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RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Effect of restricted feeding on physiological performance in male Nubian goat kids

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Abstract

This study was designed to investigate the effects of fasting for 4 days, directly after exposing the animals to two levels (30 and 60%) of feed restriction for 6 weeks, on the physiological performance of Nubian goats. Twelve male Nubian goat kids (2-3 months of age) were divided into three equal groups according to the level of feed restriction; A (30% feed restriction), B (60% feed restriction) and C (control, *ad libitum* feed consumption) for 6 weeks. Then, the three groups were exposed to fasting (100% feed restriction) for 4 days, followed by re-feeding for 1 week. During the fasting phase, previous exposure of the animals to the two levels of feed restriction did not exert any significant difference in water intake, body weight and body temperature compared to the feeding *ad libitum*. *Ad libitum* feed consumption and 30% feed-restricted groups showed significant ($P<0.05$) increase in haematocrit (PCV) during the fasting phase compared to 60% feed-restricted group. The previous feed restriction significantly ($P<0.05$) decreased hemoglobin (Hb) concentration during the re-feeding phase compared to the fasting phase. The feed-restricted groups revealed a slight increase in erythrocytes count during the fasting phase. These results indicate that feed restriction prior to starvation periods can enhance the ability of Nubian goats to tolerate the adverse effects of starvation.

Keywords: Goat; feed restriction; fasting; physiological performance; feed deprivation

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Introduction

The amount of water requirement for goats depends on their needs for the maintenance of normal water balance and for satisfactory levels of production. The normal body water content of the goat varies with age, amount of fat in the body and environmental temperatures (Wani, 2010). Goats should be provided unlimited access to fresh and clean water. They are among the most efficient domestic animals in their use of water, approaching the camel in their low rate of water turnover per unit of body weight (Maloiy and Taylor, 1971; Macfarlane and Howard, 1972). A positive relationship between dry matter intake and water intake has been reported (Ahmed and El-Shafei 2001).

Feed restriction reduces nutrient availability for growth and production and modifies the metabolic utilization of energy (Prince et al., 1983). This affects the ratio of the lipid to protein deposition and hence, the body composition (Pond and Mersmann, 1990; Van Milgen et al., 2000). Moreover, feed restriction for a long period has been observed to decrease body weight gains (Ryan et al., 1993; Sahlu et al., 1999).

Feed restriction leads to a reduction in the whole-body oxygen consumption and heat production (Degen and Young, 1980; Kelly et al., 1993). This adaptation to low energy intakes is likely to be important to animal survival during periods of scarce feed supplies (Ekpe et al., 1999). However, the restricted feeding reduces metabolizable

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energy available for protein deposition (Reeds and Fuller, 1983).

Feed restriction significantly reduces Hb concentration, PCV and erythrocytes number (Ali et al., 1984). Packed cell volume has been shown to be sensitive to restricted feed and water intake in ruminants (Szabuniewicz and Clark, 1965; Taneja, 1966). Hematocrit increases linearly with increasing level of offered feed in the restriction phase and decreases in the re-feeding phase in goats (Sahlu et al., 1999).

The ability of animals to survive feed deprivation is of considerable value, especially in the hot dry environment. There are scarce reports on changes in the physiological performance of ruminants during and after short-term feed deprivation. Noteworthy, many animals exhibit adaptive biochemical and physiological responses to the lack of feed. Goats inhabit environments in which food availability fluctuates or encounters with appropriate food items (Wang et al., 2006). Therefore, this study was designed to study physiological adaptations to fasting and starvation in Nubian goats.

Materials and Methods

Location of study

This study was conducted in the Department of Physiology, Faculty of Veterinary Medicine, University of Khartoum (Shambat).

Source and management of experimental animals

Twelve male Nubian goat kids were used in this study. The kids were 2-3 months old with an average body weight of 9.5 Kg. The age was determined by dentition. The animals were kept in closed shed with adequate ventilation to facilitate the dissipation of sensible heat and disposal of water vapour. The housing system was provided with appropriate facilities for feeding and watering. The animals were kept individually in a separate cage. Water intake, body temperature and body weight were measured and blood samples were collected immediately before fasting, after 4 days of fasting and after 1 week of re-feeding (*ad libitum* feed intake).

They were randomly assigned to three experimental groups. Group A (30% feed-restricted) was offered 70% of *ad libtium* consumption, group B (60% feed-restricted) was offered 40% *ad libitum* consumption and group C was considered as control and let to feed *ad libitum* (voluntary intake). The three experimental groups A, B and C were exposed to 100% feed restriction (fasting) for 4 days after 6 weeks of feed restriction regime. The haematological parameters were determined immediately after blood sampling.

Source of water and feed

The animals were fed on alfalfa hay and were offered quantities of feed according to the experimental groups and they had free access to fresh tap water.

Data recording

Before each blood sampling, water intake for each goat was determined using graduated glass cylinder. The kids were weighed to the nearest ±0.5 kg using a traditional balance (Avery, United Kingdom). The temperature of experimental animals was measured at the same time to the nearest ±0.1°C using digital thermometer (ECT-1, china). Blood samples were collected by jugular venipuncture with plastic disposable syringes. Samples of 3ml of blood were collected in clean test tubes with florid oxalate as anticoagulant for haematological studies. The PCV was measured using a microhematocrit centrifuge (Hettich-Germany). Haemoglobin (Hb) concentration was determined by cyano methaemoglobin method as described by Van Kampen and Zijlstra (1961). The total erythrocytes count was performed in an improved Neubauer-haemocytometer (Schlam et al., 1975).

Statistical analysis

The experimental data was statistically analyzed using analysis of variance (ANOVA) model to determine level of significance ($P<0.05$) between different treatments. General Linear Method (GLM) procedure of Statistical Analysis System (SAS, 2000) was used to perform the analysis.

Results

All experimental animal groups showed a significant ($P<0.05$) decrease in water intake during fasting phase compared to pre-fasting and re-feeding phases. Interestingly, there was no significant difference between the three experimental groups during fasting phase (Table 1). Noteworthy, during re-feeding phase the feed-restricted groups showed significantly ($P<0.05$) lower water intake compared to *ad libitum* fed group (Table 1). During fasting phase, the feed restricted groups showed a slight, but not significant decrease in the body weight, while the control group showed a significant ($P<0.05$) decrease compared to pre-fasting phase (Table 1). Moreover, during re-feeding phase, all experimental groups showed a slight increase in body weight compared to fasting phase (Table 1). Although it was not significant, fasting decreased the body temperature (°C) in all experimental groups (Table 1). This decrease is more prominent in 60% feed restricted group compared to other groups.

Group A (30% feed-restricted) showed a significant ($P<0.05$) increase in PCV during fasting

Table 1: Effects of fasting for 4 days and *ad libitum* re-feeding on water intake (l/d), body weight (Kg) and body temperature (°C) in feed-restricted male Nubian goat kids

Parameters	Feed restriction (Pre-starvation)			Fasting			Re-feeding		
	C	A	B	C	A	B	C	A	B
Water intake	2.30±0.31^{a}	1.70±0.21^{b}	1.50±0.29^{b}	0.95±0.40^{c}	0.93±0.15^{c}	0.88±0.10^{c}	2.25±0.31^{a}	1.68±0.21^{b}	1.53±0.29^{b}
Body weight	14.00±1.25^{b}	13.00±0.96^{a}	12.00±2.83^{a}	12.10±1.97^{a}	11.80±1.06^{a}	10.40±2.53^{a}	12.93±1.50^{a}	12.78±1.08^{a}	11.85±2.91^{a}
Body temperature	39.00±0.06^{a}	39.00±0.22^{a}	39.00±0.32^{a}	38.70±0.40^{a}	38.60±0.34^{a}	38.30±0.25^{a}	39.13±0.52^{a}	38.90±0.08^{a}	38.75±0.31^{a}

A: 30% feed restriction; B: 60% feed restriction; C: *ad libitum* feed consumption; ^{abcd}Means in the same row bearing different superscript are significantly different at P<0.05

Table 2: Effects of fasting for 4 days and *ad libitum* re-feeding on hematocrit (PCV, %), hemoglobin concentration (Hb, mg/dl) and red blood cells count (RBCs, ×10^{6}/mm^{3}) in feed-restricted male Nubian goat kids

Parameters	Feed restriction (Pre-starvation)			Fasting			Re-feeding		
	C	A	B	C	A	B	C	A	B
PCV	23.00±1.50^{abc}	25.00±1.73^{abc}	23.00±1.41^{ac}	25.80±1.89^{ab}	26.00±2.45^{b}	23.80±1.50^{ac}	21.25±1.50^{d}	21.00±1.15^{d}	19.50±1.91^{d}
Hb	10.00±0.71^{ad}	11.00±0.55^{ac}	9.60±0.53^{ae}	12.60±0.30^{b}	12.70±0.80^{b}	11.70±0.84^{bc}	9.25±0.29^{de}	9.38±0.63^{de}	7.50±0.91^{f}
RBCs	16.6±1.16^{a}	17.0±1.89^{a}	15.5±2.24^{a}	15.4±3.18^{a}	17.5±0.81^{a}	17.2±0.66^{a}	16.65±1.79^{a}	17.75±1.77^{a}	16.75±1.39^{a}

PCV: Packed Cell Volume; Hb: Haemoglobin concentration; RBCs: Red Blood Cells count; A: 30% feed restriction; B: 60% feed restriction; C: *ad libitum* feed consumption; ^{abcd}Means in the same row bearing different superscript are significantly different at P<0.05.

phase compared to group B (60% feed-restricted) and a slight, but not significant, increase in comparison to the control group (group C). Groups A and B showed a significant (P<0.05) decrease in PCV during re-feeding phase compared to fasting phase (Table 2). However, all experimental groups did not show any significant difference in Hb concentration during fasting phase. During the re-feeding phase group B (60% feed-restricted) showed a significant (P<0.05) decrease in Hb concentration compared to other groups (Table 2). All experimental groups showed a significant (P<0.05) increase in Hb concentration during fasting phase compared to pre-fasting and re-feeding phases (Table 2). Noteworthy, groups A and B showed a significant (P<0.05) decrease in Hb concentration during re-feeding phase compared to fasting and feed restriction (pre-fasting) phases (Table 2). Groups A (30% feed-restricted) and B (60% feed-restricted) showed a slight, but not significant increase, in RBCs count during fasting phase compared to feed restriction phase (Table 2). However, there were no significant differences in RBCs between all experimental groups during fasting phase (Table 2).

Discussion

When deprived of food, animals employ various behavioural, physiological, and structural responses to reduce metabolism, which prolongs the period in which energy reserves can cover metabolism (Tobias et al., 2006). Behavioural responses include a reduction in spontaneous activity and lowering in body temperature, although in later stages of food deprivation in which starvation commences, activity may increase as food-searching is activated (Tobias et al., 2006). Body temperature, serum electrolytes and haematocrit (PCV) have been shown to be sensitive to restricted feed and water intake in ruminants (Rumsey and Bond, 1976).

The different levels of feed restriction (30% and 60%) and *ad libitum* consumption groups showed a significant decrease in water intake during the fasting phase compared to the pre-fasting phase. Owing to the close relationship between food and water intake, it is not surprising that water intake was diminished during fasting. The experience of the animals with the two levels of feed restriction did not exert any significant difference in water intake compared to the feeding *ad libitum* during the fasting phase. Partially, similar results have been reported by several authors (Forbes, 1968; Little and Shaw, 1978; Dahlborn, 1987a), which indicated that feed deprivation in ruminants results in such a marked fall in water consumption. Several explanations have been suggested by Dahlborn and Karlberg (1986) that prandial drinking is abolished during starvation. Furthermore, in small ruminants, lack of food and especially its contents of K impedes Na uptake from the reticulo-rumen causing hyponatraemia and hypo-osmolality (Holtenius and Dahlborn, 1990). This theory is strengthened by experiments in which it was shown that giving goat a saline drink does not improve the Na uptake from the reticulo-rumen during food deprivation (Dahlborn, 1987b). Hyponatraemia forces water to be transported into cells, including the osmo-Na sensitive cells in the hypothalamus, thereby attenuating the urge to drink (Andersson, 1978).

Although it was not significant, the three experimental groups showed a slight decrease in the body weight during the fasting phase. Noteworthy, the exposure of the animals to the two levels of feed restriction did not exert any significant difference in body weight compared to the control group during the

fasting phase. Similar results were reported in feed-deprived meat goats (Kannan et al., 2002), fasted sheep (Fisher et al., 2011) and feed-deprived steers (Galyean et al., 1981).

The three experimental groups showed a slight decrease in body temperature during the fasting phase. Nevertheless, the previous feed restriction did not exert any significant effect. The present result agrees with the finding of Piccione et al. (2002) that fasting in goats and sheep causes a decrease in body temperature. These results suggested that lower metabolic rate tends to conserve body resources during food deprivation; feed restriction results in energy conservation in both the cold and the warm environments (Ekpe et al., 1999). This is obviously related to a decrease in the mean rectal temperature, due to limited heat production (Geiser, 2004).

In the present study, *ad libitum* consumption and 30% feed-restricted groups have shown significant increase in PCV during the fasting phase compared to 60% feed-restricted group. Similarly, Dahlborn and Karlberg (1986) reported a slight increase in the PCV in feed-deprived goats. Nevertheless, other studies did not report any effect on PCV in response to feed deprivation in sheep and goats (Holtenius and Dahlborn, 1990; Kheir and Ahmed, 2008). The reported increase in PCV following reduced water intake in the present study resulted in lower plasma volume, whereas after re-feeding the water intake increased and plasma volume also increased, and consequently the PCV decreased.

All experimental groups have shown a significant increase in the Hb concentration during the fasting phase compared to the pre-fasting and the re-feeding phases. Feed deprivation in small ruminants leads to hyponatraemic hypovolaemia (Dahlborn and Karlberg, 1986). This may lead to hemoconcentration, which results in a relative increase in Hb concentration. In contrast to the current result, Byung and Chong-Sup (1989) reported that feed deprivation causes a reduction in Hb concentration in 72 h fasted goats during last period of feed deprivation. Exposing the animals to the two levels (30 and 60%) of feed restriction significantly decreased the Hb concentration during the re-feeding phase compared to the pre-fasting and the fasting phases. Reduction in Hb concentration in the present study may be related to the decreased PCV.

The feed-restricted groups revealed a slight increase in erythrocytes count during the fasting phase compared to the pre-fasting phase compared to control. Similar results were obtained by Byung and Chong-Sup (1989) who reported that feed deprivation for 72 h caused increase in RBCs count in fasted goats. In addition, Binev et al. (2006) found similar results in 48 h feed-deprived lambs. This slight increase in PCV and RBCs count was most probably related to the dehydration during the fasting phase. Furthermore, it could be assumed that the increase in total RBCs count is a result of an enhanced erythropoiesis (Sapolsky et al., 2000) due to the increased endogenous production of cortisol from the adrenal glands following the stress caused by feed deprivation (Binev et al., 2006).

Conclusion

It is concluded from the present study that fasting for 4 days after feed restriction (30% and 60%) for 6 weeks may not have any adverse effects on body temperature, body weight and RBCs count. Water intake decreased and PCV and Hb concentration increased in the blood in which group???.

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