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Changes in body weight, hematology and serum chemistry in captive plains viscachas *(Lagostomus maximus)* with presumptive diabetes type II after a diet change

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Summary

We report body weights (BW) and blood and serum analyses for 6 fully mature and 8 not-yet-mature captive plains viscachas before and 3, 6 and 9 months after switching from a low-fiber, high-energy diet to a high-fiber, low-energy diet. Initially, body weights, serum glucose, fructosamine and cholesterol levels were above the reference range in the fully mature animals. Furthermore, 4 of these animals had bilateral cataracts. After the diet change, these parameters dropped into the reference range. However, 9 months later, a slightly increased BW became evident again. The findings are consistent with a type II diabetes mellitus and underline the importance of dietary prevention.

Keywords: hematology, blood chemistry, diabetes, cataract, rodent

Veränderungen nach Futterumstellung in Körpergewicht, Hämatologie und Serologie bei Flachland-Viscachas *(Lagostomus maximus)* in Menschenobhut mit vermutetem Typ II Diabetes

Es wird über Veränderungen in Körpergewicht (KG), Hämatologie und Serologie bei 6 voll ausgewachsenen und 8 noch nicht ausgewachsenen Viscachas, vor – und 3, 6, und 9 Monate nach – einem Futterwechsel von einer faserarmen, energiereichen – auf eine faserreiche, energiearme Futterration berichtet. Zuerst lagen bei den adulten Tieren das Körpergewicht (KG) sowie die Serumwerte von Glucose, Fructosamin und Cholesterolwerten oberhalb des Referenzbereiches; zusätzlich zeigten 4 dieser Tiere bilateral Katarakte. Nach der Futterumstellung sanken diese Parameter in die Referenzbereiche. Neun Monate später allerdings stieg das KG wieder leicht an. Die Befunde deuten auf einen Typ II Diabetes hin und unterstreichen die Bedeutung einer diätetischen Prävention.

Schlüsselwörter: Hämatologie, Serologie, Diabetes, Katarakt, Nager

Introduction

The plains viscacha *(Lagostomus maximus)* is a social rodent that inhabits the pampas grasslands of Paraguay, Bolivia, and Argentina. Despite its comparatively large size (for a rodent) and its attractive fur coloration, it is rarely kept in zoological gardens (ISIS, 2001). These animals have been kept and bred successfully at Zurich Zoo since 1964 (Rübel et al., 1989). A comparatively frequent clinical occurrence of bilateral cataracts, glucosuria, and elevations in glucose, cholesterol and fructosamine levels, as well as necropsy findings of fatty livers, led to the suspicion that – like some other rodents (Besselmann and Hatt, 2004), the plains viscacha might be particularly prone to diet-induced diabetes. However, it was only until blood reference values, in particular for fructosamine, for free-ranging viscachas were established (Wenker et al., 2007), that an actual clinical diagnosis based on serum chemistry became possible. The purpose of this study was to investigate blood analytes in a group of captive plains viscachas with presumptive diabetes type II from the Zurich Zoo in comparison with the data of free-ranging animals, and to observe levels from repeated blood samples after a diet change.

Animals, Material and Methods

Animals and husbandry

Fourteen plains viscachas were available for this study. The animals were classified into mature individuals (older than 1 year of age, exact birth data and age were not available) and not-yet-matured individuals (up to 1 year of age). The mature viscachas comprised 4 males and 2 females (total 6), the not-yet-matured viscachas comprised 2 animals that had just reached maturity (male and female), 2 subadult females, and 4 juveniles (male and 3 females). They were weighed and bled four times: before the diet change (0), and 3, 6 and 9 months after. The viscachas were housed indoors at two different loca-

Table 1: Body weights of the viscachas (Lagostomus maximus) used in this study before (0) and 3, 6, and 9 months after the diet change.

Animal No. (sex)	Cataract?	Stage	Body mass (g)*			
			0	3	6	9
1 (m)	yes	adult, matured	9050	7600	6400	6650
2 (m)	yes	adult, matured	8700	7600	6800	7450
3 (m)	no	adult, matured	7500	6550	6500	7600
4 (m)	yes	adult, matured	6300	5900	5850	6600
5 (f)	yes	adult, matured	4900	4100	3950	3800
6 (f)	no	adult, matured	4200	4200	3600	3950
7 (m)	no	adult, just-matured	4000	4000	4300	4500
8 (f)	no	adult, just-matured	3400	3300	3650	3400
9 (f)	no	subadult	2900	2680	2700	2800
10 (f)	no	subadult	2500	2650	3100	2850
11 (m)	no	juvenile	1600	1800	2200	2500
12 (f)	no	juvenile	1500	1700	2100	2400
13 (f)	no	juvenile	1400	1500	1700	1900
14 (f)	no	juvenile	1300	1600	2000	2100
Mean 1–6			6775^{a}	5992^{a}	5517^{b}	6008^{ab}
SD			±1989	±1567	±1388	±1702
Mean 7–14			2325^{a}	2404^{a}	2719^{b}	2806^{b}
SD			±1031	±911	±904	±828

different superscripts within a row indicate significant differences between the time periods; for all time periods, the difference between the two groups (animals 1–6 vs. animals 7–14) was significant
* reference body weights for free ranging viscachas from Wenker et al. (2007) are, for males 4600 (range 2900-6600) g and for females 3100 (range 1800-4200) g

Table 2: Red and white blood cell count of captive plains viscachas (Lagostomus maximus) as compared to the reference range established for free-ranging individuals before (0) and 3, 6, and 9 months after the diet change.

Parameter	Reference range	Fully mature adults (n=6)			
		0	3	6	9
Hematocrit (%)	34–42	39^{aA} ±4	34^{b} ±3	34^{b} ±3	38^{aA} ±3
RBC (10^6/µl)	4.44–5.64	4.79^{ab} ±0.46	4.34^{ac} ±0.42	4.33^{cA} ±0.36	4.81^{b} ±0.40
WBC (10^3/µl)	8.2–17.8	18.0^{A} ±6.6	25.5 ±16.0	23.7 ±20.2	30.5 ±28.0
Neutrophils (/µl)	6384–13667	8332 ±2405	8801 ±2912	8537 ±3365	9485 ±2110
Monocytes (/µl)	196–865	1712^{A} ±1362	1215^{A} ±656	1669^{A} ±1187	959^{A} ±485
Lymphocytes (/µl)	532–4049	7449 ±4245	14876 ±15518	13142 ±16210	19734 ±26462

different small superscripts (abc) within a row indicate significant differences between the time periods in a group; different captial superscripts (AB) indicate significant differences between the two groups

tions, with the 6 adults in one and all the other animals in the other group. The animals were kept in indoor enclosures of 23.9 m^2 and 20.1 m^2 for the mature and the other animals, respectively. Enclosures had a concrete floor covered with gravel and sand, and were furnished with artificial rocks containing artificial burrows as well as artificial hollow logs, offering the animals a variety of opportunities to hide, climb, and dig.

Feeding

Study animals were fed as a group, not individually. Drinking water was available at all times. The diets used were recorded and analyzed for proximate nutrients (Naumann and Bassler, 1988) in the course of a dissertation project (Besselmann, 2005). The original diet consisted of apples, carrots, bread, a commercial mineral/vitamin supplement (Multiforsa M21, Multiforsa AG, 6312 Steinhausen, Switzerland), and rye grass hay and local browse branches ad libitum; however, the apples, carrots and bread alone were provided in amounts theoretically large enough to meet the animals' estimated energy requirements without any additional hay intake. This ration, the intake of which was not actually determined, contained, calculated without intake of additional hay or branches, in dry matter: 9.0% crude protein, 5.2% crude fiber, 1.0% ether extracts, 3.9% crude ash and 80.8% nitrogen-free extracts. After the diet change, the diet consisted of a 1:1 rye grass hay and straw mixture, a mineral/vitamin supplement (Multiforsa M21, Multiforsa AG, 6312 Steinhausen, Switzerland) and a pelleted feed based on alpine meadow hay (PRE ALPIN Lepo, Agrobs GmbH, 82541 Degerndorf, Germany). The actual intake of this diet was measured during three days. It contained, in dry matter (DM): 7.5% crude protein, 39.2% crude fiber, 1.7% ether extracts, 5.6% crude ash and 46.1% nitrogen-free extracts. Using data on nutrient content, data on nutrient digestibility measured in viscachas on a mixed diet from Besselmann (2005), and the factorial estimation of digestible energy (DE) for rabbits from Kamphues et al. (2004), DE content of the first ration was estimated at 12.5 MJ/kg DM, and of the second ration at 10.3 MJ/kg DM.

Blood sampling

At each sampling interval, the animals were anaesthetized by mask induction and maintenance with isoflurane in oxygen. They were weighed, and a complete physical and ophthalmologic examination was performed. Blood samples taken from the medial branch of the saphenous vein were subject to complete hematology counts and serum chemistry profiles following the standard procedures outlined in Wenker et al. (2007) for the samples analyzed at the Clinical Laboratory of the University of Zurich in Switzerland.

Statistical analysis

For each group, a repeated measurements-ANOVA, with subsequent Tukey-Kramer post hoc tests, was used to compare the time points. Furthermore, for each time point, a t-test was used to compare the two groups. Statistical analyses were carried out using Instat 3.0 (GraphPad Software Inc.) and SPSS 12.0 (SPSS Inc., Chicago, IL), respectively. The significance level was set to 0.05.

Results

Matured adults were significantly heavier than growing and recently-matured animals, and before the diet change had almost consistently higher body weights than the reference range for free-ranging animals of the same sex (Tab. 1). Whereas the body weights of the two female animals dropped and remained within the reference range after the diet change, the drop in body weight after the diet change was only temporary in the males; the latter all gained weight again between months 6 and 9, again mostly exceeding the reference range for free-ranging animals. By contrast, juveniles, subadults and recently-

Parameter	Reference range	Juveniles and subadults (n=8)			
		0	3	6	9
Hematocrit (%)	34–42	33^{abB} ±3	32^{a} ±2	35^{b} ±3	34^{abB} ±3
RBC (106/µl)	4.44–5.64	4.53 ±0.50	4.28 ±0.27	4.73^{B} ±0.32	4.57 ±0.38
WBC (103/µl)	8.2–17.8	11.6^{B} ±3.4	12.0 ±2.0	13.1 ±3.5	13.5 ±1.9
Neutrophils (/µl)	6384–13667	6159 ±2538	6659 ±1741	6385 ±1780	7330 ±1635
Monocytes (/µl)	196–865	237^{B} ±180	454^{B} ±213	302^{B} ±181	316^{B} ±159
Lymphocytes (/µl)	532–4049	4974 ±2048	4694 ±1663	6132 ±3245	5670 ±1776

matured adults gained weight more-or-less consistently throughout the experiment, and were always within the body weight reference range. Opthtalmologic examination revealed that 4 of the 6 adults had bilateral cataracts. The blood cell count for the group of younger animals was within the reference ranges, but the fully matured group had high counts of white blood cells, monocytes, and particularly lymphocytes (Tab. 2). Although there was substantial variation between individuals in this group, most individuals had values well above the reference ranges for these parameters.

Whereas the younger group had serum glucose and fructosamine levels consistently within the reference range, the fully matured group had levels above the reference range before the diet change (above reference range for fructosamine for all animals, and for glucose for all but one individual; Tab. 3). These individuals were therefore considered to fall within the diabetic condition range. In this group, glucose values fell within the reference range directly after the diet change, as did the average fructosamine value. For 4 animals of this group, however, the fructosamine value, though decreasing already at 3 months, dropped into the reference range only at 9 months after the diet change. For the younger group, cholesterol levels were always within the reference range, but values for fully matured animals exceeded the reference range before the diet change. In the latter case, cholesterol only fell within the reference range 6 months after the diet change.

Blood urea nitrogen values for most individuals were below the reference range throughout the study. The same was observed for total protein levels for the younger group. In both groups, amylase levels, which were actually below the reference range in the younger group before the diet change, increased after the diet change to a level similar to the mean measured in free-ranging animals. Glutamate dehydrogenase (GLDH) was within the reference range in the fully mature group, but lower in the younger group. In both groups, GLDH levels increased above the reference range after the diet change, only dropping back within the referene range 9 months after the diet change. In the younger group, aspartate-aminotransferase (ASAT) and alanine-aminotransfersase (ALAT) decreased over time. Lactate dehydrogenase (LDH) decreased in both groups over time.

Discussion

The viscachas of this study were separated into two groups, distinguishing animals that were still growing or had just completed their growth from animals that had been on the original diet not only during growth but also during their adult life. In contrast to growing animals, fully matured animals had body weights and serum glucose, fructosamine and cholesterol levels above the reference range, and 4 out of 6 had bilateral cataracts. The findings are consistent with type II diabetes mellitus (T2DM).

Table 3: Serum biochemistry in captive plains viscachas (Lagostomus maximus) as compared to the reference range established for free-ranging individuals before (0) and 3, 6, and 9 months after the diet change.

Parameter	Reference range	Fully mature adults (n=6)			
		0	3	6	9
Glucose (mmol/L)	4.7–11.2	14.2^{aA} ±3.7	9.0^{b} ±0.9	8.2^{b} ±0.7	9.1^{b} ±1.5
Fructosamine (µmol/L)	161–297	348^{aA} ±34	281^{b} ±33	281^{b} ±39	278^{b} ±13
BUN (mmol/L)	10.1–23.7	9.4^{a} ±2.0	3.8^{bA} ±0.5	4.1^{b} ±0.9	7.2^{c} ±2.1
Creatinine (µmol/L)	94–219	139^{a} ±21	179^{bA} ±32	171^{bcA} ±22	154^{ac} ±25
Total Protein (g/L)	61–77	69^{A} ±5	68^{A} ±7	64^{A} ±9	69^{A} ±6
Cholesterol (mmol/L)	0.5–2.1	3.2^{aA} ±1.4	2.3^{abA} ±0.9	1.4^{b} ±0.6	2.0^{abA} ±0.2
Triglycerides (mmol/L)	0.2–2.4	1.2^{A} ±0.6	1.2^{A} ±0.3	0.8 ±0.1	1.2^{A} ±0.3
Alkaline Phosphatase (IU/L)	20–316	31^{A} ±6	70 ±31	64 ±57	33 ±13
Amylase (IU/L)	377–5091	673^{aA} ±142	531^{aA} ±130	1373^{bA} ±224	1345^{bA} ±262
Glutamate Dehydrogenase (IU/L)	17.3–39.0	15.4^{A} ±6.8	57.3 ±42.0	50.1 ±40.2	36.7 ±19.3
Aspartate aminotransferase (IU/L)	86–215	74^{A} ±29	92 ±29	65 ±15	65 ±7
Alanine aminotransferase (IU/L)	29–62	42^{a} ±25	33^{ab} ±13	18^{b} ±5	22^{ab} ±7
Creatine Kinase (IU/L)	4620–48600	4343 ±4135	2736 ±1407	2312 ±1246	2080 ±1282
γ Glutamyl-transferase (IU/L)	1–3	2 ±1	2 ±1	2 ±1	1 ±1
Lactate Dehydrogenase (IU/L)	801–2530	610^{ab} ±168	621^{a} ±77	375^{bcA} ±153	324^{c} ±117

different small superscripts (abc) within a row indicate significant differences between the time periods in a group; different captial superscripts (AB) indicate significant differences between the two groups

Given reports on diabetes susceptibility in other rodents, including cataract development (Schmidt-Nielsen et al., 1964; Weir, 1974; Shafir and Adler, 1983; Barnett et al., 1994; Kalman et al., 1996; Krugner-Higby et al., 2000) support this hypothesis. As serum glucose values alone are difficult to interpret (possible increase due to the handling stress is likely in wild animals), fructosamine proved to be particularly useful as a reliable long-term indicator for hyperglycemia, reflecting glycemic control during the preceding 2–3 weeks as reported in dogs and cats (Reusch et al., 1993). The fact that parameters associated with T2DM or prolonged hyperglycemia, including body weight, serum glucose, fructosamine and cholesterol, decreased after the diet change is in accord with similar dietary intervention studies in other rodents (Barnett et al., 1994; Bar-On et al., 1999; Walder et al., 2002).

In the group of growing animals such elevated parameters were not found. Based on these four parameters alone, one would suggest that the condition only develops if growth reaches completion and surplus energy is directed towards adipose tissue stores only. However, a closer look at other parameters measured in this study, as explained further down below, suggests that an incipient diabetic state did potentially characterize the juvenile animals on the old diet as well.

In human cases with diabetes mellitus linked to pancreatic tissue damage, elevated serum amylase levels have been reported (Abou-Seif and Youssef, 2004). On the other hand, decreased amylase values have been reported in diabetic humans (Foo et al., 1980; Aughsteen et al., 2005), rats (Mori et al., 2003) and guinea pigs (Balk et al., 1975) and in particular, reduced pancreatic amylase secretion was noted in human juvenile-onset diabetes mellitus (Frier et al., 1976). Therefore, the below-reference range serum amylase activities measured also in our juvenile viscachas could be considered an indication that a diabetic condition was already beginning to manifest itself. Activities of the hepatic enzymes AST and ALT in juveniles also decreased after the diet change, a trend that has been reported to occur in insulin-treated experimental diabetic rats (Mori et al., 2003). Additionally, LDH in both juvenile and adult viscachas showed a similar trend (Tab. 3) to that usually reported for experimetal rats, i.e. to increase in diabetic specimens and decrease with antidiabetic treatment (Stanely et al., 2000; Narendhirakannan et al., 2006). In sum, it seems likely that even juvenile viscachas kept on the old diet were in the initial metabolic stages of T2DM.

Based on findings of the first clinical examinations and blood samples, the diet change resulted in a body weight decrease in the fully matured group but did not appear to compromise growth in the younger group. Concomitant with the drop in serum parameters already discussed, body weight changes could indicate that such a low-energy diet is adequate even for growth in this species, and presents a possible prophylactic measure in these animals. The fact that body weights of the fully matured animals had increased again 9 months after the diet change might

Parameter	Reference range	Juveniles and subadults (n=8)			
		0	3	6	9
Glucose (mmol/L)	4.7–11.2	7.4^{B} ±1.5	8.5 ±1.0	7.4 ±1.3	8.2 ±0.9
Fructosamine (µmol/L)	161–297	276^{aB} ±19	253^{ab} ±26	248^{b} ±33	255^{ab} ±24
BUN (mmol/L)	10.1–23.7	9.4^{a} ±1.3	8.8^{aB} ±1.7	4.0^{b} ±0.9	5.7^{b} ±1.0
Creatinine (µmol/L)	94–219	120^{a} ±21	136^{abB} ±17	144^{bB} ±18	140^{b} ±19
Total Protein (g/L)	61–77	54^{abB} ±5	52^{aB} ±4	$56a^{bB}$ ±3	58^{bB} ±5
Cholesterol (mmol/L)	0.5–2.1	1.0^{B} ±0.2	1.1^{B} ±0.2	1.4 ±0.4	1.1^{B} ±0.2
Triglycerides (mmol/L)	0.2–2.4	0.4^{aB} ±0.1	0.3^{aB} ±0.1	0.7^{b} ±0.3	0.6^{abB} ±0.2
Alkaline Phosphatase (IU/L)	20–316	41^{B} ±8	48 ±11	45 ±19	39 ±9
Amylase (IU/L)	377–5091	195^{aB} ±123	249^{aB} ±62	937^{bB} ±184	707^{cB} ±204
Glutamate Dehydrogenase (IU/L)	17.3–39.0	45.7^{B} ±21.1	45.6 ±21.8	112.4 ±112.2	36.0 ±24.1
Aspartate aminotransferase (IU/L)	86–215	129^{aB} ±34	103^{ab} ±28	78^{bc} ±12	64^{c} ±12
Alanine aminotransferase (IU/L)	29–62	51^{a} ±16	39^{a} ±6	23^{b} ±5	22^{b} ±6
Creatine Kinase (IU/L)	4620–48600	2945 ±2690	2225 ±884	1694 ±1446	3256 ±3803
γ Glutamyl-transferase (IU/L)	1–3	1 ±1	2 ±1	2 ±1	1 ±0
Lactate Dehydrogenase (IU/L)	801–2530	763^{a} ±406	618^{ab} ±179	572^{abB} ±125	411^{b} ±177

indicate that even such a diet should be provided in more restricted amounts, or that components with a higher digestibility should be further reduced. We recommend strictly limited diets for successful long-term control of the reported problem in this species.

Blood urea nitrogen values in this study were lower than those measured in free-ranging animals. For free-ranging animals, it was speculated that capture and handling of the animals, including a potential dehydration, might have led to an increase of BUN levels (Wenker et al., 2007), but differences in dietary protein between captive and free-ranging animals or even renal damage as a consequence of diabetic conditions, could also be implicated. After the diet change, which also represented a decrease in dietary protein concentration, the BUN of both captive viscacha groups dropped temporarily and then increased again. This either reflects a change in the protein content of the roughage used or it could present an adjustment period during which the animals learned to compensate for lower protein levels by increasing total intake. In other rodents, it has been shown that the gastrointestinal tract does adapt to diets of lower nutritional quality within several months, in particular by increasing in both length and volume (Karasov and McWilliams, 2005). However, there are no reports about the time period that animals habituated to a diet high in energy will actually need to adjust to a new diet of lower quality. The development in body weight in the adult animals suggests that such an adaptation might actually occur only much later than would be expected in free-ranging animals that are adapted to seasonal fluctuations in forage quality. For studies on the dietary flexibility of a species, in which captive animals (like animals from zoos) are used, these results indicate that findings based on diet changes need to be evaluated over long time periods.

Wenker et al. (2007) found that free-ranging viscachas have a predominantly neutrophilic white blood cell count. This contrasts with the lymphocyte-dominated white blood cell count of chinchilla. These authors speculated that this difference might represent a stress response in the form of neutrophil release during capture and handling. The captive viscachas in this study show similar absolute neutrophil counts as the free-ranging animals. Captive animals had distinctively higher total leukocyte, monocyte and lymphocyte counts, a trend especially pronounced in the fully matured animals. While different disease processes not further investigated in this study cannot be ruled out, and might be considered likely due to the high variation in these parameters between individuals, this finding is nevertheless striking. This could indicate that animals with a potentially developing or established T2DM are more susceptible to other diseases in general.

One other factor might play a minor additional role in the development of potential T2DM in captive plains viscachas, namely the lack of exercise in comparison to free-ranging animals. In sand rats, is has been demonstrated that physical exercise has a prophylactic effect against T2DM (Heled et al., 2002). While exercise opportunities in the form of running wheels are common practice in husbandry of small laboratory or pet rodents (Brown and Donnelly, 2004; Gebhardt-Henrich et al., 2005), they are hardly ever used in zoological gardens. This might represent a valuable enrichment strategy, the effect and the acceptance of which warrants further investigation. Finally, e.g. in the sand rat, the suceptibility to T2DM has been shown to vary between the genetic lineages within the species (Walder et al., 2000). Although the small sample set of this study does not allow genetic evaluation, hereditary factors might play a role in the proneness to develop T2DM in viscachas as well.

In conclusion, the results of this study suggest that the diet change at Zurich zoo was an important measure to reduce the diabetogenic state in the captive plains viscacha. However, in particular the incipient relapse in body weight in the adult animals raises the question whether this diet change can actually be considered satisfactory in the long run. This will have to be answered in the future by comparison of medical records and necropsy reports from before and after the diet change.

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Modifications, après un changement d'alimentation, du poids, de l'hématologie et de la sérologie chez des viscaches des plaines *(Lagostomus maximus)* détenues en captivité, avec un diabète de type II supposé

On rapporte les modifications du poids, de l'hématologie et de la sérologie chez 6 viscaches ayant terminés

Modifica, sotto controllo, del regime alimentare sul peso corporeo, ematologia e sierologia nella viscaccia comune *(Lagostomus maximus)* con probabile diabete di tipo II

Si presentano qui di seguito le variazioni di peso corporeo, ematologia e sierologia, dopo un cambiamento di regime alimentare, in 6 viscacce adulte e 8 non an-

leur croissance et 8 encore en croissance avant ainsi que 3, 6 et 9 mois après un changement alimentaire passant d'une nourriture pauvre en fibre et riche en énergie à une nourriture riche en fibre et pauvre en énergie. A l'origine, chez les animaux adultes, le poids ainsi que les valeurs sériques de glucose, de fructosamine et de cholestérol étaient supérieures aux valeurs de référence. En outre, 4 de ces animaux présentaient une cataracte bilatérale. Après le changement d'alimentation, ces paramètres sont retournés à la normale. Toutefois, 9 mois plus tard, le poids augmentait à nouveau légèrement. Ces constatations évoquent un diabète de type II et soulignent l'importance d'une prévention diététique.

cora adulte durante 3,6, e 9 mesi le quali sono passate da una razione di alimenti povera di fibre ma ricca di energia ad una ricca di fibre e povera di energia. Dapprima, negli animali adulti, il peso corporeo e i valori sierologici del glucosio, fruttosamina e colesterolo sono rimasti al di sopra dei limiti di referenza e 4 animali mostravano una cataratta bilaterale. Dopo il cambiamento di regime alimentare e sempre in rapporto ai limiti di referenza, questi parametri diminuirono. Tuttavia nove mesi dopo vi si è notato un leggero aumento del peso corporeo. I risultati che indicano un diabete di tipo II sottolineano l'importanza della prevenzione dietetica.

References

Abou-Seif M. A., Youssef A. A.: Evaluation of some biochemical changes in diabetic patients. Clin. Chim. Acta 2004, 346: 161–170.

A*ughsteen A. A., Abu-Umair M. S., Mahmoud S. A.:* Biochemical analysis of serum pancreatic amylase and lipase enzymes in patients with type 1 and type 2 diabetes mellitus. Saudi Med. J. 2005, 26: 73–77.

Balk M. W., Lang C. M., White W. J., Munger B. L.: Exocrine pancreatic dysfunction in guinea pigs with diabetes mellitus. Lab. Invest. 1975, 32: 28–32.

Bar-On H., Den-Sasson R., Ziv E., Arar N., Shafrir E.: Irreversibility of nutritionally induced NIDDM in Psammomys obesus is related to beta-cell apoptosis. Pancreas 1999, 18: 259–265.

B*arnett M., Collier G. R., Zimmet P., O›Dea K.:* The effect of restricting energy intake on diabetes in Psammomys obesus. International Journal of Obesity 1994, 18: 789–794.

Besselmann D., Hatt J. M.: Diabetes mellitus bei Kaninchen und Nagern. Tierärztl. Praxis 2004, 32 K: 370–376.

Besselmann D: Untersuchungen zur Anatomie und Verdauungsphysiologie des Flachland-Viscachas (Lagostomus maximus). Dissertation, University of Zurich, 2005.

Brown C. J., Donnelly T. M.: Rodent husbandry and care. Vet. Clin. N. Am. Exot. Anim. Pract. 2004, 7: 201–225.

Foo Y., Rosalki S. B., Ramdial L., Mikhailidis D., Dandona P.: Serum isoamylase activities in diabetes mellitus. J. Clin. Pathol. 1980, 33: 1102–1105.

Frier B. M., Saunders J. H. B., Wormsley K. G., Bouchier I. A. D.: Exocrine pancreatic function in juvenile-onset diabetes mellitus. Gut 1976, 17: 685–691.

Gebhardt-Henrich S. G., Vonlanthen E. M., Steiger A.: How does the running wheel affect the behaviour and reproduction of golden hamsters kept as pets? Appl. Anim. Behav. Sci. 2005, 95: 199–203.

Heled Y., Shapiro Y., Shani Y., Moran D. S., Langzam L., Braiman L., Sampson S. S., Meyerovitch J.: Physical exercise prevents the development of type 2 diabetes mellitus in Psammomys obesus. Am. J. Physiol. Endocrinol. Metabol. 2002, 282: E370–E375.

ISIS: International Species Information System. Hyperlink. http://www.worldzoo.org/abstract/abs02201.htm. 2001.

Kalman R., Lazrovici G., Baron H., Ziv E.: The sand rat (Psammomys obesus): morphologic, physiologic, and biochemical characteristics of a model for type-II diabetes mellitus. Cont. Topics Lab. Anim. Sci. 1996, 35: 67–70.

Kamphues J., Coenen M., Kienzle E., Pallauf J., Simon O., Zentek J.: Supplemente zu Vorlesungen und Übungen in der Tierernährung, 10. Aufl. M. & H. Shaper, Alfeld-Hannover, 2004.

Karasov W. H., McWilliams S. R.: Digestive constraints in mammalian and avian ecology. In: Physiological and ecological adaptations to feeding in vertebrates. Eds. J. M. Starck and T. Wang, Science Publishers Inc., Plymouth, UK, 2005, 87–112.

Krugner-Higby L., Shadoan M., Carlson C., Gendron A., Cofta P., Marler C., J W.: Type 2 diabetes mellitus, hyperlipidemia, and extremity lesions in California mice (Peromyscus californicus) fed commercial mouse diets. Comp. Med. 2000, 50: 412–418.

Mori D. M., Baviera A. M., Oliveira Ramalho L. T. d., Vendramini R. C., Brunetti I. L., Pepato M. T.: Temporal response patterns of biochemical analytes in experimental diabetes. Biotechnol. Appl. Biochem. 2003, 38: 183–191.

Narendhirakannan R. T., Subramanian S., Kandaswamy M.: Biochemical evaluation of antidiabetogenic properties of some

commonly used Indian plants on streptozotocin-induced diabetes in experimental rats. Clin. Exp. Pharmacol. Physiol. 2006, 33: 1150–1157.

Naumann K., Bassler R.: Handbuch der landwirtschaftlichen Versuchs- und Untersuchungemethodik. III. Die chemische Untersuchung von Futtermitteln. VDLUFA Verlag, Darmstadt, Germany, 1988.

Reusch C., Liehs M. R., Hoyer M., Vochezer R.: Fructosamine. A new parameter for diagnosis and metabolic control in diabetic dogs and cats. J. Vet. Int. Med. 1993, 7:177–182.

Rübel A., Hauser B., Ossent P.: Viscachas (Lagostomus maximus), their biology, husbandry, and diseases at Zurich Zoo. Verh. Ber. Erkr. Zootiere 1989, 31: 51–54.

Schmidt-Nielsen K., Haines H. B., Hackel D. B.: Diabetes mellitus in the sand rat induced by standard laboratory diets. Science 1964, 143: 689–690.

Shafir E., Adler J. H.: Enzymatic and metabolic responses to affluent diet of two diabetes-prone species of spiny mice: Acomys cahirinus and Acomys russatus. Int. J. Biochem. 1983, 15: 1439–1446.

Stanely P., Prince M., Menon V. P.: Hypoglycaemic and other related actions of Tinospora cordifolia roots in alloxan-induced diabetic rats. J. Ethnopharmacol. 2000, 70: 9–15.

Walder K. R., Fahey R. P., Morton G. J., Zimmet P. Z., Collier G. R.: Characterization of obesity phenotypes in Psammomys obesus. Int. J. Exp. Diabetes 2000, 1: 177–184.

Walder K. R., Oakes N., Fahey R. P., Cooney G., Zimmet P. Z., Collier G. R.: Profile of dyslipidemia in Psammomys obesus, an animal model for the metabolic syndrome. Endocr. Regul. 2002, 36: 1–8.

Weir B. J.: The development of diabetes in the tuco-tuco (Ctenomys talarum). Proc. R. Soc. Med. 1974, 67: 843–846.

Wenker C. J., Hunziker D., Lopez J., Opplinger H., Forrer R., Lutz H.: Hematology, blood chemistry, and urine parameters of free-ranging plains viscachas (Lagostomus maximus) in Argentina determined by use of a portable blood analyzer (i-STAT) and conventional laboratory methods. J. Vet. Med. Ser. A 2007, 54: 260–264.

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