were significant positive correlation between T_3 and T_4 ($P<0.05$, $r = 0.48$), fT_3 and fT_4 ($P<0.05$, $r = 0.26$) fT_3 and T_3 ($P<0.05$, $r =0.34$). There were no significant correlations between other biochemical parameters.

Discussion

The results of the present study indicated a significant positive correlation between the serum concentration of copper and T_3 ($P<0.01$, $r = 0.27$). This finding is supported by the studies of ESIPENKO and MARSAKOVA (1990). The results of their experiment in copper deficient rats demonstrated a decrease in the value of iodine metabolism in different organs and tissues excluding the liver where a sharp increase in the content of organic iodine was observed. In addition their results indicated that copper deficiency can exert both a direct effect on the metabolic process and an indirect one disturbing iodine metabolism, and sharply decreasing protein-bound iodine production by the thyroid gland. These results agreed with those of AURTHOR OLIVER (1975) who studied the interrelationship between athyroetic and copper deficient states in rats. They revealed that copper deficiency enhances the effect of hypothyroidism. The results of another study showed that copper deficiency has only a slight effect on thyroid hormone metabolism in growing rats. Moreover copper deficiency enhances the effects of hypothyroidism (AURTHOR et al., 1996). Although changes in the concentration of serum thyroid hormones in copper-deficient animals, also after the administration of copper supplemented rations, have been investigated earlier, there is no published information about the correlation between concentrations of serum copper and thyroid hormones in clinically healthy Iranian fat-tailed sheep. The results of this study show that there is a weak positive correlation between the serum concentration of copper and fT_3 in this breed of sheep, but more work is required. Based on the results of the present study a positive significant correlation was observed between serum concentrations of zinc and fT_3 ($P<0.05$, $r = 0.41$). In contrast to our results, KECECI and KESKIN (2002) reported a slight decrease in the level of serum thyroxine (T_4) and triiodothyronine (T_3) after the administration of zinc supplemented rations in healthy male Merino lambs and Angora goats.

PFEIFFER and BRAVERMAN (1982) stated that the zinc concentration of erythrocytes in hyperthyroidism patients was lower than in the control group. Therefore, they revealed a significant negative correlation between zinc concentrations of erythrocytes and serum thyroid hormones (T_3 and T_4). The results of PFEIFFER and BRAVERMAN (1982) illustrated that after the treatment of hyperthyroidism, the serum levels of T_4 and T_3 returned to the normal range. Again there is no published information about the correlation between the serum level of zinc and thyroid hormones in clinically healthy Iranian fat-tailed sheep, so that the results of this research can be a base for further research in future. These results of the present study illustrated no significant correlation between serum levels of thyroid hormones and selenium. These results disagree with the reports of AURTHOR et al. (1992) who indicated selenium deficiency impairs thyroid hormone metabolism by inhibiting synthesis and activity of the iodothyronine deiodinases, which convert thyroxine (T_4) to the more metabolically active 3,5,3'- triiodothyronine (T_3). They proved that type I iodothyronine 5′- deiodinase is a selenoenzyme. Moreover, in rats concurrent selenium and iodine deficiency produce a greater increase in thyroid weight and plasma thyrotropin than iodine deficiency alone (AURTHOR et al., 1992). Similar results were obtained by DONALD et al. (1993). They studied the effect of selenium and iodine supplementation on the serum level of T_3 and T_4 in selenium deficient sheep. The results of this study indicated that control ewes had lower circulating triiodothyronine (T_3) and higher thyroxine (T_4) concentrations than selenium supplemented ewes; similar trends occurred in their lambs at birth. In addition, they stated supplementary iodine increased thyroid hormone concentrations but reduced T_3 values in lambs (DONALD et al., 1993). These findings were supported by the studies of NAZIROGLU et al. (1998). They proved that levels of T_3 were slightly increased and also of T_4 and the ratio of T_4/T_3 were slightly decreased when vitamin E and selenium were supplemented. However, WICHTEL et al. (1996) showed that the plasma concentration of total thyroxine was increased ($P<0.001$) by selenium treatment. The plasma concentration of total triiodothyronine was reduced ($P<0.001$) by iodine treatment but unaffected by selenium treatment. These results disagree with the findings of BIK (2003), who determined the effect of selenium and iodine oral supplements on the concentration of T_3 and T_4 in the serum of sheep. The results indicated that simultaneous treatment with selenium and iodine stimulated the metabolism of the two hormones by increasing their synthesis and concentrations in the serum. Moreover a significant positive correlation between the concentrations of selenium and triiodothyronine ($P<0.05$, $r = 0.667$) and selenium and thyroxine ($P<0.05$, $r = 0.737$) suggests a synergism between the latter. As already mentioned supplementary selenium have some effect on the serum concentration of thyroid hormones in selenium-deficient animals but less information is available concerning the relationship between the serum level of selenium and thyroid hormones in clinically healthy animals.

The results of the present study revealed no significant correlation between selenium and thyroid hormones in the serum of Iranian fat-tailed sheep. It is important to note that only when selenium levels decreased by more than 80%, was deiodinase activity markedly decreased (BATES et al., 2000). BATES et al. (2000) stated that, with the exception of liver, skin and non-pregnant uterus, all the tissues studied (including cerebrum, thyroid, pituitary, brown adipose tissue, ovary, testes and placenta) maintained substantial deiodinase activity (>50%) during prolonged selenium deficiency. Although the ability of a tissue to maintain deiodinase activity in the face of dietary selenium deprivation was associated in some tissues with a concomitant local preservation of selenium concentration, this was not the case for all tissues. The question of how selenium levels are maintained in specific tissues, whether selenium is sequestered in specific cells of a tissue or organ during dietary selenium deprivation, and the precise mechanism by which plasma T_3 levels are maintained in selenium deficient animals, remain unanswered. Further insights may be gained by using diets that are even lower in selenium than those used here and/or by conducing studies using radioactive forms of selenium and thyroid hormones (BATES et al., 2000).

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SAŽETAK

Istražen je odnos selena, bakra, cinka i mangana prema trijodtironinu (T3), tiroksinu (T4), slobodnom trijodtironinu (sT3) i slobodnom tiroksinu (sT4). Uzorci krvi bili su prikupljeni od 56 klinički zdravih, negravidnih ovaca u tri navrata tijekom 45 dana. Serumski T4, T3, sT4 i sT3 bili su određeni postupkom RIA, a selen, bakar, cink i mangan atomskim apsorpcijskim spektrofotometrom. Usporedba vrijednosti elemenata u tragovima i tiroidnih hormona kod tri uzorkovanja pokazala je da nije bilo značajne razlike u bilo kojem od navedenih pokazatelja. Ustanovljena je jaka pozitivna korelacija između sT3 i cinka ($P<0,05$, $r = 0,41$), sT3 i mangana ($P<0,05$, $r = 0,49$) te bakra i T3 ($P<0,01$, $r = 0,27$). Također je ustanovljena značajna negativna korelacija između mangana i T3 ($P<0,01$, $r = -0,30$). Nije ustanovljena značajna korelacija među drugim biokemijskim pokazateljima.

Ključne riječi: tiroidni hormoni, bakar, cink, selen, mangan, iranska mesnata ovca