P. bridgesi has been introduced[5,6]. Therefore, adequate measure is urgently needed to stop their access into the open-air water bodies in India.

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Endurance exercise-induced alterations in antioxidant enzymes of old albino male rats

Antioxidant defence prevents the formation of active oxygen radicals and lipoperoxides and the antioxidant capacity decreases[1] with advancement of age. This increased production of reactive oxygen species with age leads to oxidative damage and mutations in DNA molecules. These damaged molecules transcribe and translate to produce dysfunctional protein subunits that give rise to defective enzymes[2].

Normally the free radicals that are generated are disposed off quickly by antioxidant defence system (ADC) present in cells. The ADS consists of free-radical scavenging enzymes like MnSOD, Cu, ZnSOD, catalase and antioxidants such as reduced glutathione (GSH), vitamin C, vitamin E, etc. An imbalance caused by increased generation of free radicals and decreased functional efficiency of ADS has been suggested to be one of the primary factors that contributes to the aging process[3]. An acute bout of exercise is known to increase the activities of antioxidant enzymes, including SOD and catalase in the tissues of rat[4–7]. The threshold and magnitude required for activation appear different among different enzymes and tissues. The studies on the impact of age and exercise on these enzymes are limited. In the present study an attempt has been made to know the effect of endurance exercise on free-radical scavenging enzymes in the tissues of old albino rats.

Healthy male albino rats (Wistar) were maintained in the animal house at 30 ± 2°C with photoperiod of 12 h light and 12 h darkness and fed standard rat diet supplied by Hindustan Lever Limited, Mumbai, India and water *ad libitum*.

The age-matched rats were divided into two batches of six each. One batch of rats was subjected to treadmill exercise, 30 min/day, maintaining a running speed of 23 m/min for 5 days/week for 12 weeks. The other batch of animals served as control. Both sets of rats were sacrificed by cervical dislocation 48 h after completion of exercise protocol. Liver, brain and heart were excised at 4°C and weighed immediately and homogenized in specified media.

The lipid peroxides (LP) were determined by the TBA method of Hiroshi *et al.*[8]. Xanthine oxidase (XOD) activity was estimated by the dye reduction method of Srikanthan and Krishna Murthy[9]. Superoxide dismutase (SOD) was assayed according to the method of Beauchamp and Fridovich[10]. Catalase (CAT) activity was measured by the method of Chance and Machlin[11].

Table 1 presents the changes in the activity levels of SOD, catalase, xanthine oxidase and lipid peroxides in liver, brain and heart of rats as a function of age and endurance exercise. The results indicated a drop in the activity levels of free-radical scavenging enzymes (SOD, catalase) with advancement of age. Three months endurance exercise to the rats reversed the age-induced changes in the activities of these enzymes almost to normal level.

The levels of XOD activity and lipid peroxides, the major indicators of oxidative stress, were found to increase in the tissues with age and exercise training caused further elevation in the activity.

Xanthine oxidase generates superoxide radicals during the reduction of O_2 to H_2O_2 and an age-related increase in the activity of XOD was observed in the present study (Table 1). The increase in enzyme activity with age shows increased production of oxygen radicals during aging. Further elevation in the activity levels of enzyme was observed due to exercise-induced oxidative stress and consequent increase in the production of radicals in the rat tissues. Xanthine oxidase was more in the tissues of young rats which were studied than in old rats, after three months exercise.

Lipid peroxidation is a complex process and the cell membranes enriched with PUFAs are more prone to lipid peroxidation, resulting in the loss of their fluidity and permeability properties leading to tissue damage in old

Table 1. Effect of exercise on age-dependent changes in tissue antioxidant enzymes (values represent means ± SD for 6 animals)

Measurement	Units	Control Young	Control Old	Exercised Young	Exercised Old	% change Young Control vs exercised	% change Old Control vs exercised
Liver							
XOD	μmoles of formazan formed/h/mg protein	0.74 ± 0.09	1.07 ± 0.14 (44.5)*	1.33 ± 0.14	1.74 ± 0.16 (30.8)	79.7*	62.6*
LP	μmoles of malondialdehyde present/g wet wt.	91 ± 5.8	111 ± 4.9 (21.9)*	118 ± 2.9	141 ± 3.3 (19.4)	29.6@	27.0@
SOD	Units of superoxide anions reduced/mg protein	12.30 ± 0.61	8.60 ± 0.38 (–30.0)	15.20 ± 4.9	11.30 ± 0.48 (–25.6)	23.5@	31.3@
CAT	μmoles of H_2O_2	5.46 ± 0.23	3.30 ± 0.31 (–39.5)	9.11 ± 0.39	4.39 ± 0.18 (–45.8)*	66.8*	49.3*
Brain							
XOD	μmoles of formazan formed/h/mg protein	0.95 ± 0.24	1.69 ± 0.17 (77.8)	1.31 ± 0.40	2.12 ± 0.24 (61.8)*	37.8@	30.7@
LP	μmoles of malondialdehyde present/g wet wt.	48.70 ± 2.8	62.6 ± 6.1 (28.5)	73.6 ± 4.3	90.20 ± 4.3 (22.5)	51.1*	44.0*
SOD	Units of superoxide anions reduced/mg protein	19.80 ± 0.6	16.60 ± 0.5 (–16.6)	36.6 ± 0.7	31.50 ± 1.7 (–13.9)	84.8*	89.7*
CAT	μmoles of H_2O_2 consumed/mg protein/min	3.84 ± 0.6	2.09 ± 0.3 (–45.5)*	6.62 ± 0.5	3.91 ± 0.5 (–40.9)*	72.3*	87.0*
Heart							
XOD	μmoles of formazan formed/h/mg protein	0.73 ± 0.14	0.92 ± 0.09 (26.0)@	1.03 ± 0.15	1.42 ± 0.26 (37.8)*	41.0*	54.3*
LP	μmoles of malondialdehyde present/g wet wt.	40.40 ± 3.6	55.70 ± 2.1 (37.8)	69.20 ± 3.1	79.30 ± 3.6 (14.5)@	71.0*	42.3*
SOD	Units of superoxide anions reduced/mg protein	9.78 ± 0.95	5.60 ± 0.53 (–42.7)	15.3 ± 0.99	8.90 ± 0.55 (–41.8)	56.4*	58.9*
CAT	μmoles of H_2O_2 consumed/mg protein/min	4.46 ± 0.37	1.59 ± 0.19 (–64.3)*	8.47 ± 0.42	3.01 ± 0.24 (–62.9)*	89.9*	89.3*

*Values significant at $P < 0.001$; values in parentheses indicate per cent change over young; @Significant at $P < 0.01$.

subjects[12]. A significant increase in lipid peroxidation observed in the present study in the three tissues (Table 1), suggests decreased functional efficiency of antioxidants and antioxidant enzymes with advancement of age, leading to increased free radical generation. Treadmill exercise further increased levels of LP in the tissues of young rats than in old rats.

The age-related decrease in the SOD activity observed in the present study indicates either reduced synthesis of the enzyme or elevated degradation or inactivation of the enzyme as age advances. Exercise increases O_2 consumption rate by 10–15 fold, which results in the production of superoxide radicals[7]. The increased XOD in the present study was in line with increased generation of superoxide anion radicals (Table 1) which would have triggered the induction of SOD, thereby preventing the accumulation of superoxide radicals in the tissues of old rats. SOD converts these superoxide radicals into H_2O_2, which is considered to be an adaptational change by exercise training to mitigate superoxide toxicity. The increase in SOD activity was more pronounced in the tissues of trained old rats, particularly in the brain, due to higher iron content in brain regions[13].

The increase in the activity of CAT indicates its active involvement in the decomposition of H_2O_2 during exercise. A change in the binding characteristics of enzyme to membranes or their release from peroxisomes has been proposed as a possible mechanism for increased activity levels of CAT[14]. The rise in CAT activity indicates major role of this enzyme in inorganic peroxide detoxification to prevent the secondary effects of peroxides formed during exercise. The exercise-induced elevation in the CAT activity was more pronounced in the brain of old rats compared to their younger counterparts.

To sum up, the present findings suggest that both aging and exercise influence oxidative stress and antioxidant capacity in the tissues of rat. The differential effect of training on various antioxidant enzymes may reflect the specific cellular locations where reactive oxygen species are produced, as well as basal antioxidant capacity in various tissues. The exercise training by inducing antioxidant capacity protects the individual against oxidative stress. In conclusion, it can be stated that three months endurance treadmill exercise has beneficial effect in improving antioxidant defence capacity by augmenting SOD, CAT and XOD activities of old rats, thereby preventing oxidative damage to the tissues.

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Population fluctuation of entomopathogenic nematode, *Heterorhabditis* sp. in South Andaman as influenced by weather parameters

The study on the population fluctuation of *Heterorhabditis* sp. in South Andamans indicated that the rainfall was positively correlated to nematode population ($r = 0.92^{**}$), whereas relative humidity ($r = -0.87^{**}$) and maximum temperature ($r = -0.67^{*}$) were negatively correlated. The prevalence increased from May onwards, reaching a peak in July and thereafter decreasing gradually till January coinciding with the wet period, thus having sufficient soil moisture for survival and persistence.

Entomopathogenic nematodes (Rhabditidae: Heterorhabditidae) occur throughout the world, where they play an important role in soil[1]. They are also used as biological control agents against many soil-dwelling insect pests[2].

The study of population dynamics of entomopathogenic nematodes is fundamental to understanding their persistence, distribution and effect on insect populations and for the development of predictive models for control programmes[3].

The weather parameters such as rainfall, relative humidity, soil and air temperature have influence on the persistence of entomopathogenic nematodes. Soil, the natural habitat for entomopathogenic nematodes varies greatly in chemical composition and physical structure. It is a dynamic system in a continual state of flux combined with its physical, biological and chemical complexity; this dynamic state makes the soil a difficult medium in which to conduct quantitative research.

A random survey undertaken during August 1996–December 1999, showed the presence of *Heterorhabditis* sp. in soil samples collected from various localities representing various agro ecosystems in South Andamans.

For study of the population dynamics of *Heterorhabditis* sp., a permanent site was selected at Chidiyatapu (latitude 11°41′–13°04′N and longitude 92°43′–30°16′E) where the nematode existed naturally. The soil of the site was sandy with organic matter content of 1.27% and pH of 7.11. Soil samples were collected at monthly intervals from a depth of 30 cm for a period of 41 months. The samples were baited with ten larvae of rice moth, *Corcyra cephalonica* and three replicates were maintained. The per cent larval mortality due to parasitization after three days of inoculation gave indirect measurement of the population of *Heterorhabditis* sp. in soil.

The data on per cent mortality of *Corcyra cephalonica* were pooled and subjected to simple correlation analysis against weather parameters[4]. The per cent *Corcyra* mortality served as dependent variable and weather parameters as independent variables.

The prevalence of *Heterorhabditis* sp. was significantly positively correlated with rainfall ($r = 0.92^{**}$). The prevalence was influenced by rainfall to the extent of 92%, the rest being contributed by other factors (Table 1). The prevalence started increasing from May onwards and reached a peak in July; thereafter it dropped gradually till January (Figure 1). Hence, the prevalence is greatly influenced by soil moisture. In Florida citrus groves, *Steinernematids* and *Heterorhabditids* were recovered from the soil most often from May to November[5].

Moisture plays a major role in survival of the entomopathogenic nematodes, which is influenced by the rainfall and soil type. Most of the positive sites were coastal, with sandy soils. The sandy soils have large pore space but less total pore space, than loam or clay soils[6]. The survival of *Steinernema carpocapsae* and *S. glaseri* was best in the sandy loam and sandy soils; high clay content resulted in lower nematode survival[7]. Similar observations were noticed with *S. carpocapsae* and *Heterorhabditis bacteriophora*[8]. Hence, *Heterorhabditis* sp. was recovered in coastal sandy soils frequently during May to January, coinciding with well-distributed rainfall and thus maintaining required conducive moisture and relative humidity in soil.

The prevalence of *Heterorhabditis* sp. was significantly negatively correlated with the relative humidity ($r = -0.87^{**}$).