Effect of magnetic field on food and water intake and body weight of spinal cord injured rats

Suneel Kumar, Suman Jain, Jitendra Behari1, Valery D Avelev2 & Rashmi Mathur*

Department of Physiology, All India Institute of Medical Sciences (AIIMS), New Delhi 110 029, India
1School of Environmental Sciences, Jawaharlal Nehru University (JNU), New Delhi 110 067, India
2Pavlov Institute of Physiology, Russian Academy of Science, 6, St. Petersburg, Russia

Chronic (2h/d × 8 weeks) exposure to magnetic field (MF; 50 Hz, 17.9 µT) in complete spinal cord (T13) transected rats restored food intake (FI), water intake (WI) and body weight (BW) which were decreased in the spinal cord injured rats. The results suggest a significant beneficial effect of chronic exposure to magnetic field of paraplegic rats.

Keywords: Body weight, Food intake, Magnetic field, Spinal cord injury, Water intake

A complete transection of spinal cord (SCI) leads to an immediate hind limb paralysis, lack of reflexes, loss of sensations below the level of injury, bowel and bladder dysfunction with significant residual complications of marked osteoporosis and chronic pain1,2. Weight loss is a common consequence of any surgical injury including SCI3. Nonetheless, only a few animal studies are there reporting weight loss in contusion/deafferentation models of SCI. However they have not correlated with their food and water intake4,5. A significant reduction in body weight, whole body fat, lean tissue mass ratio, area under the curve of glucose tolerance test and insulin are reported in SCI rats although, their cumulative consumption of standard laboratory chow (4.0 kcal/g) and mean energy intake (kcal. day−1.100 g body wt−1) were significantly more, associated with lower thermogenesis than control6. These observations have the limitations of being reported in female rats, complete transection SCI at T3 and during wk 16-18 post-SCI only. The authors suggest that the prolonged post-SCI body weight loss, including fat mass, is not due to hypophagia but possibly is due to permanent changes in homeostatic mechanisms, atrophy of muscles, gastrointestinal transit and absorption7. These contradictions lead us to understand that the regulatory mechanisms for food intake and body weight are dissociated.

Nevertheless, clinical reports indicate that SCI patients are at risk for a lifelong inability to maintain a neutral energy balance6-10. The early stages of SCI are marked by decrease in energy expenditure, increase in catabolic rate, extensive nitrogen loss, and body composition characteristic of malnutrition7,8,11,18, which persist despite parenteral nutritional supplementation. An underweight body mass in SCI patients present a number of risk factors namely; infection, pressure ulcers and prolongation of the recovery process to the individual12-15. Recurrent pressure ulcers, in turn, trigger pro-inflammatory cytokine release, which can exacerbate the cachexic state of the patient16,17.

Pulse magnetic field (PMF) is reported to be beneficial in SCI induced paraplegia including altered muscle properties, chronic pain, osteoporosis, and bladder dysfunction19-22. Moreover, functional magnetic stimulation (FMS) is also reported to improve the quality of life in SCI patients and animals by better autonomic control of bladder and bowel; respiratory and coughing capabilities; colon emptying and gastrointestinal liquid transit time23-27.

Moreover, in intact animals (birds, cows) exposure to varied intensity (50900-40100 nT, 30 µT), frequency (60 Hz) and duration (21h/d × 95d, 12d, 16h/d × 28d) of magnetic field (MF) has been reported to increase body weight and food intake28-32. Therefore, it was pertinent to study the desired restoration of body weight and food intake by exposure to MF in SCI animal model.

It appears that the vital parameter of energy balance post-SCI has skipped the attention of researchers. Therefore, the present study has been
undertaken to document the pattern of feeding behavior and body weight in lower thoracic complete transection (T13) injury of spinal cord.

Materials and Methods

Animals—Adult male Wistar rats (weighing 200-250 g) were obtained from the Experimental animal facility of AIIMS. Rats were cared for, handled and procedures performed on them were strictly in accordance with the rules and regulations of Institutional Ethical Committee. They were housed in separate polypropylene cages (50 × 20 × 15 cm) and provided with fresh tap water and laboratory food pellets ad libitum. The room temperature and light dark cycle were (24°±2.0°C, 14:10 h respectively) maintained. The rats were divided into sham injury (sham, n=7), spinal cord injury+sham exposure (SCI, n=8), and SCI+magnetic field exposure (SCI+MF, n=8) groups.

Spinal cord injury—The rats were anesthetized by ketamine (60 mg/kg body weight, im). Skin overlying lower thoracic region was shaved and cleaned with alcohol. Mid-line thoraco-lumbar incision was made to expose the vertebral column and laminectomy of T10-T12 vertebrae was done to expose the spinal cord. The spinal cord was transected completely (SCI) at T13 level of spinal cord using fine microsurgical scissor. The ends of the cord were retracted and the cavity was carefully explored with a glass probe for any residual fibers. The cavity was gently packed with gel foam after ensuring the completeness of the transection. In sham injury group, the surgery was terminated after a bilateral laminectomy while keeping dura intact. The muscles and skin were then sutured and the rat was returned to its home cage.

Post-operative care—The rats received Ringer’s lactate (5 ml) subcutaneously to maintain blood volume, the bladder was evacuated twice a day till the control was resumed and gentamycin (50 mg/kg body weight, intramuscular × 5-7 days) injection was given to provide systematic antibiotic cover. Antibiotic (Neosporin cutaneous cream) was also applied twice daily on the incision wound and general hygiene was maintained.

Magnetic field (MF) exposure—Exposure to MF was carried out in specially designed MF chamber consisting of electromagnetic coils mounted on a stand along with movable platform for the rat cage. Briefly, the two outer and inner coils were wound with 8 turns each and connected in series so as to provide field of 17.96 µT and 50 Hz in the centre of axis, where the rats were placed. Six rats in a specially designed cage received exposure to MF simultaneously. The intensity and frequency of the field were noted with magnetometer (WALKER Scientific Inc. USA). Exposure to MF was carried out 24h post-SCI for consecutive (2 h/day from 10.00-12.00 hrs) 7 days/week for 8 weeks.

Parameters recorded—Daily food and water intake (FI, WI), weekly body weight (BW) of rats were noted pre (7 days) and post-surgery for consecutive 8 weeks. All the rats were given pre-weighted standard laboratory food pellets (Ashirwad Industries Pvt. Ltd., Punjab, India) and fresh sterile tap water in appropriate spill proof containers.

Statistical analysis—All statistical tests were evaluated at the alpha level of significance of 0.05. Inter-group comparisons were done by repeated measure one–way anova followed by post-hoc analysis using Bonferroni test. Paired t-test was used for intra-group comparison. All the values are represented as mean ± SD.

Results

Food intake (FI)—The FI in sham group of rats decreased post-laminectomy wk 1 as compared to their wk 0 value (Table 1). It recovered and was comparable to wk 0 FI during wk 2 post-laminectomy which was then maintained until the end of study period while, in SCI rat group the FI decreased post-SCI wk 1 through 8 versus its wk 0 value although there was gradual progressive recovery during wk 2, 3, and 4. In SCI+MF rat group also, FI decreased post-SCI wk 1 through 8 versus its wk 0 value.

In SCI/SCI+MF rat groups, the FI was less as compared to sham group of rats during post-SCI wk 1 through 8 although the decrease was lesser in SCI+MF rat group. FI was higher in SCI+MF versus SCI rat group post-SCI wk 6 through 8.

Water intake (WI)—In sham rat group, pre-laminectomy (wk 0) WI was 154.71±0.95 ml and no change was observed post-SCI wk 1 through 8 while, in SCI rat group the WI decreased post-SCI wk 1 through 5 versus its wk 0 value. In SCI+MF rat group also, WI decreased post-SCI wk 1 through 5 and then increased at post-SCI wk 7 through 8 versus its wk0 value (Table 2).

In SCI/SCI+MF groups, WI was less versus sham group of rats during post-SCI wk 1 through 5 although the decrease was lesser in SCI+MF rat group.
during wk 5. WI was higher in SCI+MF versus SCI rat group post-SCI wk 1 and wk 8.

**Body weight (BW)**—Body weight decreased at post-laminectomy wk 2 and increased at wk 8 versus their wk 0 value while, in SCI rat group the BW decreased post-SCI wk 1 through 8 versus its wk 0 value. In SCI+MF rat group also, BW decreased post-SCI wk 1 through 6 versus its wk 0 value (Fig. 1).

In SCI / SCI+MF groups, BW was lower versus sham group of rats at post-SCI wk 1 through 8 although, the decrease was lesser in SCI+MF rats. BW was higher in SCI+MF versus SCI rat group post-SCI wk 4 through 8.

**Discussion**

The present results indicate a significant reduction in body weight, food intake and water intake of rats after complete transection of spinal cord at T13 level during the study period (wk 1 through 8) while the effect was significantly attenuated during post-SCI wk 4-8, wk 6-8 and wk 1, 8 respectively in SCI+MF group of rats. The results suggest a significant beneficial effect of chronic (2h/d × 8 weeks) exposure to MF (50 Hz, 17.96 µT) on food intake, water intake and body weight of paraplegic rats.

Recent survey of Indian SCI patients has revealed several secondary medical problems namely; bladder dysfunction (44%), neuropathic pain (42%), bedsores (36%), and spasticity (60%) compounded by
sarcopenia and paralysis. The resultant effect is a significant impairment of physical activity initiating a vicious circle of limited daily living activities, community mobility, cardiopulmonary health, bowel and bladder function, skin integrity, and spasticity. These factors are further worsened by redistribution of fat accumulation to supra lesion body parts leading to obesity-related diseases including: atherosclerosis, diabetes, dyslipidemia, hypertension; chronic pain; depression; and societal isolation\textsuperscript{35,9}. Moreover, the complexity is enhanced by the onset of dramatic and severe osteoporosis, which is attributed to unloading and neuro-hormonal changes\textsuperscript{36} besides the loss of calcium\textsuperscript{17}. SCI in rats has also been reported to reduce body weight, energy expenditure, whole body fat, lean tissue mass ratio, thermogenesis, and area under the curve of glucose tolerance test and insulin while it increases the catabolic rate and nitrogen loss. On the contrary, the food intake was surprisingly found to be higher post-SCI week 16-18\textsuperscript{3}. The decrease in body weight is postulated secondary to permanent changes in gastric motility and emptying; stress related hormones, regulatory homeostatic mechanisms, sarcopenia and BW/FI set-points. Although, this lacuna in literature has not been addressed, the mechanisms underlying long-term regulation of BW and FI are extensively reported. Nonetheless, it is pertinent to prevent the occurrence of these complications by non-pharmacological, non-invasive, easy to administer intervention which may significantly reduce the primary complications. Efficacy of MF in the management of these complications has been explored and has found it to be of significant benefit in restoration of locomotion, sensations, osteoporosis, eualgesia state and bladder control\textsuperscript{19-22}. Bladder control is restored by functional magnetic stimulation (FMS) in both SCI animal model and patients\textsuperscript{23-27}. The present report relates to its efficacy in the management of BW and FI too.

In SCI+MF group of rats, BW, FI, and WI reduced during post-SCI wk 4-8, wk 6-8 and wk 1, 8 respectively in a 8-week study period. MF has been reported to increase BW and FI by several researchers in intact cows and birds, which has been attributed to an increase in prolactin, and serotonin secondary to altered perception of prolonged photoperiod\textsuperscript{29,37-39}. FMS has been also reported to accelerate gastric emptying and decrease gastrointestinal transit time, stimulate colon and reduce colon transit time in both intact/SCI animals and subjects\textsuperscript{23-27}. Nonetheless, these changes cannot account solely for a significant reduction in BW, FI and WI. In our view severe osteoporosis in sub-lesional bones also contributes significantly to a decrease in BW. While, hypophagia is secondary to a central complex interaction of sensory and autonomic information, which is interrupted/ altered by SCI per se\textsuperscript{3}.

The neurophysiological mechanism underlying increase in food intake and body weight by MF exposure is not available in the literature and therefore needs to be studied systematically.

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References


