IMPACT OF SLEEP DEPRIVATION AND SLEEP RECOVERY ON REPRODUCTIVE HORMONES AND TESTICULAR OXIDATIVE STRESS IN ADULT MALE RATS

Ebtihal A. Abd El-Aziz And Dalia G. Mostafa

Department.of Physiology, faculty of Medicine, Assiut University

ABSTRACT

Objectives: sleep deprivation is a significant problem among adult men. It is considered to be a risk factor that contributes to several disease. It has been proposed that reactive oxygen species and the resulting oxidative stress may be responsible for some of the effects of sleep deprivation. The present study was performed to determine the impact of sleep deprivation for different periods on serum testosterone, luteinizing hormone, corticosterone and whether sleep deprivation causes oxidative stress indicated by measuring malondialdehyde (MDA) level in testicular tissue as a direct evidence of cellular damage and measuring glutathione (GSH) in testicular tissue to determine possibility of reversible nature of oxidative stress by scavenger antioxidant system. We studied also if sleep recovery after sleep loss could relieve these effects or not.

Material and methods: 42 adult male albino rats aged 12 weeks weighing about 200-250 gm were used in this study. They were divided into seven groups, six animals in each group, a control group and six experimental groups. Three experimental groups were used as sleep deprivation (SD) groups and another three experimental groups were used as sleep recovery (SR) groups. The SR groups were also sleep deprived and then returned to home-cages and were allowed to undisturbed and spontaneous sleep. Group I: served as a control group. Group II: rats were subjected to sleep deprivation for one day. Group III: rats were subjected to sleep deprivation for three days. Group IV: rats were subjected to sleep deprivation for five days. Group V: rats were subjected to
sleep deprivation for three days followed by a period of sleep recovery for one day. Group VI: rats were subjected to sleep deprivation for three days followed by a period of sleep recovery for three days. Group VII: rats were subjected to sleep deprivation for three days followed by a period of sleep recovery for five days. After each planned SD and SR period, blood samples were collected for hormonal assay. The rats were decapitated and the testes were dissected out and used for the study of malondialdehyde and glutathione. The parameters were measured then analyzed by using Student's t-test. **Results:** Serum testosterone level and luteinizing hormone (LH) showed significant decrease after three days of deprivation. Serum corticosterone level increased significantly from the first day of deprivation in comparison with the control group. After five days of sleep recovery, serum testosterone level and corticosterone returned to the level of the control group. Serum LH level improved after three days of sleep recovery. Sleep deprivation increased the testicular tissue MDA significantly and GSH was significantly decreased after three day of sleep deprivation when comparing with the control. Sleep recovery decreased testicular tissue MDA significantly and significant increase in GSH after the fifth day as non-significant change noticed on comparing their levels on that day with the control. **Conclusions:** The present study demonstrated the sleep deprivation effects on testosterone, luteinizing hormone, corticosterone levels in serum, malondialdehyde and glutathione in testicular tissue of rat. Sleep recovery was associated with restoration of the serum hormone levels. Also with sleep recovery MDA level was decreased and GSH content was improved in testicular tissue.

**Key words:** sleep deprivation, sleep recovery, testosterone hormone, luteinizing hormone, corticosterone hormone, malondialdehyde and glutathione
INTRODUCTION

Sleep deprivation is a significant problem among adult men (Andersen et al., 2005 and Andersen & Tufik, 2008). It is considered to be a risk factor that contributes to several disease processes (Wu et al., 2011) via its ability to alter behavioral (Andersen et al., 2000 & 2003), hormonal (Andersen et al., 2004 & 2005) and neurochemical pathways (Martins et al., 2004 and Pedrazzoli et al., 2004). Sleep deprivation is one of the consequences of the pressure from society on individuals, impacting their health and wellbeing (Tufik et al., 2009).

In rodents, sleep interference causes alterations in several aspects of physiological and behavioral functioning, such as sexual behavior (Alvarenga et al., 2009 and Andersen et al., 2009), memory (Alvarenga et al., 2008), anxiety (Suchecki et al., 2002), attention (Godoi et al., 2005), hormonal changes (Antunes et al., 2006), and damage to the immune system (Zager et al., 2009).

Several studies have shown that sleep deprivation reduces circulating androgens in healthy men including testosterone (Eacker et al., 2008 and Maia et al., 2011). Decreased testosterone levels can impair gonadal and sexual functions, and potentially result in decreased fertility (Luboshitzky et al., 2002). Circulating testosterone levels are known to increase during sleep (Cortés-Gallegos et al., 1983).

The control of androgen production from the Leydig cell is dependent upon the episodic secretion of LH hormone, which is released in pulses from the anterior pituitary gland (Dufau et al., 1984).

Sleep deprivation involves some degree of stress which results in stimulation of hypothalamic–pituitary–adrenal axis (HPA axis). This stimulation can result in an increase in the plasma level of corticosterone and a concomitant change in testosterone (Suchecki and Tufik, 2000), mediated by a change in LH (Demura et al., 1989).

Sleep deprivation per se causes changes in lipid peroxidation or in
antioxidant defenses. Oxidative stress is a condition associated with an increased rate of cellular damage induced by oxygen derived oxidants commonly known as reactive oxygen species (ROS). ROS are reported to damage almost all macromolecules of the cell, including polyunsaturated fatty acids of membranes, thus causing impairment of cellular functions (Halliwell, 1996). Testicular membranes are extremely rich in polyunsaturated fatty acids therefore; the organ is highly susceptible to oxidative stress (Manna et al., 2003). Sleep after sleep deprivation is widely considered to have restorative properties; free radicals accumulate during wakefulness and are removed during sleep (Everson et al., 2005).

AIM OF THE STUDY

The present study was designed to determine the impact of sleep deprivation for different periods on serum testosterone, luteinizing hormone, corticosterone and whether sleep deprivation causes oxidative stress indicated by measuring MDA level in testicular tissue as a direct evidence of cellular damage and measuring GSH in testicular tissue to determine the possibility of reversible nature of oxidative stress by scavenger antioxidant system and whether sleep recovery after sleep loss could relieve these effects or not.

MATERIAL AND METHODS

Animals and groups:

42 adult male albino rats aged 12 weeks weighing about 200-250 gm were used in this study. The rats were housed in animal house of Assiut University in standard cages in normal room temperature with normal light–dark cycle. Food and water were provided ad libitum. They were divided into seven groups, six animals in each group, a control group and six experimental groups. The control group was allowed to undisturbed, spontaneous sleep.

Rats were subjected to sleep deprivation according to Bergmann et al. (1989) with slight modification by placing the animal on the top of a bottle
filled with water, the diameter of which is small relative to the animal's size. The bottle is placed in a large tanks filled with water to be 5 cm less than the top of the bottle. The animal is able to rest on the top of a bottle and if it began to sleep, muscular relaxation occurred which result in either fall into the water and clamber back to its site on the top of the bottle or get its nose wet enough to awaken it. The water in the tanks was changed daily, throughout the SD period. So the groups are classified as follows:

**Group I**: served a control group.

**Group II**: subjected to sleep deprivation for one day.

**Group III**: subjected to sleep deprivation for three days.

**Group IV**: subjected to sleep deprivation for five days.

**Group V**: subjected to sleep deprivation for three days then followed by a period of sleep recovery for one day.

**Group VI**: subjected to sleep deprivation for three days then followed by a period of sleep recovery for three days.

**Group VII**: subjected to sleep deprivation for three days then followed by a period of sleep recovery for five days.

**Blood sampling and hormone determination:**

After each planned SD and SR period, blood samples were collected from the retro-orbital venous plexus before sacrifice. The whole blood was incubated to clot for 30 minutes and serum was separated by centrifugation. The separated serum was stored frozen at -20 °C until use. Samples were assayed for testosterone, luteinizing hormone and corticosterone by ELISA method using available Kits according to manufacture. Testosterone hormone levels in serum were determined using ELISA kit Coate – A count kit from diagnostic product corporation Los Anglos (A 90045 – 5597 USA). Luteinizing hormone levels in serum were determined using rat ELISA kit cattalogue No.E0830Rb according to manufacture. Corticosterone hormone in serum was determined using Assay
Max Corticosterone ELISA kit Catalloge No EC3001- 1 according to manufacture.

**Testicular tissue Collection**

After each planned SD and SR period, the rats were decapitated; the testes were dissected out and used for the study of lipid peroxidation and glutathione. The tissues of testes of different groups were homogenized in ice-cold 100 mM phosphate buffer (pH7.4). The obtained supernatants were used for estimation of lipid peroxidation (malondialdehyde) and GSH. MDA was estimated by method according to (El-Shahat et al., 2009). GSH was measured by following the standard method (Ellman, 1959).

**Statistical analysis**

Data were expressed as mean ±SD for all parameters then analyzed using Student's t-test. P values less than 0.05 were considered significant.

**RESULTS**

**Serum testosterone** (table 1 & 2, Fig. 1 & 2)

Serum testosterone level showed non-significant decrease after one day of sleep deprivation (5.5 ± 0.7 ng/ml) in comparing with the control (5.9 ±0.8 ng/ml). The level decreased significantly after three (4.6 ± 0.5 ng/ml) and five (2.9 ± 0.7 ng/ml) days of deprivation.

After one day of sleep recovery, serum testosterone level (4.7 ± 0.4 ng/ml) still significantly lower than that of the control group (5.9 ± 0.8 ng/ml) but non-significant changes were noticed in comparison with the three days deprivation (4.6 ± 0.5 ng/ml) group.

After three days of sleep recovery, serum testosterone level (4.8 ± 0.6 ng/ml) was still significantly lower than that of the control group (5.9 ± 0.8 ng/ml) but non-significantly changed in comparison with the three days of sleep deprivation (4.6 ± 0.5 ng/ml) group.
After five days of sleep recovery, serum testosterone level (5.8 ± 0.9 ng/ml) returned to the control group (5.9 ± 0.8 ng/ml) and non-significantly changed on comparing both. There was significant increase on comparing them with the three days of deprivation (4.6 ± 0.5 ng/ml).

**Serum luteinizing hormone** (table 1&2, Fig. 3&4)

Serum luteinizing hormone levels after sleep deprivation for one, three and five days were 6.03 ± 0.3 ng/ml, 4.2 ± 0.5 ng/ml and 2.8 ± 0.3 ng/ml, respectively. The effect of sleep deprivation on serum luteinizing hormone started from the third day onward. Significant decrease was reported on comparing three and five days sleep deprivation with the control (6.5 ± 0.5 ng/ml).

Serum luteinizing hormone level improved earlier from the third day of recovery. After one day of sleep recovery, serum luteinizing hormone level (3.1 ± 0.1 ng/ml) was non-significantly lower than that of three days sleep deprivation (4.2 ± 0.5 ng/ml), but significantly lower than that of the control group (6.5 ± 0.5 ng/ml).

After three days of sleep recovery, serum luteinizing hormone level (6.3 ± 0.7 ng/ml) was significantly higher than that of the three days sleep deprivation (4.2 ± 0.5 ng/ml) but no significant changes in comparison with the control group (6.5 ± 0.5 ng/ml).

After five days of sleep recovery, serum luteinizing hormone level (6.8 ± 0.7 ng/ml) was significantly higher than that of the three days sleep deprivation (4.2 ± 0.5 ng/ml) but no significant changes on comparing with the control group (6.5 ± 0.5 ng/ml).

**Serum corticosterone** (table 1&2, Fig. 5&6)

Sleep deprivation increased the serum corticosterone from the first day, significant increase was reported on comparing the sleep deprivation groups of
the three periods with that of the control (137.3 ± 8.2 ng/ml) vs (147.5 ± 5.3 ng/ml, 168.2 ± 9.4 ng/ml and 192.4 ± 6.1 ng/ml) respectively.

Serum corticosterone of the animals that underwent sleep recovery for one day (158.0 ± 8.6 ng/ml), three days (150.3 ± 5.1 ng/ml) and five days (138.5 ± 2.0 ng/ml). Non-significant change was noticed only on comparing the five days recovery with the control group (137.3 ± 8.2 ng/ml). Highly significant decrease in serum corticosterone level of the three and five days recovery groups on comparing with the three days sleep deprivation group (168.2 ± 9.4 ng/ml).

**Testicular tissue MDA** (table 3, Fig. 7)

Sleep deprivation increased the testicular tissue MDA from the first day. Significant increase was reported after three and five day of sleep deprivation on comparing with that of the control (8.62 ± 0.7 μmole/g tissue). One day sleep deprivation was (8.97 ± 0.8 μmole/g tissue), three days sleep deprivation (9.55 ± 0.8 μmole/g tissue) and five days sleep deprivation (11.96 ± 0.9 μmole/g tissue). Sleep recovery improved testicular tissue MDA after the fifth day as non-significant change noticed on comparing its level with the control. One day sleep recovery was (9.82 ± 0.7 μmole/g tissue), three days sleep deprivation (9.59 ± 0.5 μmole/g tissue) and five days sleep deprivation (8.79 ± 0.9 μmole/g tissue).

**Testicular tissue glutathione** (table 3, Fig. 8)

Sleep deprivation decreased the testicular tissue glutathione from the first day. Significant decrease was reported after three and five days of sleep deprivation on comparing with that of the control (310.0 ± 13.2 nmol/mg protein). One day sleep deprivation was (304.0 ± 10.4 nmol/mg protein), three days sleep deprivation (284.0 ± 13.8 nmol/mg protein) and five days sleep deprivation (270.0 ± 17.1 nmol/mg protein). On the fifth day, sleep recovery returned testicular tissue glutathione to control level as non-significant change noticed on comparison with the control. One day sleep recovery was (285.0 ±
20.6 nmol/mg protein), three days sleep deprivation (287.0 ± 9.5 nmol/mg protein) and five days sleep deprivation (305.0 ± 19.4 nmol/mg protein).

Table (1): Serum testosterone, luteinizing hormone and corticosterone concentrations of rats that underwent sleep deprivation (SD) for different durations.

<table>
<thead>
<tr>
<th></th>
<th>Testosterone (ng/ml)</th>
<th>P (SDvC)</th>
<th>Luteinizing hormone (ng/ml)</th>
<th>P (SDvC)</th>
<th>Corticosterone (ng/ml)</th>
<th>P (SDvC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>5.9 ± 0.8</td>
<td></td>
<td>6.5 ± 0.5</td>
<td></td>
<td>137.3 ± 8.2</td>
<td></td>
</tr>
<tr>
<td>SD1</td>
<td>5.5 ± 0.7</td>
<td>0.4 ns</td>
<td>6.03 ± 0.3</td>
<td>0.1 ns</td>
<td>147.5 ± 5.3</td>
<td>0.03 *</td>
</tr>
<tr>
<td>SD3</td>
<td>4.6 ± 0.5</td>
<td>0.02 *</td>
<td>4.2 ± 0.5</td>
<td>0.002 **</td>
<td>168.2 ± 9.4</td>
<td>0.002 **</td>
</tr>
<tr>
<td>SD5</td>
<td>2.9 ± 0.7</td>
<td>0.0001 ***</td>
<td>2.8 ± 0.3</td>
<td>&lt;0.0001 ***</td>
<td>192.4 ± 6.1</td>
<td>0.0001 ***</td>
</tr>
</tbody>
</table>

Table (2): Serum testosterone, luteinizing hormone and corticosterone concentrations of rats that underwent sleep recovery (SR) for different durations after a period of three days sleep deprivation.

<table>
<thead>
<tr>
<th></th>
<th>Testosterone (ng/ml)</th>
<th>P</th>
<th>Luteinizing hormone (ng/ml)</th>
<th>P</th>
<th>Corticosterone (ng/ml)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR1</td>
<td>4.7 ± 0.4</td>
<td>(SR1v SD3) 0.8 ns</td>
<td>3.1 ± 0.1</td>
<td>(SR1v C) 0.01 *</td>
<td>158.0 ± 8.6</td>
<td>(SR1v SD3) 0.08 ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(SR1v C) 0.01 *</td>
<td></td>
<td>(SR1v C) &lt;0.0001 ***</td>
<td></td>
<td>(SR1v C) 0.009 **</td>
</tr>
<tr>
<td>SR3</td>
<td>4.8 ± 0.6</td>
<td>(SR3vSD3) 0.5 ns</td>
<td>6.3 ± 0.7</td>
<td>(SR3vSD3) 0.002 **</td>
<td>150.3 ± 5.1</td>
<td>(SR3vSD3) 0.02 *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(SR3vC) 0.04 *</td>
<td></td>
<td>(SR3vC) 0.7 ns</td>
<td></td>
<td>(SR3vC) 0.03 *</td>
</tr>
<tr>
<td>SR5</td>
<td>5.77 ± 0.7</td>
<td>(SR5vSD3) 0.02 *</td>
<td>6.8 ± 0.7</td>
<td>(SR5vSD3) 0.0008 ***</td>
<td>138.5 ± 2.0</td>
<td>(SR5vSD3) 0.001 **</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(SR5vC) 0.8 ns</td>
<td></td>
<td>(SR5vC) 0.4 ns</td>
<td></td>
<td>(SR5vC) 0.7 ns</td>
</tr>
</tbody>
</table>
Table (3): Testicular Malondialdehyde level (MDA) and glutathione of rats that underwent sleep deprivation (SD) and sleep recovery (SR) for different durations.

<table>
<thead>
<tr>
<th>Group</th>
<th>MDA (μmoles/g tissue)</th>
<th>P</th>
<th>Glutathione (nmol/mg protein)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>8.62 ± 0.7</td>
<td></td>
<td>310.0 ± 13.2</td>
<td></td>
</tr>
<tr>
<td>SD1</td>
<td>8.97 ± 0.8</td>
<td>(SD1vC) 0.1 ns</td>
<td>304.0 ± 10.4</td>
<td>(SD1vC) 0.2 ns</td>
</tr>
<tr>
<td>SD3</td>
<td>9.55 ± 0.8</td>
<td>(SD3vC) 0.03*</td>
<td>284.0 ± 13.8</td>
<td>(SD3vC) 0.02*</td>
</tr>
<tr>
<td>SD5</td>
<td>11.96 ± 0.9</td>
<td>(SD5vC) 0.002**</td>
<td>270.0 ± 17.1</td>
<td>(SD5vC) 0.006**</td>
</tr>
<tr>
<td>SR1</td>
<td>9.82 ± 0.7</td>
<td>(SR1vC) 0.04*</td>
<td>285.0 ± 20.6</td>
<td>(SR1vC) 0.03*</td>
</tr>
<tr>
<td>SR3</td>
<td>9.59 ± 0.5</td>
<td>(SR3vC) 0.03*</td>
<td>287.0 ± 9.5</td>
<td>(SR3vC) 0.03*</td>
</tr>
<tr>
<td>SR5</td>
<td>8.79 ± 0.9</td>
<td>(SR5vC) 0.8 ns</td>
<td>305.0 ± 19.4</td>
<td>(SR5vC) 0.6 ns</td>
</tr>
</tbody>
</table>

Fig. 1: Serum testosterone level for rats that underwent sleep deprivation for different durations

Fig. 2: Serum testosterone level for rats that underwent sleep recovery for different durations compared to control and three days sleep deprivation group animals.
Fig. 3: Serum luteinizing hormone levels for rats that underwent sleep deprivation for different durations.

Fig. 4: Serum luteinizing hormone level for rats that underwent sleep recovery for different durations compared to control and three days sleep deprivation group animals.

Fig. 5: Serum corticosterone level for rats that underwent sleep deprivation for different durations.
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Fig. 6:- Serum corticosterone level for rats that underwent sleep recovery for different durations compared to control and three days sleep deprivation group animals.

Fig. 7:- Malondialdehyde level in testicular tissue for rats that underwent sleep deprivation and sleep recovery for different durations.

Fig. 8:- Glutathione level in testicular tissue for rats that underwent sleep deprivation and sleep recovery for different durations.
DISCUSSION

Sleep deprivation is a known physiological stressor and considered as a major problem for in males (Wu et al., 2011 and Meerlo et al., 2008). The activation of hypothalamo-pituitary-adrenocortical system and the sympatho-adrenomedullary system was considered to be the main regulators of the stress response (Reeder and Kramer, 2005, Joels et al., 2007 and McEwen et al., 2007). So, the current study tried to focus on the effects of sleep deprivation and recovery of different durations on changes of male reproductive hormones; serum testosterone, luteinizing hormone and corticosterone levels in adult male rats.

Our model for sleep deprivation was described as a good physiological stressor as it produces alterations in almost all studied hormones (Knutson et al., 2007). We compared our results of sleep recovery with sleep deprivation of the third day because at that day we get establish socially stable group animals, thereby obviating other possible stress variables (Suchecki & Tufik, 2000 and Suchecki et al., 2002).

We studied the effect of SD from the 1st day up to the 5th day as Andersen et al. (2002 & 2004), Andersen and Tufik (2008) and Eacker et al. (2008) reported that testosterone concentrations were decreased following one to four days of SD and this reduction was further enhanced with longer durations of SD.

The present study estimated the serum levels of testosterone, luteinizing hormone and corticosterone after recovery period from the 1st day up to the 5th day trying to estimate the time elapsed to return to the resting level.

Our study revealed reduction in serum testosterone levels after SD and the level decreased significantly after three to five days of deprivation. The same results were reported by Amikishieva et al., 2001 and Dong et al., 2004 (for mice), Almedia et al., 2000 and Manna et al., 2004 (for rats), and Oltmanns et
The reduction was explained according to Rajaratnam & Arendt (2001) and Mazaro & Lamano-Carvalho (2006) by stress. The synthesis of testosterone is dependent on endocrine (Rajaratnam & Arendt, 2001) and neuronal (Roman et al. 2006) signals which in turn are influenced by physiological conditions such as stress. Stress in fact results in secretion of several hormones such as, CRH (Rivest and Rivier, 1991), ACTH (Ishikawa et al., 1992 and Monder et al., 1994), and corticosterone (Suchecki & Tufik, 2000 and Machado et al., 2010) on HPG axis function. Although the mechanism(s) for these effects on reproductive function are not fully elucidated, possible sites of action include: (1) a centrally mediated inhibition of gonadotropin releasing hormone (GnRH) release by CRH, opioids and glucocorticoids (MacLusky et al., 1988; ); (2) glucocorticoid-induced tissue resistance to gonadal sex steroids (Rabin et al., 1990), decreasing the sensitivity of Leydig cells to LH, or decreasing testicular receptors to this hormone (Payne & Youngblood, 1995); (3) direct gonadal effects of glucocorticoids with subsequent alterations in sex steroid output (Hardy and Ganjam, 1997), corticosterone reduce testosterone production in Leydig cells and to induce apoptosis in these cells (Gao et al., 2002, Retana-Márquez et al., 2003 and) (4) a glucocorticoid-mediated decrease in pituitary responsiveness to GnRH, resulting in decreased LH secretion (Chichinadze & Chichinadze, 2008).

The decreased testosterone levels associated with SD may be in part due to serotonin-related inhibition of testosterone production (Gao et al., 2002 and Meerlo et al., 2008). In addition, both serotonin and serotonin receptors have been localized in Leydig cells isolated from the testes of golden hamsters and serotonin has also been demonstrated to inhibit testosterone production (Frungieri et al., 2002).

Kraut et al. (2004), Hones & Marin, (2006) and McEwen (2007) explained the decrease in testosterone level during SD by decrease in the blood flow to
the testicles (less vital organs) leading to suppression of its activity during stress in order to maximally increase the resources supplied to organs critically important for adaptation.

In our study we observed that a decrease of LH levels were associated with a decrease of testosterone levels in SD. This was in agreement with Almeida et al., 2000 and Manna et al., 2004 (in rat), Stackpole et al., 2003 & Wingfield & Sapolsky, 2003 (in farm animals) and Oltmanns et al., 2005 (humans). Rivest & Rivier (1995) explained that by inhibiting LHRH synthesis and release from the hypothalamus.

We found an increase of corticosterone levels during SD from the first day to the fifth day which was associated with decreased levels of testosterone. These findings are confirmed by the previous studies in rats and men. In rats González-Quijano et al., 1991 (stress by immobilization), Watanabe et al., 1991 (stress by prolonged exercise), Ishikawa et al., 1992 (stress by intermittent electric foot shocks), Bidzinska et al., 1993 (stress by forced swimming in cold water), Novati et al., 2008; Tiba et al., 2008; Tartar et al., 2009 (stress by plateform). In men Opstad, 1994 (prolonged physical stress due to military training).

In the present study, there was an increased level of testicular MDA level (the product of lipid peroxidation) significantly after three to five days of deprivation. These findings are confirmed by Ramanathan et al (2002) who found that with sleep deprivation there was increase in lipid peroxidation in the hippocampal region of the brain in wistar rats. Sleep deprivation could enhance metabolic rate and in turn increase oxidative stress. An increase in MDA level is related to an increase in the levels of lipid peroxidation in cell membrane. ROS can cause cytotoxicity, one of the manifestations of which can be observed through lipid peroxidations (Jana and Samanta, 2006).
The current study revealed a decrease of GSH level in testicular tissue during SD, the level decreased significantly after three to five days of deprivation. This was in agreement with Everson et al (2005) who found a decrease in glutathione activity in liver after 5 days of sleep deprivation and this decrease was sustained or worsened by prolongation of sleep deprivation. GSH plays multiple roles as a cellular antioxidant defense because its main function is to remove hydrogen peroxide and organic peroxides (Chainy et al., 1997). Therefore, any decline in the level of GSH indicates the increased production of free radicals (Debnath and Mandal., 2000). In contrast, Singh et al (2008) noticed that sleep deprivation did not affect oxidative stress parameters in the striatum; and the activity of glutathione peroxidase was not affected in any of the studied brain regions.

During the recovery period, the preset study showed that the testosterone and corticosterone reached the control level at the fifth day of recovery. While the LH level reached the control level at the third day of recovery. This is may be due to the ability of the rats in recovery period to accommodate the HPA axis derangements that accompany SD and allowing them to return to a normally functioning HPA axis during periods of SR.

The present results of corticosterone were in agreement with that reported by Leenaars et al. (2011). In contrast, Andersen et al. (2005) found that testosterone did not return to basal values during the recovery periods after 96 h of SD and they suggested that long periods of SD lead to long-term effects that may become harmful.

During the recovery period, we found that the level of MDA decreased and level of glutathione increased and reached the basal level at the fifth day of recovery. The decrease in lipid peroxidation following restorative sleep indicates that there is decrease in free radical production. The other possibility is that the free radicals are scavenged by the antioxidant mechanism. This is well
correlated by increase in glutathione level following restorative sleep. These results were in accordance with the results of Mallik et al. (1995). The present study provides evidence that sleep recovery restores or accentuates antioxidants and antioxidant activities in the testes. Sleep recovery resulted in dramatic returns toward normal testicular glutathione (Everson et al., 2005).

In conclusion, the present study demonstrates that sleep deprivation is a type of stress induces changes in testosterone, luteinizing hormone and corticosterone levels in serum and biochemical effects in rat testes. The increased oxidative stress resulted from SD in testicular tissue might be responsible, at least in part, for the changes occurred. SR had restoration effect evidenced by reduction of MDA and increase of GSH in testicular tissue.
REFERENCES


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النتائج: أظهرت النتائج انخفاضاً في مستوى هرمون التستوستيرون والهرمون المحفز للجسم الأصفر بعد ثلاثة أيام من الحرقان من النوم وكذلك اظهرت زيادة في هرمون الكورتيزون في الدم منذ اليوم الأول بالمقارنة مع المجموعة الضابطة.

وبعد خمسة أيام من الانتعاش بلفوم تم استعادة مستوى هرمون التستوستيرون والكورتيزون إلى مستوى المجموعة الضابطة. وقد تحسن مستوى الهرمون المحفز للجسم الأصفر بعد ثلاثة أيام من الانتعاش بالنوم.

إن الحرقان من النوم ادى إلى زيادة مستوى الشوارد الطليفة وانخفاض مستوى الجلوتاثيون في تissuedة الخصية بعد ثلاثة أيام من الحرقان من النوم بالمقارنة بالمجموعة الضابطة. أما الانتعاش بالنوم ادى إلى انخفاض مستوى الشوارد الطليفة وزيادة مستوى الجلوتاثيون في تissuedة الخصية بعد اليوم الخامس. وذلك لوحظ عند مقارنة النتائج مع المجموعة الضابطة حيث لا يوجد فارقًا إحصائيًا.

الاستنتاجات: أظهرت هذه الدراسة تأثير الحرقان من النوم على مستوى هرمون التستوستيرون، والهرمون المحفز للجسم الأصفر، وهرمون الكورتيزون في الدم، وقياس بيروكسيد دهني والجلوتاثيون في أنسجة الخصية في الفئران. استعاد الانتعاش بالنوم مستويات هذه الهرمونات في الدم، كما ادى إلى انخفاض مستوى الشوارد الطليفة وتحسين مستوى الجلوتاثيون في أنسجة الخصية.
الملخص العربي
تأثير الحمران من النوم والانتعاش بالنوم على هرمونات التكاثر ومستوى الأكسة بالخصوصية
في ذكور الفئران البالغة
أبيهال / إنور عبد العزيز - دانيا جمال مصطفى
قسم الفسيولوجى - كلية الطب - جامعة أسيوط

المقدمة وأهداف البحث: الحمران من النوم هو مشكلة كبيرة بين الرجال والشباب، فهو يعتبر عامل
خطر يساهم في العديد من العوامل المرضية وذلك لقدرته على تغيير المسارات السلوكية والهرمونية وال
الكيمائية العصبية للجسم. وقد اقترح أن أنواع الأكسجين الناقصة و الاكسة الناتجة قد تكون مسؤولة
عن بعض آثار الحمران من النوم. وقد أجريت هذه الدراسة لتحديد تأثير الحمران من النوم لفترات
مختلفة على هرمون التستوستيرون في الدم، والهرمون المحفز للجسم الأصغر و هرمون الكورتيزون،
وكذل ذلك دراسة إذا ما كان الحمران من النوم بسبب الأكسة وذلك عن طريق قياس مستوى الشوارد الطليفة
في أنسجة الخصية كدليل مباشر على تلف الخلايا وكذلك قياس الجلوتاثيون في نسيج الخصية لتحديد
إمكانية طبيعة عكسها عن طريق مضادات الأكسة. وكذلك دراسة إذا كان إعادة النوم بعد الحمران منه
يختلف من هذه الآثار أو لا.

المواضبة والأساليب: تم استخدام 42 من الفئران الذكور البالغة في هذه الدراسة الذين تتراوح
أعمارهم بين 12 أسبوعاً وأوزانهم بين 250-200 جم. وقد تم تقسمهم إلى سبع مجموعات، ستة
حيوانات في كل مجموعة. وقد استخدمت ثلاث مجموعات تجربية تمثل الحمران من النوم. و استخدمت
المجموعات الثلاثة التجريبية الأخرى كمجموعة الإشعاع بالنوم التي تعرضت للحران من النوم، ثم
أعيد للقصر وسمح لهم بالنوم دون عائق.

المجموعة الأولى: المجموعة الضابطة المجموعة الثانية: المجموعة الأولى: المجموعة ضابطة
المجموعة الثالثة: تعرض للحرمان من النوم لمدة يوم واحد. المجموعة الثالثة: تعرض للحرمان من النوم لمدة ثلاثة أيام.
المجموعة الرابعة: تعرض للحرمان من النوم لمدة خمسة أيام. المجموعة الخامسة: تعرض للحرمان
المجموعة السادسة: تعرض للحرمان من النوم لمدة ثلاثة أيام. المجموعة السابعة: تعرض للحرمان من النوم
للمجموعة الثالثة أيام، تلتها فترة من النوم ليوم واحد. المجموعة سادسة: تعرض للحرمان من النوم
لمدة ثلاثة أيام، تلتها فترة من النوم ليوم واحد. المجموعة السابعة: تعرض للحرمان من النوم
لمدة ثلاثة أيام. تلتها فترة من النوم لمدة ثلاثة أيام. بعد كل فترتين الحمران من النوم والانعاش بالنوم
المخطط لها تم جمع عينات الدم وفصل البلازما لقياس الهرمونات. وتم أخذ عينات من الخصيتين لدراسة
بيروكسيد الدهون ومضادات الأكسة الجلوتاثيون. وتم تحليل النتائج إحصائياً