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RESEARCH ARTICLE

Effects of Noise Stress on Body Weight and Adrenal Gland Weight of Male Wistar Rats

Ravinder Kr Mehra[1,2]*, Mahesh Prasad[3], Dinesh Kr Sharma[4], Ravinder Kr Mehra[2]

[1]*Department of Pharmacology, School of Pharmacy, Bharat Institute of Technology, Meerut, Uttar Pradesh, India,* [2]*Department of Pharmaceutical Sciences, IFTM University, Moradabad, Uttar Pradesh, India,* [3]*Department of Pharmacology, Kamla Nehru Institute of Management and Technology, Sultanpur, Uttar Pradesh, India,* [4]*Department of Pharmaceutical Sciences, Himalayan Institute of Pharmacy and Research, Uttarakhand, Uttar Pradesh, India.*

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ABSTRACT

The present study was designed to investigate the effects of varying intensities of noise stress onto the body and adrenal gland weight (absolute) of 17 weeks old (291–296) gram (g) Wistar rat. Animals were exposed to varying intensity of noise, i.e., 60 dB (Decibel), 80 dB, 100 dB, 120 dB, and 140 dB for 1 h (h)/day for 30 days. The dose of different noise intensities was delivered through a special fabricated noise chamber which had provided all daily needs of animal-like oxygen, food, and water. Food and water consumption behavior was recorded on 1st, 14th, and 29th days and body weight change recorded on 1st, 15th, and 30th days after the exposure of noise stress. Absolute adrenal glands weight was recorded on the 30th day. The results of the present study showed that the food, water consumption behavior, and body weight (g) of the experimental group EG_1 (60 dB), EG_2 (80 dB), EG_3 (100 dB) EG_4 (120 dB), and EG_5 (140 dB) were found to be significantly ($P < 0.001$) decreased during 1st–14th days and during 15th–30th days a recovery which were observed in food, water consumption, and in body weight of the EG_1 (60 dB), EG_2 (80 dB), and EG_3 (100 dB). A percentage (%) decrease was found, i.e., 0.76, 0.37, 3.87, 25.89, and 30.06% in body weight of EG_1 (60 dB), EG_2 (80 dB), EG_3 (100 dB), EG_4 (120 dB), and EG_5 (140 dB) experimental groups, respectively.

Keywords: Body weight, decibel, noise stress

INTRODUCTION

In the current scenario, human and animal health affected by uncountable stimuli and these stimuli may responsible for the progression of several health issues. At present, we are surrounded by an environment that is filled with uncountable stressors.

Stress can be defined as; it may a kind of physical, chemical, and emotional stimuli to which an individual fails to make a suitable adaptation.[1] Stress is a condition that aggravated by psychological, physiological, or environmental stressors and could insult the homeostasis. It provokes the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system causing in a physiological change.[2] Our surrounding is layered with so many types of stress, from all others, noise stress intentionally (any loud concert) and non-intentionally (occupational) is regarded as the most common stimuli. Noise is regarded to every surplus sound generated by natural phenomena (e.g., wind, volcanic eruption, and oceans) or human-based sources (e.g., automobiles, machines, and explosions).[3,4] and environmental stress that is capable of causing hearing impairment, behavioral, mental, and physiological alterations.[5] Many epidemiological studies established a clear

***Corresponding Author:**
Ravinder Kr Mehra,
E-mail: rxravimehra@gmail.com

connection between noise and vascular diseases including hypertension[6,7] and coronary heart disease.[8,9] Even, constant exposure to high levels of sound, for more than 5 years, may eventually lead noise-induced permanent threshold shift and can lead to elevated stress levels as well as stimulate violent behavior;[10] likewise, explosive noise may produce a massive adverse effect on the human body and mind.[11] Continuous noise stress can severely insult the homeostasis and this may initiate the events of cellular injury if the injury may stay continue due to persistent stress could open the way for several disease pathogenesis.

It has been known that peptic ulcers occurred much more frequently in wartime than in peacetime.[12] The study revealed that due to high levels of noise stress variety of health issues including cardiovascular diseases,[13] mental illness,[14] sleep disorder,[15] immune function,[16] hormonal levels,[17] respiratory systems,[18,19] and hypertension occurred. Furthermore, gastrointestinal motility disorder, gastritis, and peptic ulcers have been noticed in populations[2] because noise acts as a non-specific biological stressor and causes dysfunction of body organs and systems[20] and widespread disturbances at several levels in human organs and apparatus due to chemical and physiological modification of endocrine.[21]

Noise stress of any kind is known to be a stress factor which alters some physiological and behavioral changes in human as well as animals. The present work is designed to study the effect of noise stress on animal body weight and the adrenal gland weight.

MATERIALS AND METHODS

Experimental animals

17 weeks old male Wistar rats weighing around 291–296 g were used for the present study. The research project was initiated after obtaining clearance from the Institutional Animal Ethical Committee of Kamla Nehru Institute of Management and Technology, Sultanpur, Uttar Pradesh, India. All procedures for housing and caring of animals were followed according to the guidelines of the ethical committee. Animals were acclimatized in normal animal house conditions for a week before starting the experimental protocol. Wistar rats were housed in an open wire cage in a temperature-controlled room (22–24°C) and 12 h light-dark cycle with free access to standard laboratory rat chow and tap water. To minimize all undesired stressors, such as handling, and habitat, animals were not exposed to noise for at least 1 week after delivery to the experimental room.

Noise treatment

A rectangular special noise chamber was fabricated to create a noise environment inside by fixing two adjacent speakers with amplifier and a noise meter was set to record and a controller knob was fixed to ensure the delivery of desired sound intensities in dB. A transparent acrylic front was provided to the noise chamber for viewing the activity of animals during experimentation. The chamber had all provisions for water, feed, and aeration. Before starting, the procedure animals were left inside the noise chamber without sound to get accustomed to the interior of the chamber during the acclimatization period.

Study design

Male Wistar rats of 17 weeks old (291–296 g) were included in this study. The animals were divided into five subgroups (n=6) as EG_1, EG_2, EG_3, EG_4, and EG_5 based on noise stress exposure of for 1 h/day for 30 days, respectively. Every five groups were considered a statistical unit in this study in case of investigating effects of noise onto body weight. The time of noise stress exposure (9:00 AM–10: AM) was kept constant for each exposed group throughout the end of the experiment. Noise stress of 60, 80, 100, 120, and 140 dB intensities were delivered for 1 h/day for 30 day through a specially designed noise chamber to EG_1, EG_2, EG_3, EG_4, and EG_5 experimental groups. To avoid age variation between all groups, an unbiased experimental protocol was decided to conduct and total study was conduct in total 150 days (30 days for each group) so, initially EG_1 group was exposed to 60 dB noise stress for

1 h/day for 30 days and then the reaming $EG_{2,}$ $EG_{3,}$ EG_4, and EG_5 groups were separately exposed to noise stress of 80, 100, 120, and 140 dB in 120 days, respectively.

A normal control group was also constructed to evaluate the absolute weight of adrenal glands (g) and for comparing food and water consumption of EG_1, $EG_{2,}$ $EG_{3,}$ EG_4, and EG_5 experimental groups, respectively, whereas in case of evaluating the effect of noise stress on the body weight in EG_1, $EG_{2,}$ $EG_{3,}$ EG4, and EG5 experimental groups, each group was considered a statistical unit and compared with EG_1 (60 dB) group on 1st, 15th, and 30th days.

Water and food intake observation

Consumption of the food and water intake was recorded of the experimental animal group after delivery to the experimental room without access to noise stress and fed a homogeneous chow diet. A per-day analysis was performed to calculate food and water consumption in 1 week. During this acclimatization, per day food and water consumption was recorded. After the 1 week of acclimatization, animals have attained an age of 17 weeks and their average weight was found to be 291–296 g. Exposure to noise stress was started at the age of 17 weeks. On the 0th day, the initial body weight of each animal was recorded and exposure of noise stress started. A per-day analysis of food and water consumption behavior was recorded to evaluate the effect of noise stress onto the same but final interpretation was done with results of 1st, 14th, and 29th days consumption.

Measurement of body weight and adrenals weight

Weight measurement was done on 1st, 15th, and 30th days with the help of an electronic weighing scale of the group under experimentation. Exposure of noise was started on the 1st day after recording the initial body weight. On the 29th day, all animals were deprived of food and had to access only water in their habitat. On the 30th day, after recording the final weight, animals were sacrificed as per the norms of animal ethical committee and collection of adrenal glands was done immediately after ½ h of sacrifice and placed in normal saline. To avoid variations due to circadian rhythm, the sacrifice time was kept constant between 10:30 and 11:30 AM. The fat and connective tissue around the glands capsule were taken away carefully and weighed.

Statistical analysis

The results are presented as MEAN±SEM of all groups. The various parameters were subjected to statistical analysis using GraphPad Prism 5 (version 5.03). Statistical significance was determined by one-way ANOVA followed by Dunnett's multiple comparison test and "*P*" value ($P < 0.05$) being considered statistically significant.

RESULTS

Effect of noise stress on food, water, body weight, and adrenal glands

The body weights of the $EG_{1,}$ EG_2, EG_3, EG_4, and EG_5 rats were checked at the beginning of the experiment no difference between their mean body weights was observed (294.67 g. 293.22 g, 293.50 g, 294.80 g, and 293.82 g in rats). The effect of varying intensities of noise stress for 1 h/30 day onto the body weight of the experimental group is depicted in Table 1 and Graph 1. Data showed [Table 1] that, on 1st day, no significant ($P > 0.05$) mean difference observed in the body weight of $EG_{1,}$ EG_2, EG_3, EG_4, and EG_5 group when exposed to noise stress of 60, 80, 100, 120, and 140 dB, respectively [Graph 1], but after the 1st day exposure of above noise stress a significant ($P < 0.05$) increase in food consumption [Table 2 and Graph 2a] and highly significant ($P < 0.001$) increased in water consumption [Table 2 and Graph 2b] was noted in all the experimental group compared to their normal control group, respectively.

The consumption of food and water was decreased in a highly significant ($P < 0.001$) manner of $EG_{1,}$ EG_2, EG_3, EG_4, and EG_5 groups when compared to their normal control group on 14th day [Table 2 and Graph 2a and b] and also, a highly significant

(*P* < 0.001) reduction was recorded in body weight of EG_3, EG_4, and EG_5 groups but no significant (*P* > 0.05) mean difference was recorded in the weight of EG_1 and EG_2 groups of animals [Table 1 and Graph 1]. A weight gain was observed in EG_1, EG_2, and EG_3 groups of animals and there mean difference was not found statistically significant (*P* < 0.05), whereas a highly significant loss in body weight was recorded in EG_4 and EG_5 groups when compared to EG_1 (60 dB) group on 30^{th} day, respectively [Table 1 and Graph 1]. On the other hand, 29^{th} day a recovered food consumption pattern in EG_1, EG_2, and EG_3 was found and the mean difference of food consumption was not statistically significant, conversely, the food consumption was found to be highly significantly (*P* < 0.001) reduced in EG_4 and EG_5 groups when compared to their normal control group. In contrast, animals of group EG_1 and EG_2 showed a normal water consumption as their water consumption mean value not found significantly different (*P* > 0.05) but EG_3 group showed a significant decrease (*P* < 0.05) and EG_4 and EG_5 group showed a highly significant reduction in water consumption when compared to

Table 1: Effect of noise stress onto the body weight (g) of rats

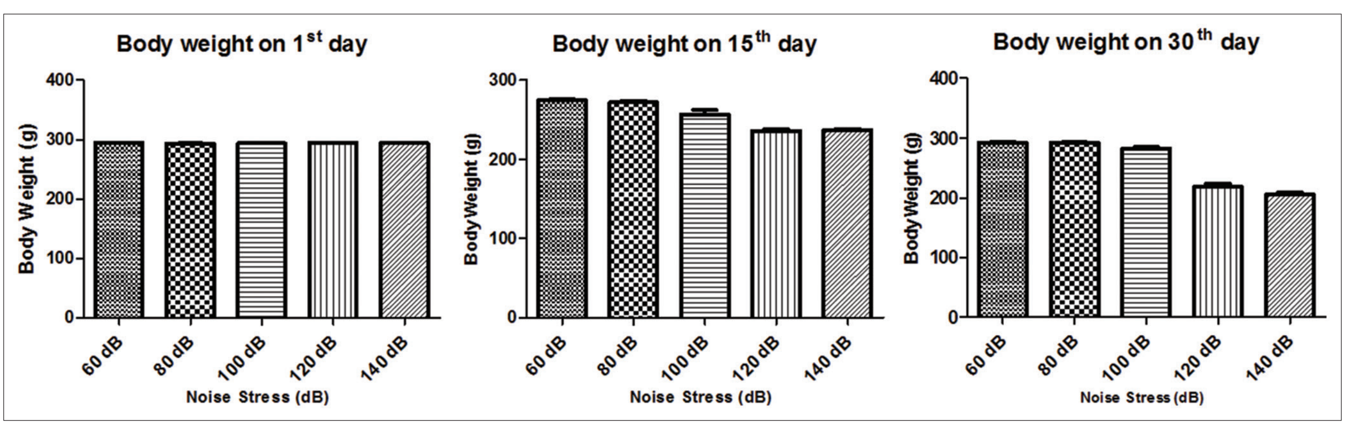
Groups	Noise treatment (1 h/30 days)	Body weight (g)			% decrease in body weight(g) between 0^{th} and 30^{th} day
		1^{st} day	15^{th} day	30^{th} day	
EG_1	60 dB	294.67±0.30	274.98±1.19***	$292.40±1.10^{ns}$	0.76
EG_2	80 dB	293.22±0.46	272.22±1.98***	$292.12±1.20^{ns}$	0.37
EG_3	100 dB	293.50±0.63	256.97±5.51***	$282.13±2.96^{ns}$	3.87
EG_4	120 dB	294.80±0.28	236.00±2.17***	218.47±4.87***	25.89
EG_5	140 dB	293.82±0.68	237.48±0.61***	205.47±3.26***	30.06

The values are expressed in Mean±SEM; (*n*=6). One-way ANOVA followed by Dunnett's post-test; ****P*<0.001 versus 0^{th} days; $^{ns}P>0.05$ versus 0^{th} day

Table 2: Effects of noise stress on the average total food and water consumption on 1^{st}, 14^{th}, and 29^{th} days

Group	Noise stress	Total food consumption (g) on			Total water consumption (mL) on		
		1^{st} day	14^{th} day	29^{th} day	1^{st} day	14^{th} day	29^{th} day
Normal control	-	$128.80^{@}$	$128.50^{\#}$	$129.10^{\$}$	192.5^{a}	193^{b}	192.5^{c}
EG_1	60 dB	$136.30^{@}$*	$65.90^{\#}$***	$110.00^{\$ns}$	219.50^{a}***	152.00^{b}***	$190.00^{c\text{-}ns}$
EG_2	80 dB	$136.10^{@}$*	$67.60^{\#}$***	$102.40^{\$ns}$	218.00^{a}***	151.00^{b}***	$183.00^{c\text{-}ns}$
EG_3	100 dB	$122.00^{@}$*	$54.50^{\#}$***	$80.40^{\$ns}$	223.50^{a}***	140.00^{b}***	$170.50^{c\text{-}}$*
EG_4	120 dB	$125.70^{@}$*	$47.50^{\#}$***	$33.30^{\$}$***	221.50^{a}***	134.00^{b}***	$78.00^{c\text{-}}$***
EG_5	140 dB	$117.30^{@}$*	$33.90^{\#}$***	$18.00^{\$}$***	214.00^{a}***	106.00^{b}***	$59.50^{c\text{-}}$***

The values are expressed in Mean±SEM; (*n*=6). One-way ANOVA followed by Dunnett's post-test; **P*<0.05 versus $^{@}$normal control; *P*<0.001 versus $^{\#}$normal control; $^{ns}P>0.05$ versus $^{\$}$normal control (of food consumption on 1^{st}, 15^{th}, and 30^{th} days), ****P*<0.001 versus ^{a}normal control; ****P*<0.001 versus ^{b}normal control; $^{ns}P>0.05$ versus ^{c}normal control; **P*<0.05 versus ^{c}normal control; $^{***}P<0.001$ versus ^{c}normal control (of water consumption on 1^{st}, 14^{th}, and 29^{th} days)



Graph 1: Effect of noise stress onto the body weight. The values are expressed in Mean±SEM; (*n* = 6). One-way ANOVA followed by Dunnett's post-test; ****P* < 0.001 versus 1^{st} day; $^{ns}P > 0.05$ versus 1^{st} day

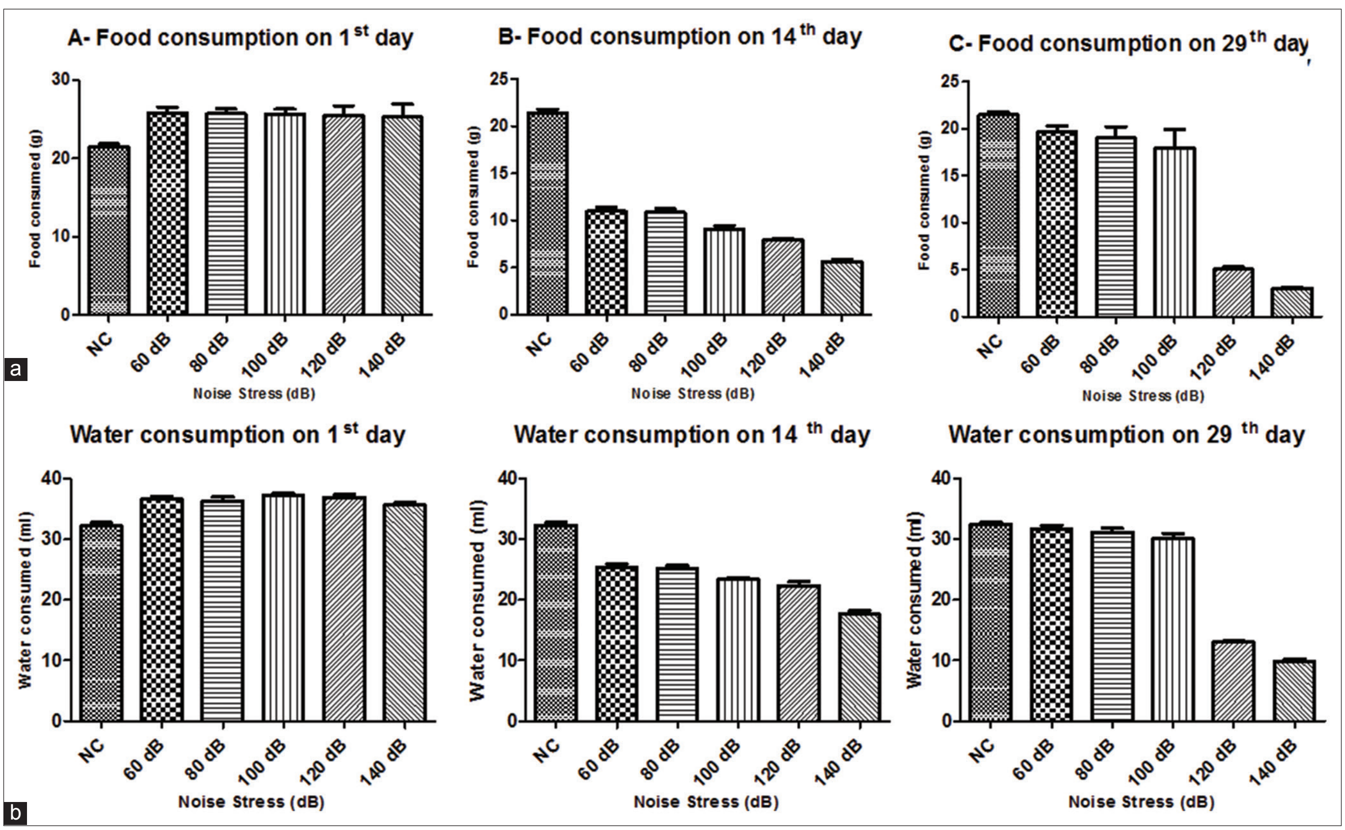
their normal group on 29th day, respectively [Table 2 and Graph 2a and b).

At the end of the study EG_1, EG_2, EG_3, EG_4, and EG_5 group showed a percentage loss in body weight, i.e., 0.76, 0.37, 3.87, 25.89, and 30.06% and in contrast mean absolute weight of adrenal glands [Graph 3] in EG_1, EG_2, EG_3, EG_4, and EG_5 group was increased, i.e., 0.05, 0.05, 0.09, 0.12, and 0.18 g when compared to their normal control group (0.03 g) in the noise stress of 60, 80, 100, 120, and 140 dB for 1 h/day for 30 days, respectively.

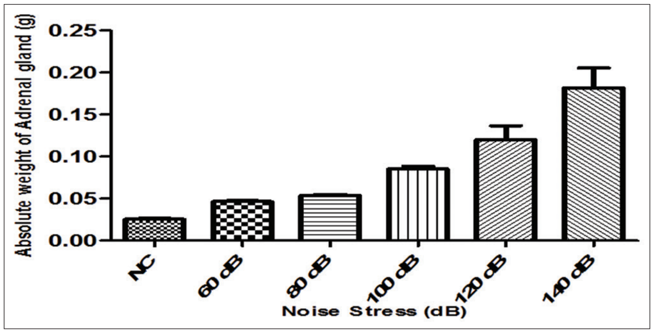
DISCUSSION

Noise stress of varying sound level (dB) was utilized as a tool to create noise stress and demonstrated its effects on the food consumption behavior, water consumption behavior, body weight, and absolute adrenal glands weight of the 17-week old male Wistar rats.

The present study shows that the noise stress of 60, 80, 100, 120, and 140 dB for 1 h daily to 30 days produced a minimum 0.76% (60 dB), 0.36% (80 dB), and 3.87% (100 dB) to maximum 25.89% (120 dB) and 30.06% (140 dB) percentage loss of body weight in EG_1, EG_2, EG_3, EG_4, and EG_5 group of animals. The loss of body weight in animals suggests some previously reported mechanisms that stress could onset depressive episodes and it activates the HPA axis resulting from regular short but long-duration exposure to any stressful stimuli. The stress has played a major role in altering the PA axis proving that noise pollution is a stress to which if exposed chronically will produce alteration in the PA system thereby affecting the various physiological and anatomical features of the individual. In general, any level of stress which is caused by a stimulus, definitely triggers adrenocorticotropic hormone (ACTH) level, i.e., hypothalamo-hypophyseal-adrenocortical axis is affected.[22] The noise could be a hurtful stimulus and does a negative impact on animals as well as humans through many well-known mechanisms. Like other stress, noise stress sets off neuronal and



Graph 2: (a) Effect of noise on food consumption behavior. The values are expressed in Mean±SEM; (n = 6). One-way ANOVA followed by Dunnett's post-test; *P < 0.05 versus normal control; P < 0.001 versus normal control; ns$P$ > 0.05 versus normal control. (b) Effect of noise on water consumption behavior ***P < 0.001 versus normal control; ***P < 0.001 versus normal control; ns$P$ > 0.05 versus normal control; *P < 0.05 versus normal control; ***P < 0.001 versus normal control



Graph 3: Effect of noise on absolute adrenal weight. The values are expressed in Mean±SEM; ($n = 6$). One-way ANOVA followed by Dunnett's post-test; $^{ns}P > 0.05$ versus normal control; $^{**}P < 0.001$ versus normal control; $^{***}P < 0.001$ versus normal control (of adrenal weight on 30th day)

hormonal stress responses or it can cause severe harmful impact through direct organ vibration.[9]

The present study's observations showed that there was a significant reduction in food and water consumption behavior during 1st–14th days in all experimental animals, when exposed to varying repeated noise stress and it leads to a reduction in body weight in the same duration so, the reduction in weight loss could be associated with the reduced intake of food and water during that specific duration. Our results were correlated to the reported finding of Hariram *et al*.[10] and Sundar and Radha[22] they have also reported that reduced food and water consumption could be a reason for sudden weight loss during noise stress burden. The reported work concluded that a normal food and water consumption behavior of animals could change if exposure to noise stress is about 80 dB,[10] in our procedure, we exposed experimental animals not only at 80 dB but exposed at lower to higher noise stress from 80 dB and observed some interesting mechanism of adaptation at lower noise stress from 80 dB. Although, on the 1st day, during noise exposure in all groups, food, and water consumption was reduced, when noise exposure was stopped in all groups, animals consume a large volume of water and food which may be because of inhibition and stimulation of ventromedial hypothalamus and lateral hypothalamus due to the pressure exerted in cortical areas of the brain[10] but when exposure was continued for 14 days some observations were changed. Other research revealed and confirm our study that reduced body fluids and partially to a reduction in food consumption leads to tissue catabolism.[23, 24]

In prolongation, when our study continued for another 15 days with the same time duration and exposure of noise stress it was observed that body weight, food, and water consumption behavior were recovered in some groups of animals, i.e., EG_1 (60 dB) EG_2 (80 dB), and EG_3 (100 dB) after the 14th–29th days while exposure of noise stress remains in continuous, alternatively, in during the same time period, EG_4 (120 dB) and EG_5 (140 dB) group of animals fails to regain body weight, food, and water consumption behavior, this finding suggests that when the animals exposed to the same noise stress, the behavioral and physiological impact of stress exposure are reduced, indicating that the animals become adapted to the continued noise stress. This process also termed habituation. Quality, quantity, and duration can greatly influence adaptation. Release of ACTH and prolactin appears to be specific for the applied stressor so that the potentiality of the PA axis and prolactin to respond to a novel (heterotypic) stressor can be preserved. This phenomenon has been termed as facilitation and can be unmasked alternating stress.[25]

In present study, animals of group EG_1, EG_2, and EG_3 may follow "facilitation" and acquired adaption after during 14th–29th days and defensive against stress response, whereas other groups of animals, i.e., EG_4 and EG_5, which showed reduced weight, food, and water consumption behavior may not facilitate themselves and it is well known that dysregulation of the HPA axis by frequent stress or elevated levels of circulating cortisol produces hyperactivity of the sympathetic adrenal-medullary system, such as cortisol, corticosteroid-binding globulin, and ACTH.[26]

Adaptation to continuous stress may further slowdown the corticoadrenal response to the stimulus and some neural circuits scheming pituitary hormone secretion in response to a stress stimulus are modified by frequent exposure. It looks like there should be reallocation in the sensitivity of the hormonal response to repeated experience with a stress stimulus.[27] In contrast, animals were exposed to lower noise stress, i.e., 60, 80, and 100 1 h/day for 30 days, after 15 days they were capable to adapt themselves comparatively to those animals, received higher intensities of noise level 120 and 140 dB fails to adapt themselves. This could be due the mechanism discussed above and it could be a factor of initiation of animal's homeostasis mechanism that helps animals by changing hormonal pattern, as discussed above, conversely failing of homeostasis in 120 and 140 dB noise stress exposed animals could be a reason to gradual reduction in body weight, food, and water consumption behavior. It may be concluded that higher noise stress exposure regularly for a longer time period could affect the neurohumoral apparatus and it suggests pathogenesis of some diseases like hypertension and in a diseased state feeding and water, consumption could suffer. In support of this, we discussed a reported study that revealed the role of catecholamine.

Stress is greater in the hypertensive than in the normotensive subject and more catecholamines in such stressed hypertensive subjects and production of catecholamines give rise to a large variety of symptoms and signs due to their effect on hemodynamics and metabolism, including weight loss even with normal appetite and food intake.[28,29]

Under different noise stress (conditions), the absolute weight of adrenal glands was increased in our observations. Experimental animals of the group EG_1 (60 dB and EG_2 (80 dB) were not statistically significant when compared to normal control but the numerically absolute weight of the adrenal glands was increased in respect to normal control, whereas the absolute weight of adrenals in group EG_3 (100 dB), EG_4 (120 dB), and EG_5 (140 dB) showed a highly significant increase in weight. This confirms some previously reported work.

That stress induces adrenal-medullary response to release adrenaline which in turn stimulates β2 receptors on the pituitary gland. It initiates the release of ACTH that can excite the adrenal medulla and cortex ensuing in the excess release of adrenaline and corticosterone, respectively. The adrenal hypertrophy (increase in adrenal gland weight) takes place in response to the secretion of ACTH from the pituitary for increased corticosterone from cortical cells to contest stress[30] and also continues stress could alter the endocrine balance that disrupts the establishment of the HPA axis, thus it leading to inappropriate stress responses[31] and also adrenal medulla is alarmed due to rapid-onset responses to stress challenges, consisting of an early release of previously stored catecholamines which is directly neurally mediated. By contrast, the adrenocortical response to stress is delayed and consists of a neuroendocrine cascade of humoral mediated processes. It can thus be hypothesized that with a short duration of noise stress (<1 h), the adrenal medulla response can be considered physiological, and not yet implying morphological changes.[31]

CONCLUSION

In the light of above observation, it was concluded that noise stress of varying level could affect the normal physiological and psychological behavior of the experimental animals. The results of the present study showed that the effects of noise stress of varying sound level (dB) on the body weight, feeding and drinking behavior, and absolute weight of adrenal glands of the male Wistar rats. Based on the changes, it can be concluded that the body weight of rats was decreased as feeding and drinking behavior reduced by the effect of all applied noise stress and body weight was increased in some group of animals as their feeding and drinking were increased while remaining in the same noise exposure till the end of the study, this means there is some adaption against the less noise stress whereas in high noise stress some group of rats fails to adapt themselves. Hence, it can be concluded longer duration noise exposure of high noise stress can induce an endocrine imbalance that disturbs the establishment of the HPA axis, thereby, leading to abnormal stress responses, whereas absolute adrenal weights of all the experimental animals found increased and it can also be concluded that there is a positive role of the adrenal gland in stress management by producing corticosterone animals. Further studies are needed to identify the role of hormones which help animals to acquired adaptation. The acute and chronic study with respect to noise stress levels may be extended.

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