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Original research

Diurnal rectal temperatures and body weight as homeostatic indices in unilaterally adrenalectomized female Wistar rats

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ABSTRACT

There is growing interest in the investigation of the homeostatic adjustment of the remnant adrenal gland following unilateral adrenalectomy. This adjustment which is characterized by diverse physiological indices is critical to the survival of animals with unilateral adrenalectomy. This work studied the diurnal rectal temperature and body weight changes as physiologic indices for the evaluation of homeostasis in apparently healthy unilaterally adrenalectomized female Wistar rats. A total of twenty Wistar rats comprising ten adults (24 weeks) and ten growers (9 weeks) were used for this study. Each age class was randomly assigned into two groups of five rats each. The rats in one group from each age class were unilaterally adrenalectomized while the rats in the remaining groups were sham-operated (laparotomy only). The rats were weighed just before the surgery and at days 21 and 30 post-surgery. Also, from day 21 post-adrenalectomy, the morning and evening rectal temperatures were measured for 10 consecutive days. Body weight changes and the mean, maximum, minimum and ranges of morning and evening rectal temperatures were recorded. The results showed that after 21 days post-adrenalectomy, diurnal rectal temperature variations remained stable between 34.42±0.09 to 34.65±0.08 for the growers and 34.48±0.13 to 35.45±0.10 for the adults. Both adrenalectomized groups recorded increase in body weight. The increase in body weight of the adult adrenalectomized group occurred more within the first 21 days post-surgery (5.59±0.98 to 9.16±1.90) and stabilized by day 30 post-surgery (9.16±1.90 to 9.64±1.52). For the grower rats also, the unilaterally adrenalectomized rats showed a greater increase in weight gain (76.99±2.87) than their sham counterparts (control) (64.08±5.25) by day 30 post-adrenalectomy, but the difference was not statistically significant ($p>0.05$). We conclude that the result of this study has demonstrated that body weight changes could be a major homeostatic adjustment to unilateral adrenalectomy in rats.

KeyWords: Body weight, diurnal rectal temperature, homeostatic indices, adrenalectomy

INTRODUCTION

Adrenalectomies have been indicated in functional and non-functional tumours of the adrenal glands that show tendencies or confirmations of malignancy (Uludag *et al*., 2020). Patients presented for adrenalectomy must be thoroughly investigated to ascertain if a complete or a unilateral adrenalectomy is required. Complete (bilateral) adrenalectomy is not compatible with life thus bilaterally adrenalectomized patients are placed on lifelong hormone-replacement therapies (Shen *et al.*, 2006). However, unilaterally adrenalectomized individuals can live a normal quality of life because of compensatory changes by the remaining adrenal gland (Fossum, 2013; Citton *et al.*, 2019). Whatever the option recommended, changes would be expected in the physiology, metabolism and homeostasis of the patient. This is due to the unique role the adrenal glands play in these biological processes.

In unilaterally adrenalectomized individuals, homeostatic changes may reflect not only in the endocrinology but also as somatic changes/adaptations. This is because the secretions of the adrenal glands (glucocorticoids, aldosterone and catecholamines) have long been known to be directly or indirectly implicated in the physiologic processes of metabolism and maintenance of homeostasis (Vogt, 1954; De Silva and Wijesiriwardene, 2007). Usually, changes in metabolism, either due to changes in nutritional patterns or in the endocrine system, especially the thyroid and the adrenals, are reflected as changes in the somatic weight of affected individuals (Farhana and Rehman, 2022).

Physiologically normal and homeostatically stable individuals are also able to regulate their body temperatures

within a range considered as normal or clinically acceptable, rather than at fixed points over a 24-hour period (Del Bene, 1990). Body temperatures usually rises and falls within a narrow range in accordance with the ambient temperature and the physiological demand during the day before returning to a 'normal' or resting point in the evenings when these factors have declined (Del Bene, 1990). This ability to thermo-regulate the body within a narrow acceptable range is known as diurnal body temperature variations and is part of the physiologic process of homeostasis in animals (Osilla *et al*., 2022). When an animal is not able to regulate its body temperature, or is unable to maintain it within the acceptable range, it will imply that its homeostatic mechanism has become clinically impaired. Also, hyper- and hypothermias which are upper and lower deviations, respectively, from the physiologically normal range for the species are indications of a disease/disorder.

Thus body weight changes and diurnal rectal temperature fluctuations in animals can be used as physiologic indices for the study or monitoring of metabolism and homeostasis in mammals.

MATERIALS AND METHODS

EXPERIMENTAL ANIMALS AND MANAGEMENT

Twenty female Wistar rats were used for this work. Ten of the rats were aged 24 weeks and ten were aged nine weeks. The 24-week old rats represented mature adults, while the 9-Week old rats represented young growing rats. The rats were acclimatized for one week, fed standard rat feed (Chikun® Finisher, Nigeria) and provided water *ad libitum* all through the duration of the experiment.

UNILATERAL ADRENALECTOMY

The 24 week-old rats and the 9 week-old were both randomly assigned into two groups of 5 rats each. For each age category, group 1 rats were sham operated group (Laparotomy only) while the group 2 rats underwent left unilateral adrenalectomy.

The rats were premedicated using xylazine (VMD, Arendonk-Belgium) (5 mg/kg, IM) and anaesthetized with Ketamine (Ketamine hydrochloride injection USP® Rotexmedica, Germany) at the dose of 35 mg/kg, after 10 minutes. Unilateral adrenalectomy was done using the paracostal approach described by Fossum (2013) but with the adrenal glands removed intact without ligation of the blood vessels. The day of surgery was considered day 0.

All procedures were subject to ethical approval from the Ethic Committee for use of animal for experimental research of the College of Veterinary Medicine, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria (MOUAU/CVM/REC/202302).

BODY WEIGHT AND TEMPERATURE MEASUREMENTS

BODY WEIGHT

The 24-week old rats were each weighed on day 0, just before the unilateral adrenalectomy, on day 21 and day 30 post-surgery, while the 9-week old were weighed on days 0 and 30 only.

RECTAL TEMPERATURE

The rectal temperature of each rat was taken twice daily, morning and evening, 3 weeks post-surgery for 10 consecutive days (day 21-30 post-surgery) using a digital thermometer.

DATA ANALYSIS

The data were presented as mean ± standard error of mean (SEM) and analyzed using descriptive statistics and Student t test. The value of $P<0.05$ was considered significant.

RESULTS

The results of the diurnal rectal temperature variations and body weight changes in 24-week old rats, representing mature adults, and 9-Week old rats, representing young growing rats, were presented in table 1 and Figures I-VII.

RECTAL TEMPERATURE CHANGES

The result of the rectal temperature after 30 days post-adrenalectomy, for both the 24-week old rats and the 9-Week old rats are presented in Table I and Figures I-III.

The result of the mean, maximum, minimum and range of morning and evening rectal temperatures for 24-week old and 9-week old unilaterally (Table 1) showed that there was no significant ($p>0.05$) difference in the means of morning (34.40±0.11) and evening (35.43±0.10) rectal temperatures of the 24-week old unilaterally adrenalectomized rats when compared to the morning (34.48±0.13) and evening (35.45±0.10) rectal temperatures of the sham-operated counterparts. Also, there was no significant ($p>0.05$) difference between the means of morning (34.27±0.08) and evening (34.87±0.08) rectal temperatures of the 9-week old unilaterally adrenalectomized rats and that [morning (34.42±0.09) and evening (34.65±0.08)] of their sham-operated control. Similarly, there was no significant ($p>0.05$) difference in the maximum, minimum and range of morning and evening rectal temperatures between the 24-week old unilaterally adrenalectomized rats and their sham-operated counterparts. There were also no significant ($p>0.05$) differences in the mean, maximum, minimum and range of morning and evening rectal temperatures between the 24-week old unilaterally adrenalectomized rats and the 9-Week old unilaterally adrenalectomized rats.

From Figure I, it can be seen that there were no significant ($p>0.05$) differences in the daily rectal temperature variations between the 24-Week old unilaterally

Table 1: Mean, maximum, minimum and range of morning and evening rectal temperatures for 24-week old and 9-week old unilaterally adrenalectomized female Wistar rats and their sham-operated counterparts.

	M_{AVE}	M_{MAX}	M_{MIN}	M_{RANGE}	E_{AVE}	E_{MAX}	E_{MIN}	E_{RANGE}
SHAM 24	34.48 ± 0.13	36.20	32.60	2.60	35.45 ± 0.10	36.90	33.80	3.10
UNI 24	34.40 ± 0.11	36.10	32.70	3.40	35.43 ± 0.10	37.00	33.60	3.40
SHAM 9	34.42 ± 0.09	35.80	32.60	3.20	34.65 ± 0.08	36.00	33.20	2.80
UNI 9	34.27 ± 0.08	35.30	33.00	2.30	34.87 ± 0.08	36.20	33.60	2.80

There was no significant (p > 0.05) difference between the treatment groups and their respective controls

adrenalectomized rats and their sham counterparts. There were also no significant (p>0.05) differences in the daily rectal temperature variations between the 9-Week old unilaterally adrenalectomized rats and their sham counterparts as seen in Figure II

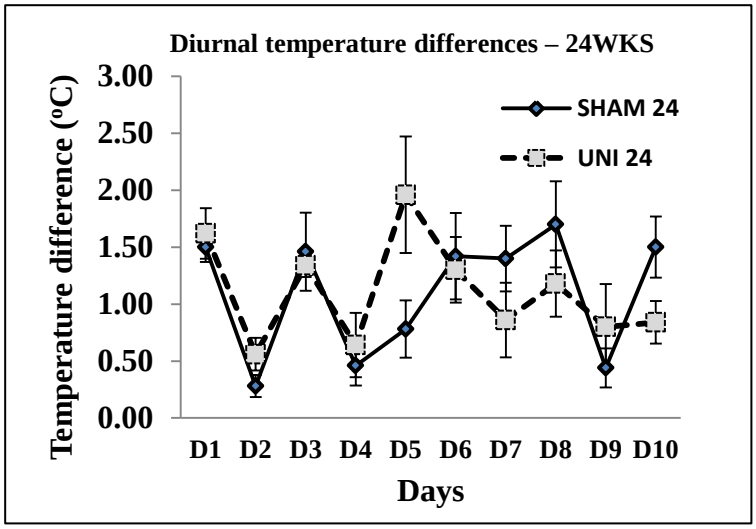

Fig 1: Daily rectal temperature variations between the 24-week old unilaterally adrenalectomized female Wistar rats and their sham counterparts. *There was no significant* (p>0.05) *difference in the daily rectal temperature variations between unilaterally adrenalectomized female Wistar rats and their sham counterparts.*

The result of the comparison of the daily rectal temperature variations for both unilaterally adrenalectomized groups (figure III) showed a significant (p<0.05) difference between the rectal temperatures of both groups at day 3 (0.50±0.13 for growers and 1.34±0.10 for adults) and day 10 (0.36±0.07 for growers and 0.84±0.19 for adults). It can also be observed from figures I–III that despite slight differences in daily values, the pattern or trend in the variations of rectal temperature for all the groups compared were generally similar.

BODY WEIGHT CHANGES

The result of the body weight changes expressed as weight gain after 30 days post-surgery, for both age groups and their controls are presented in figures IV-VII.

The result of weight gain as presented in figure IV showed that there was an increase in the weight gain (3.72%) between the 24-Week old unilaterally adrenalectomized rats and their sham control group. However, this increase was not statistically significant (p>0.05). In figure V, there was also an increase in the weight gain (12.91%) between the 9-Week old unilaterally adrenalectomized rats and their sham control which was also not statistically significant (p>0.05).

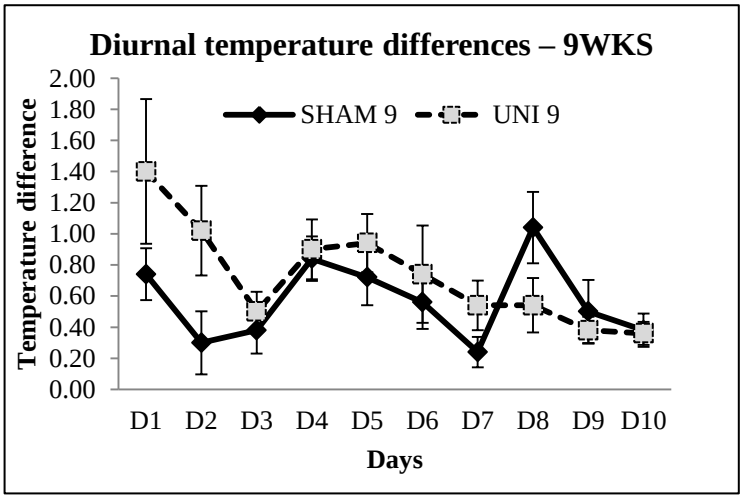

Figure II: Daily rectal temperature variations between the 9-week old unilaterally adrenalectomized female Wistar rats and their sham counterparts. *There was no significant* (p>0.05) *difference in the daily rectal temperature variations between unilaterally adrenalectomized female Wistar rats and their sham counterparts.*

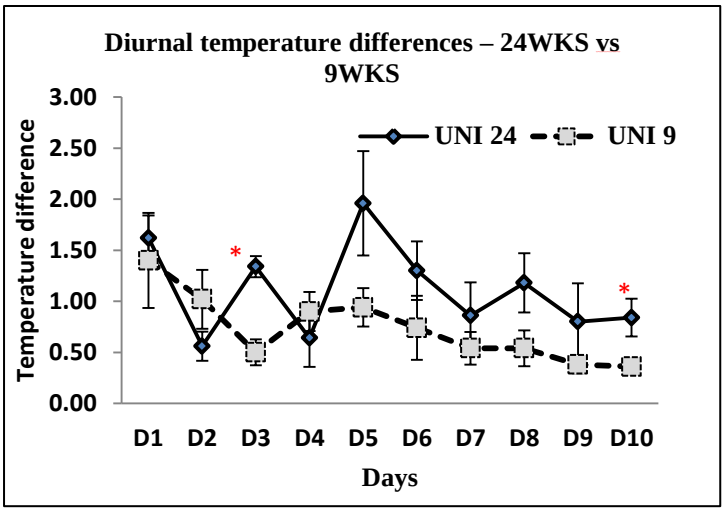

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Figure III: Daily rectal temperature variations between the 24-week old and 9-week old unilaterally adrenalectomized female Wistar rats. *There was a significant ($p < 0.05$) difference in the daily rectal temperature variations at days 3 and 10 between 24-wk and 9-wk old unilaterally adrenalectomized female Wistar rats.*

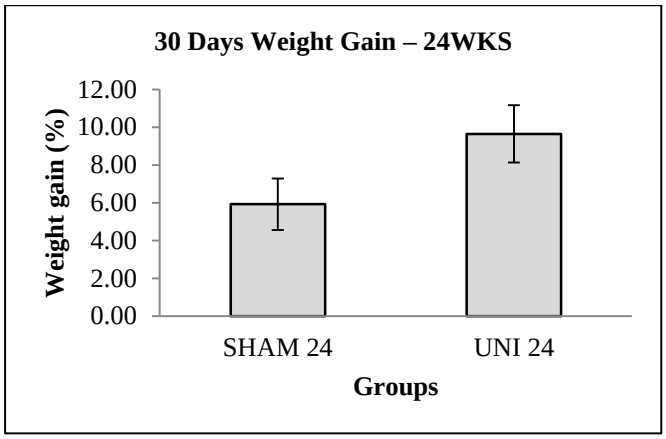
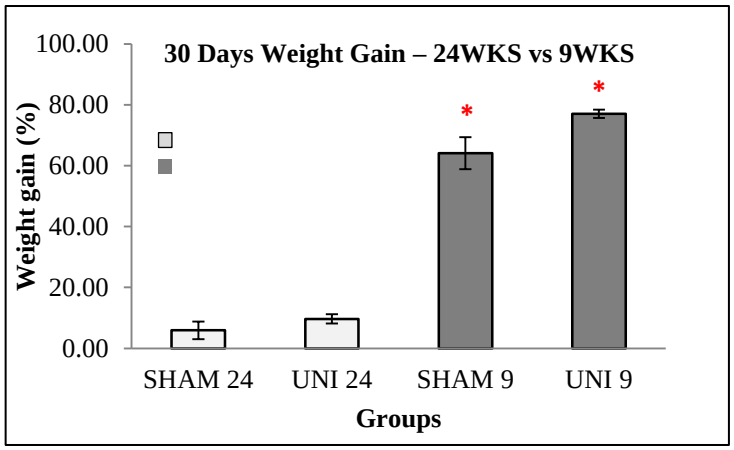


Figure IV: Weight gain for the 24-week old unilaterally adrenalectomized female Wistar rats. *There was no significant ($p>0.05$) difference in weight gain between unilaterally adrenalectomized 24-wk old female Wistar rats and their sham counterparts.*



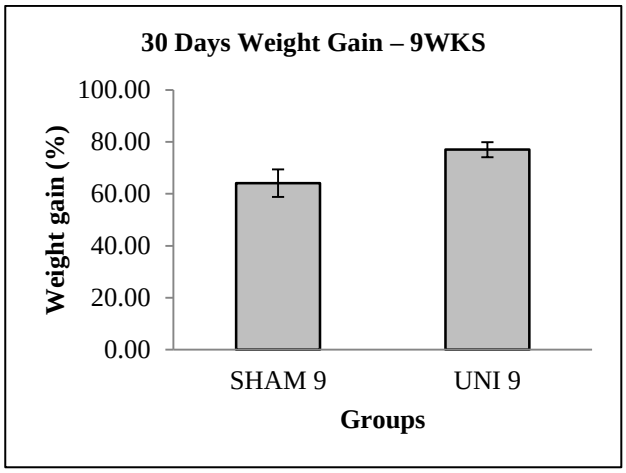


Figure V: Weight gain for the 9-week old unilaterally adrenalectomized female Wistar rats. *There was no significant* ($p>0.05$) *difference in weight gain between unilaterally adrenalectomized 9-wk old female Wistar rats and their sham counterparts.*

Figure VI is the result of the comparison of both unilaterally adrenalectomized groups and showed a significant ($p<0.05$) increase in the weight gain for the unilaterally adrenalectomized 9-week old rats (76.99±2.87) when compared with their 24-week old counterparts (9.64±1.52).

Figure VI: Weight gain for 24-week old and 9-week old unilaterally adrenalectomized female Wistar rats and their sham counterparts. *There was a* significant ($p<0.05$) increase *in the weight gain between 24-wk and 9-wk old unilaterally adrenalectomized female Wistar rats.*

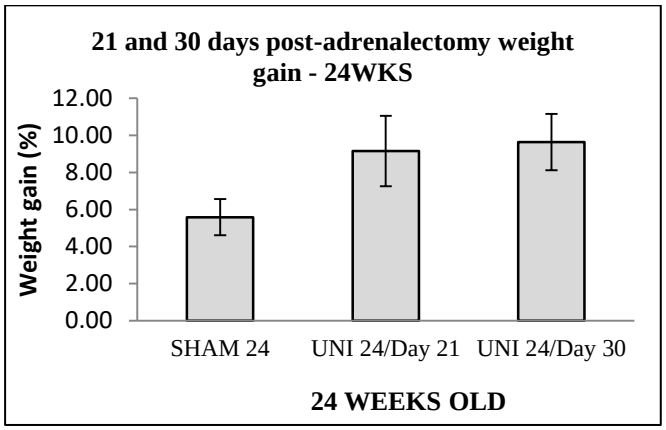


Figure VII: Weight gain for the 24-week old unilaterally adrenalectomized female Wistar rats after 21 days and 30 days post-adrenalectomy. *There was no significant (p>0.05) difference in weight gain between unilaterally adrenalectomized 24-wk old female Wistar rats and their sham counterparts.*

DISCUSSION

This study shows that rectal temperatures changes in unilaterally adrenalectomized adult and young rats were not significantly different from their controls, which indicates that unilateral adrenalectomized rats regardless of age can maintain their body temperature. This represents stability in homeostasis for both adrenalectomized groups. The ability of the body to maintain its temperature within a normal range is an indicator for stable homeostasis (Del Bene, 1990; Osilla *et al*., 2022) similar to what was obtainable in the control groups. Although there were slight differences in the average daily temperatures across the days, the fact that the temperature variations in both adrenalectomized groups of rats generally followed a similar pattern or trend with their respective controls was further indications of homeostatic and metabolic stability.

When the temperature variations are considered holistically, the significant differences ($p<0.05$) between the 24-week old and the 9-week old unilaterally adrenalectomized groups seen at days 3 and 10 (Fig III) may represent incidental occurrences and not deviations from a norm. Thus, temperatures remained stable under this procedure, implying stability in the thermoregulatory physiology of the rats.

The adrenal glands are directly involved in metabolism (Vogt, 1954; De Silva and Wijesiriwardene, 2007). Despite the compensatory adaptations of the intact gland, it would be expected that the metabolic rate of unilaterally adrenalectomized rats will be reduced (Harvard Medical School, 2021). The lowered metabolic rate could be responsible for the increased body weight observed in both unilaterally adrenalectomized groups (Figures IV and V).

Although the increase recorded in body weight for both unilaterally adrenalectomized groups was not statistically significant ($P>0.05$) when compared with their respective controls, these body weight increases occurring in both adrenalectomized groups is still be noteworthy. The differences in the percentage increase in body weight for each experimental age group is significant; 3.72% for 24-weeks and 12.91% for 9-weeks, was statistically significant ($p<0.05$) when compared together (Fig 6). This may be due also to on-going somatic growth in the younger groups of rats compared to their full grown adult rats. This difference in weight gain was also observed between the controls of both age groups. We suggest that somatic growth in young rats is not suppressed by unilateral adrenalectomy and may be the reason why increase in body weight is more evident in young adrenalectomized rats than in adult adrenalectomized rats. Thus, it can be argued that unilateral adrenalectomy increased the tendency for weight gain in the adrenalectomized rats. This propensity to gain weight was highest within the first 21 days post-adrenalectomy in the 24-week old rats. This was obviously the period it took for the animals to recover from the procedure and for the remaining adrenal gland to adapt and compensate (Johns Hopkins medicine, 2022; University of Maryland Medical Centre, 2022).

In conclusion, diurnal rectal temperature variations remained stable 30 days post-surgery in unilaterally adrenalectomized female Wistar rats. Also, the tendency for weight gain following unilateral adrenalectomy in female Wistar rats was highest within the first three weeks after surgery in adult rats and stabilized after 30 days. This shows that both parameters can be used as supportive indices for the monitoring of stability of homeostasis in unilaterally adrenalectomized individuals.

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