Effects of Taurine Supplement in Conjunction with Exercise on Body Weight, Organ Weights and Blood Chemistry Parameters in Aged Rats

Jiraporn Onsri and Rungrudee Srisawat

***Abstract*—Taurine is the most abundant free amino acid in the body. The levels of taurine in plasma and tissue decrease with aging which may contribute to oxidative damage that occurs during the aging process. Regular exercise can delay the onset of age-related diseases by attenuating potentially harmful oxidative damage and suppressing inflammatory processes. However, there is no report about taurine supplement in conjunction with exercise in aging. This study investigated effects of taurine supplement in conjunction with exercise on body weight, relative organ weights (ROWs), and blood biochemical parameters in aged rats. Fifteen months old male Wistar rats (n=52) were allocated to 4 sedentary groups and 4 exercise groups. Rats in both groups were daily orally administered with DDD water, 1% Tween 80, vitamin E (50 IU/kg), or taurine (800 mg/kg), for 8 weeks at a volume of 8 ml/kg. Body weights were recorded weekly. At the end of experiment, blood samples were collected via cardiac puncture. The plasma biochemical parameters [Total cholesterol (TC), Triglyceride (TG), glucose, creatinine, blood urea nitrogen (BUN), aspartate aminotransferase (AST), and alanine aminotransferase (ALT)] were assessed using automate analyzer. The ROWs of liver, kidney, lung, spleen, heart, and gastrocnemius muscle were then measured. Final body weights (DDD water and vitamin E treatments) and plasma glucose levels (DDD water, 1% Tween 80, and taurine treatments) in exercise groups were significant lower than sedentary groups (P<0.05). Plasma BUN levels (DDD water treatment), plasma ALT levels (DDD water treatment), and heart ROW (DDD water, 1% Tween 80, and vitamin E treatments) in exercise groups were significant higher than sedentary groups (P<0.05). Taurine significant enhanced plasma TC levels in sedentary groups, significant reduced plasma TG levels in sedentary groups, and significant reduced plasma BUN levels in exercise groups (compared with DDD water treatment, P<0.05). Vitamin E significant reduced plasma TG and AST levels in sedentary groups (compared with 1% Tween 80 treatment, P<0.05). The present study provided the information about long term supplement of taurine alone and in conjunction with exercise on body weight, organ weights, and blood biochemical parameters in elderly. The future study should focus on the effects of taurine supplement in conjunction with exercise on modulation of oxidative stress in aging and aging-related disease.**

***Keywords*— exercise, aging, taurine, blood chemistry.**

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I. Introduction

Aging is an individual biological degenerative process that begins with birth and ends only with death. Aging is characterized by progressive deterioration in physiological functions and metabolic processes. Accumulation of the diverse deleterious changes that drive numerous age-related disorders produced by aging throughout the cells and tissues progressively impairs function and can eventually cause death. Within cellular alterations are found oxidative stress, inflammation, and mitochondrial dysfunction, factors that converge in the aging [1].

Regular physical activity or exercise appears to delay the onset of age-related diseases by attenuating potentially harmful oxidative damage and suppressing inflammatory processes [2]. Exercise has been reported to up-regulate protein synthesis, which in turn can improve cellular ability to remove damaged proteins postsynthetically by free radicals, with the capacity varying in the mitotic and nonmitotic cells [3]. Regular exercise is associated with reduction of risks of all causes of mortality and with increases in life expectancy. Physical activity and exercise can reduce the risk of age-associated diseases such as cardiovascular diseases, type 2 diabetes, metabolic syndrome, colon cancer, obesity, osteoporosis, sarcopenia, anxiety, and cognitive impairment [2].

Taurine (Tau), 2-aminoethanesulphonic acid, is found in liver, kidney, brain, retina, muscle tissue, and organs throughout the body [4, 5]. Taurine is essential for cardiovascular function, and development and function of skeletal muscle, the retina, and the central nervous system. Physiological and pharmacological roles of taurine has been reported including bile acids conjunction, plasma membrane stabilization, osmoregulation, neuromodulation, neurotransmission, anti-oxidation, and detoxification [6-8]. Taurine possesses hepatoprotective [9, 10], neuroprotective [11] and blood cholesterol-lowering effects [12]. Taurine also decreased body weight in young overweight adults [12]. These properties of taurine are related to its antioxidant activity that has been attributed to its ability to scavenge reactive oxygen species, to reduce the production of lipid peroxidation end products, and to stabilize biomembranes [5, 13]. It has been reported that the levels of taurine in plasma and tissue decrease with aging [14, 15] which may contribute to oxidative damage that occurs during the aging process [15]. However, the effects of taurine supplement in conjunction with exercise are not reported in aging. This study investigated effects of taurine supplement in conjunction with exercise on

body weight, organ weights, and blood biochemical parameters in aged rats.

II. Methods

Male albino rats of Wistar strain (15 months old) were obtained from Institutional Animal Care Unit, Suranaree University of Technology (SUT), Nakhon Ratchasima Province, Thailand. Animals were housed 1-2 per cage and maintained at standard laboratory conditions (a temperature of 20±1°C and under a daily photoperiod of 12 h-light and 12 h-dark cycles) with ad libitum food and water. All studies were conducted with permission from the SUT Animal Care and Use Committee.

After one week of acclimatization, rats (n=52) were randomly allocated to 4 sedentary groups, which did not undergo physical activity (Se), and 4 exercise groups (Ex), which were subjected to swimming exercise. Sedentary groups received a daily oral supplementation of 8 ml/kg of double deionized distilled water (DDDW+Se, n=7), 8 ml/kg of 1%Tween80 (1%Tween 80+Se, n=6), 50 IU/kg of vitamin E (Vit E+Se, n=7) [16], or 800 mg/kg of taurine (Tau+Se, n=7) [17]. Exercise groups were received a daily oral supplementation of 8 ml/kg of DDD water (DDDW+Ex, n=7), 8 ml/kg of 1%Tween 80 (1%Tween80+Ex, n=5), 50 IU/kg of vitamin E (Vit E+Ex, n=6) [16], or 800 mg/kg of taurine (Tau+Ex, n=7) [17]. Taurine and vitamin E (α-tocopherol) were purchased from Sigma-Aldrich Chemical (St. Louis, USA). All study drugs were given orally on a once-daily basis at a volume of 1 ml/kg body weight for 28 days. Training protocol for exercise groups was similar to the protocol as described earlier [18]. Briefly, the experiments were performed during the day (8:00–17:00 hr). Thirty minutes after dosing, rats in exercise groups were made to swim with 3% of their body weight tied to their tails. Initially, they were made to swim individually in a plastic pool (90 cm × 45 cm × 45 cm) filled with fresh water maintained at 37±1°C, approximately 60 cm deep so that rats couldn't support themselves by touching the bottom with their tails. Rats were made to exercise for 5 min per day with a progressive increase to 30 min per day for a total training period of 8 weeks with 5 days training days per week. Rats in sedentary groups were restricted to cage activity. Rats' body weights were recorded weekly.

At the end of observation period, all rats were fasted overnight. Immediately after last training, rats were anesthetized with pentobarbital sodium (Nembutal, Ceva Sante Animale, Libourne, France) at a dose of 60 mg/kg, (i.p.). Blood samples were collected *via* cardiac puncture into heparinized tubes and centrifuged at 2000×g at 4°C for 5 min. The obtained plasma were then used for determination of the plasma biochemical parameters [Total cholesterol (TC), Triglyceride (TG), glucose, creatinine, blood urea nitrogen (BUN), Aspartate aminotransferase (AST), and alanine aminotransferase (ALT)] using automate analyzer [19]. Immediately after blood collection, the organs (liver, kidney, lung, spleen, heart, and gastrocnemius muscle) were quickly dissected and weighed individually. The relative organ weight (ROW) of each organ was calculated using the following formula:

$$\text{ROW} = (\text{organ weight} \div \text{body weight}) \times 100.$$

Statistical analysis—All data are presented as the mean ± standard error of mean (SEM). Statistical significance for all variables was determined by analysis of variance (ANOVA) followed by a Duncan's method post hoc analysis by using program SigmaStat Version 3.5 (Systat Software, Inc., USA). P-values less than 0.05 ($P<0.05$) were considered statistically significant.

III. Results

The present study was conducted to determine the effects of 8 weeks supplementation of taurine and vitamin E in conjunction with exercise on body weight, relative organ weights (ROWs), and blood biochemical parameters in aged rats. At the beginning of the experiment, there were no significant differences in body weight between the groups (Fig. 1). No significant changes in body weight, beginning versus end of 8 weeks treatment, were noted in all treatment groups (Fig. 1). At the end of the 8 weeks treatment period, significant reductions in body weight were found following exercise in DDDW and vitamin E treated rats when compared with their respective sedentary rats ($P<0.05$, Fig. 1). There were no statistically significant differences in body weight between the exercise and sedentary groups treated with 1% Tween 80 and taurine for 8 weeks (Fig. 1). No significant differences in body weight were found between vitamin E and taurine in both in conjunction with exercise and sedentary as compared with their respective controls (Fig. 1).

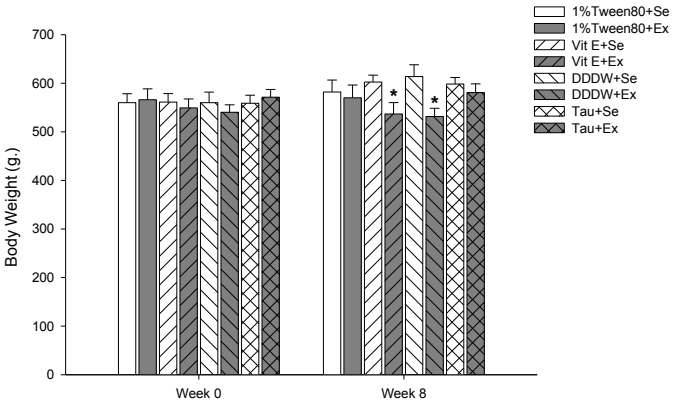

Fig. 1. Effects of taurine and vitamin E supplement in conjunction with exercise on body weight. Values are expressed as mean ± SEM. Asterisk indicates significant difference ($P<0.05$) between exercise and sedentary groups received same treatment.

Blood biochemical parameters were evaluated after the 8 weeks treatment period. Significant reductions in plasma glucose levels were found following exercise in DDDW, 1% Tween 80 and taurine treated rats when compared with their respective sedentary rats ($P<0.05$, Fig. 2). There were no statistically significant differences in plasma glucose levels between the exercise and sedentary groups treated with vitamin E for 8 weeks (Fig. 2). No significant differences in plasma glucose levels were found between vitamin E and taurine in both in conjunction with exercise and sedentary as compared with their respective controls (Fig. 2).

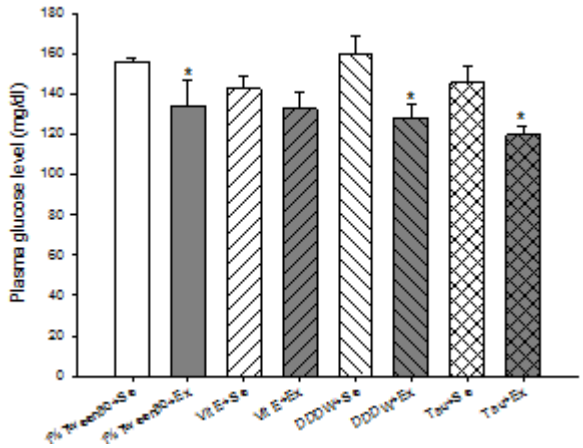

Fig. 2. Effects of taurine and vitamin E supplement in conjunction with exercise on plasma glucose levels. Values are expressed as mean ± SEM. Asterisk indicates significant difference (P<0.05) between exercise and sedentary groups received same treatment.

Significant increase in plasma BUN levels was found following exercise in DDDW, but not 1% Tween 80, vitamin E and taurine, treated rats when compared with their respective sedentary rats (P<0.05, Fig. 3). Eight weeks supplementation of taurine in conjunction with exercise (Tau+Ex) significantly decreased plasma BUN levels as compared to its control (DDDW+Ex) group (P<0.05, Fig. 3). In sedentary groups, plasma BUN levels in taurine treated rats and DDDW treated rats were not different (Fig. 3). No significant differences in plasma BUN levels were found between vitamin E in both in conjunction with exercise and sedentary as compared with their respective controls (Fig. 3).

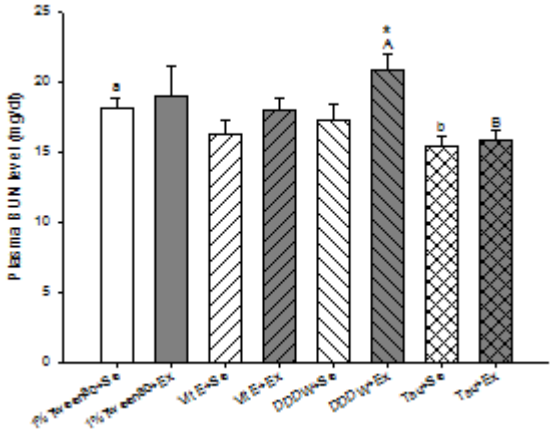

Fig. 3. Effects of taurine and vitamin E supplement in conjunction with exercise on plasma BUN levels. Values are expressed as mean ± SEM. Different letters indicate statistically significant differences (P<0.05) among different treatments in sedentary groups (lower case) or exercise groups (upper case). Asterisk indicates significant difference (P<0.05) between exercise and sedentary groups received same treatment.

There were no significant differences in plasma TC levels between exercise and sedentary in all treatments (Fig. 4). In sedentary groups, plasma TC levels in taurine treated rats were significantly higher than 1% Tween 80 and vitamin E treated rats (P<0.05, Fig. 4). Plasma TC levels in Vit E+Se group were similar to 1% Tween 80+Se group. In exercise groups, plasma TC levels were not different in all treatment groups (Fig. 4).

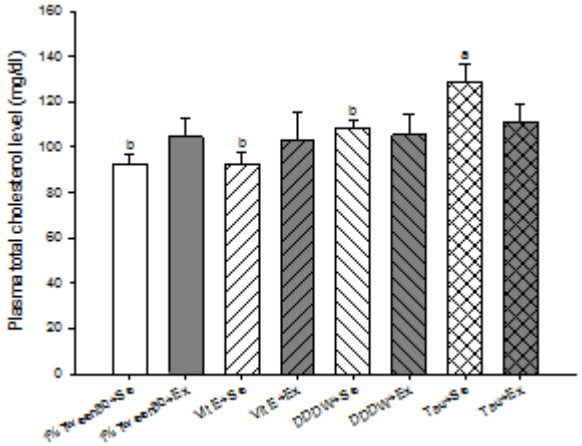

Fig. 4. Effects of taurine and vitamin E supplement in conjunction with exercise on plasma TC levels. Values are expressed as mean ± SEM. Different letters indicate statistically significant differences (P<0.05) among different treatments in sedentary groups (lower case).

There were no significant differences in plasma TG levels between exercise and sedentary in all treatments (Fig. 5). In sedentary groups, plasma TG levels in taurine and vitamin E treated rats were significantly lower than their respective controls (P<0.05, Fig. 5). No significant differences in plasma TG levels were found between taurine and vitamin E in conjunction with exercise as compared with their respective controls (Fig. 5).

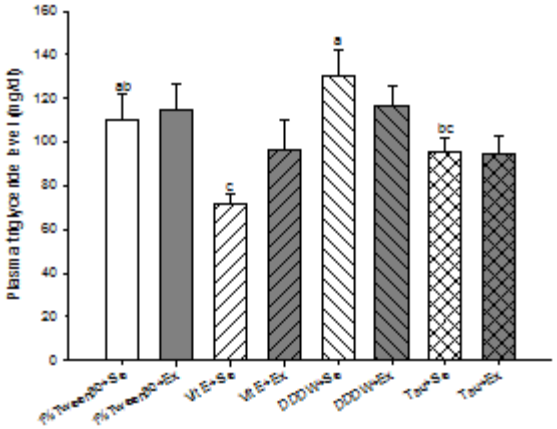

Fig. 5. Effects of taurine and vitamin E supplement in conjunction with exercise on plasma TG levels. Values are expressed as mean ± SEM. Different letters indicate statistically significant differences (P<0.05) among different treatments in sedentary groups (lower case).

There were no significant differences in plasma creatinine levels between exercise and sedentary in all treatments (Fig. 6). In sedentary groups, no significant differences in plasma creatinine levels were found between taurine and vitamin E as compared with their respective controls (Fig. 6). Plasma creatinine levels following taurine supplementation in conjunction with exercise was significantly higher than that of vitamin E (P<0.05, Fig. 6). Plasma creatinine levels in 1% Tween+Ex group were significantly lower than DDDW+Ex group (P<0.05, Fig. 6).

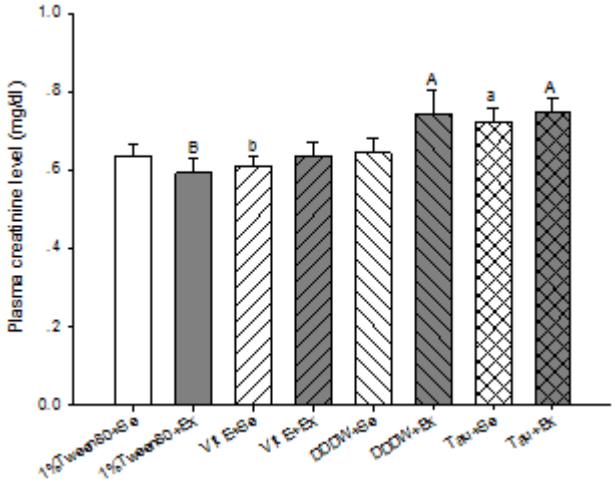

Fig. 6. Effects of taurine and vitamin E supplement in conjunction with exercise on plasma creatinine levels. Values are expressed as mean ± SEM. Different letters indicate statistically significant differences (P<0.05) among different treatments in sedentary groups (lower case) or exercise groups (upper case).

There were no significant differences in plasma AST levels between exercise and sedentary in all treatments (Fig. 7). In sedentary groups, 1% Tween 80 treatment showed significant higher plasma AST levels than DDDW and vitamin E treatments (P<0.05, Fig. 7). Morever, taurine treatment showed significant lower plasma AST levels than vitamin E treatment, DDDW treatment, in sedentary groups (P<0.05, Fig. 7). No significant differences in plasma AST levels were found between taurine and vitamin E in conjunction with exercise as compared with their respective controls (Fig. 7).

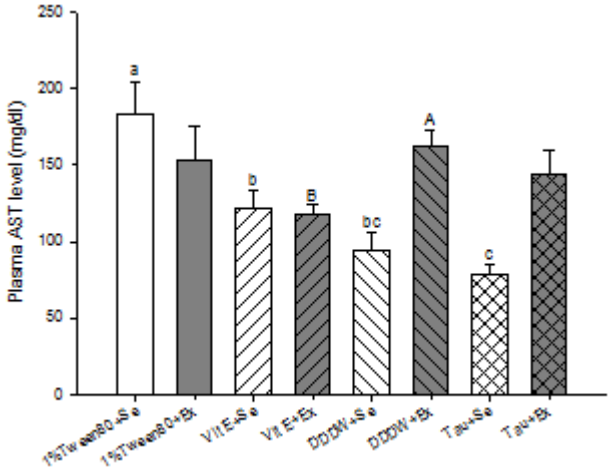

Fig. 7. Effects of taurine and vitamin E supplement in conjunction with exercise on plasma AST levels. Values are expressed as mean ± SEM. Different letters indicate statistically significant differences (P<0.05) among different treatments in sedentary groups (lower case) or exercise groups (upper case).

Significant increase in plasma ALT levels was found following exercise in DDDW treated rats when compared with its respective sedentary rats (DDDW+Se) (P<0.05, Fig. 8). There were no statistically significant differences in plasma ALT levels between the exercise and sedentary groups in all other treatments (Fig. 8). No significant differences in plasma ALT levels were found between vitamin E and taurine in both in conjunction with exercise and sedentary as compared with their respective controls (Fig. 8). Plasma ALT levels following taurine supplementation in conjunction with exercise was significantly higher than that of vitamin E (P<0.05, Fig. 8).

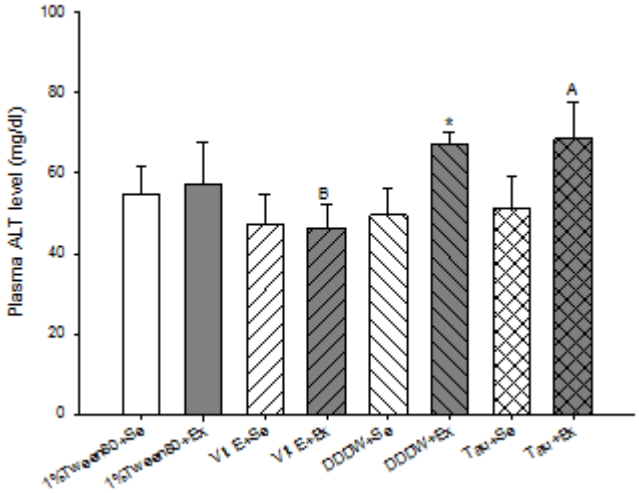

Fig. 8. Effects of taurine and vitamin E supplement in conjunction with exercise on plasma ALT levels. Values are expressed as mean ± SEM. Different letters indicate statistically significant differences (P<0.05) among different treatments in exercise groups (upper case). Asterisk indicates significant difference (P<0.05) between exercise and sedentary groups received same treatment.

The effects of taurine and vitamin E supplement in conjunction with exercise on the ROWs of liver, kidney, lung, spleen, heart, and gastrocnemius muscle in aged rats were shown in Table I. Significant increase in the ROW of heart were noted following exercise in rats treated with DDDW, 1% Tween 80 and vitamin E when compared with their respective sedentary rats (DDDW+Se, 1% Tween 80+Se and Vit E+Se, respectively) (P<0.05). The ROW of heart was not different in supplementation of taurine in conjunction with exercise as compared to sedentary. There were no statistically significant differences in the ROWs of other studied organs (liver, kidney, lung, spleen, and gastrocnemius muscle) between the exercise and sedentary groups in all treatments. No significant differences in the ROWs of all studied organs were found between vitamin E and taurine in both in conjunction with exercise and sedentary as compared with their respective controls.

TABLE I: EFFECTS OF TAURINE AND VITAMIN E SUPPLEMENT IN CONJUNCTION WITH EXERCISE ON THE RELATIVE ORGAN WEIGHT (ROW) OF LIVER, KIDNEY, LUNG, SPLEEN, HEART AND GASTROCNEMIUS MUSCLE IN AGED RATS.

Group	ROW (g per 100 g body weight)					
	Liver	Kidney	Lung	Spleen	Heart	Gastrocnemius
DDDW+Se	2.25 ± 0.22	0.53 ± 0.05	0.48 ± 0.11	0.18 ± 0.03	0.24 ± 0.02	1.04 ± 0.11
DDDW+Ex	2.64 ± 0.48	0.63 ± 0.15	0.62 ± 0.17	0.20 ± 0.04	0.32 ± 0.05*	1.18 ± 0.29
1%Tween80+Se	2.22 ± 0.36	0.53 ± 0.10	0.54 ± 0.17	0.20 ± 0.02	0.27 ± 0.04	1.07 ± 0.14
1%Tween80+Ex	2.31 ± 0.28	0.57 ± 0.07	0.60 ± 0.20	0.18 ± 0.01	0.33 ± 0.03*	1.08 ± 0.06
Vit E+Se	2.19 ± 0.22	0.56 ± 0.05	0.63 ± 0.21	0.20 ± 0.02	0.26 ± 0.03	1.10 ± 0.09
Vit E+Ex	2.27 ± 0.46	0.63 ± 0.09	0.52 ± 0.17	0.20 ± 0.05	0.33 ± 0.06*	1.15 ± 0.13
Tau+Se	2.20 ± 0.27	0.60 ± 0.07	0.49 ± 0.09	0.20 ± 0.02	0.26 ± 0.03	1.04 ± 0.13
Tau+Ex	2.45 ± 0.42	0.62 ± 0.11	0.48 ± 0.21	0.18 ± 0.03	0.31 ± 0.05	1.07 ± 0.13

Values are expressed as mean ± S.E.M. Asterisk indicates significant difference ($P<0.05$) between exercise and sedentary groups received same treatment.

IV. DISCUSSION

The present study demonstrated that taurine supplement (oral daily administration of taurine at a dose of 800 mg/kg for 8 weeks) with exercise has been shown to help maintain body weight level in aging rat model since taurine did not cause changes in final body weight. This finding is consistent with the previous study [6]. Body weight was not change in adult rats with and without oral daily administration of taurine up to 500 mg/kg/day for 2 weeks. Therefore, taurine supplement with exercise appears to be safe to aging rats.

In the present study, taurine supplement with and without exercise did not cause changes in ROWs of all studied organs (liver, kidney, lung, spleen, heart, and gastrocnemius muscle) in aging rats. Previous study in adult rats, oral daily administration of taurine up to 500 mg/kg/day for 2 weeks caused no change in wet weight of liver and gastrocnemius muscle [6]. Oral daily administration of taurine (at a dose of 500 mg/kg/day) increased wet weight of heart. Without taurine and low doses of taurine did not cause change in wet weight of heart of adult rats.

In comparison to sedentary, taurine supplement in conjunction with exercise showed significant reduction in plasma glucose levels in aging rats. In contrary to previous study in adult rats [6], the serum glucose level in the exercise without taurine group was significantly decreased compared to that in the non-exercise without taurine group, but remained unchanged among exercise groups with taurine up to 500 mg/kg/day.

In sedentary groups, taurine caused significant reduction in plasma TG levels and significant enhancement in plasma TC levels. The hypotriglyceridemic effect, but not hypercholesterolemic effect, of taurine in aging is consistent withthe previous study in young rats fed with hypercholesterolemic diet (HCD) [20]. Addition of taurine in HCD diet showed a significant reduction in serum total cholesterol and triglyceride levels compared to the animals fed HCD alone.

In exercise groups, taurine caused significant reduction in the plasma BUN levels. Taurine did not cause changes in plasma levels of creatinine in both exercise and sedentary groups in rat models of aging. Creatinine and BUN are nitrogenous end products of metabolism that are commonly used markers of renal function and also considered to be one of the uremic toxins, and it's increased in renal failure [18]. Thus, taurine supplement can help prevent kidney damage and may improve renal function.

Taurine did not cause changes in plasma levels of AST and ALT in both exercise and sedentary groups in rat models of aging. Consistent with previous study [21], taurine supplementation did not cause changes in serum AST and ALT levels in healthy mice. Taurine supplementation could suppress the increased serum levels of AST and ALT in iron-overloaded mice. Since both ALT and AST are important biomarkers for liver function [22]. Thus, taurine supplementation could be a useful therapeutic alternative to reduce the hepatic toxicity.

V. CONCLUSION

The present study provided the information about long term supplement of taurine alone and in conjunction with exercise on body weight, organ weights, and blood biochemical parameters in elderly. The future study should focus on the effects of taurine supplement in conjunction with exercise on modulation of oxidative stress in aging and aging-related disease.

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