Wu et al., Afr J Tradit Complement Altern Med., (2017) 14 (1): 52-61
doi:10.21010/ajtcam.v14i1.7

EFFECTS AND MECHANISMS OF A NEW MULTIVITAMIN ON CHRONIC METABOLIC SYNDROMES AND AGING

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Abstract

Background: Increased occurrence of chronic syndromes has prompted researchers to investigate and develop drugs and methods for controlling chronic syndromes with a view to improve human health and reduce early aging.
Material and methods: Human trials: After the allotted multivitamin pills or placebo pills had been taken for a stipulated period of about 2 months, the volunteers filled out feedback forms on curative effects of the pills in line with the health examination reports. The effects of the multivitamin on various symptoms or diseases and dysfunctions of the chronic metabolic syndromes were noted and evaluated based on the information provided in forms.
Animal experiments: Mouse aging model induced by D-galactose were administered the multivitamin by oral gavage every morning. At the end of the sixth week, activity or content of the components associated with ageing and anti-aging in the brain and liver of the aging mice were determined to investigate the mechanisms of the new multivitamin on chronic metabolic syndromes and aging.
Results: We found that multivitamin can eliminate or attenuate 38 types of symptoms or dysfunctions of the investigated metabolic syndromes; and that it has both preventive and curative/adjunctive therapeutic effects on the metabolic syndromes. The effects of this multivitamin on components associated with aging and anti-aging were significantly decreased - malondialdehyde content and monoamine oxidase activity but significantly increased activity of superoxide dismutase and glutathione peroxidase. This multivitamin has significant anti-aging effects.
Conclusion: Supplementing with this multivitamin can prevent and provide treatment/ adjunctive therapy for these chronic metabolic syndromes and delay the aging process.

Keywords: Aging, Anti-aging, Metabolic syndrome, Mechanism, Multivitamin

List of Abbreviations: BW, body weight; Cu/Zn-SOD, cuprum/zinc-superoxide dismutase; **MAO,** monoamine oxidase; **MDA,** malondialdehyde; Mn-SOD**,** manganese-superoxide dismutase; T-SOD, total superoxide dismutase; TP, total protein.

Introduction

Although remarkable progress has been made in research on the aetiology and pathogenesis of human chronic metabolic syndromes and chronic diseases, especially their genetic basis (Arner, et al. 2011; Hotamisligil, 2006; Mani, et al. 2007; Turek et al., 2005), their occurrence keep increasing. The prevention and treatment of some chronic metabolic syndromes have for long become global issues in medicine (Vijg, et al. 2008). Conducting research and

doi:10.21010/ajtcam.v14i1.7

developing drugs for prevention and treatment of chronic metabolic syndromes and decreased aging process have great scientific impact and wide application value for improving the health of the people and retards the aging process (Bard, 2006; Chen, et al. 2008; Rader, et al. 2008).

The life processes of organisms essentially consist of a series of enzymatic reactions. If an enzymatic biochemical reaction is interrupted, the physiological function is affected, which may in turn cause diverse chronic disease, especially chronic metabolic syndromes and accelerate aging (Khor, et al. 2011; Bensinger, et al. 2008; Chocano-Bedoya et al., 2011).

When aging, malondialdehyde (MDA) content and monoamine oxidase (MAO) activity increase, whereas superoxide dismutase (SOD) activity and glutathione peroxidase (GSH-Px) activity decreases. Studies have shown that MDA is an important component that accelerates aging of the body; such that increase in the MAO activity increases the breakdown of monoamine neurotransmitters and affect body health; the GSH-Px activity and SOD activity increase can accelerate the removal of free radicals and peroxides and delay aging. Therefore, MDA content, MAO activity, GSH-Px activity and SOD activity are important parameters for assessing the severity of body aging and health (Chen, et al. 2000; Li, et al. 2007; Pan, et al. 2012).

Modern studies have confirmed that vitamins B-1, B-2, B-6 and PP are key components that form many coenzymes (thiamine pyrophosphate, flavin adenine dinucleotide, flavin mononucleotide, pyridoxal phosphate, nicotinamide adenine dinucleotide, nicotinamide adenine dinucleotide phosphate) (Wang, et al. 2002). Those coenzymes participate in more than 300 enzymatic reactions related to the metabolism of matter–energy and protein. For example, the coenzymes that make up vitamin PP participate in more than 200 enzymatic reactions related to matter–energy metabolism (Huang, 2003), and those that make up vitamin B-6 participate in approximately 100 enzymatic reactions related to the metabolism of proteins and fat (Wu, 2005). Those coenzymes play a key role in the transfer of hydrogen ions and electrons, decarboxylation, transamination and racemisation in those enzymatic reactions (Wang, et al. 2002). Vitamins B-1, B-2, B-6 and PP can improve matter-energy metabolism and protein metabolism and to prevent the formation and the accumulation of the components associated with chronic metabolic syndromes and aging in organisms and strengthen the body's health by means of their synergistic effects (Wang, et al. 2002; Huang, 2003; Wu, 2005). So we believed that chronic metabolic syndromes and aging process can be controlled through supplementing with vitamins B-1, B-2, B-6, PP and antioxidant vitamins.

In order to verify our conjecture, we performed human trials, animal experiments, and biochemical analysis of the components (MDA, MAO, GSH-Px and SOD) associated with aging and anti-aging to investigate the effects and mechanisms of a new multivitamin on chronic metabolic syndromes and aging. We found this multivitamin can eliminate or attenuate many symptoms ore dysfunctions of the investigated chronic metabolic syndromes and delay the aging process.

Material and Methods

Design of multivitamin

When we developed this multivitamin, we took into consideration the causes and Mechanism of chronic metabolic syndromes and age-related diseases (see Additional file 1). We determined the basal dosage of various vitamins according to the recommended nutrient intake for adult. Our focus was on creating a new multivitamin with suitable proportions of vitamins PP, B-1, B-2 and B-6 and of antioxidant vitamins. This process also involved factoring in the synergistic effects of these components. Specifically, we increased the amount of vitamin PP and B-6 according to their importance in controlling chronic metabolic syndromes and decreased the number of fat-soluble vitamins (vitamins A and E), which have been reported as producing side effects (Bjelakovic, et al. 2007). A multivitamin pill contains 50 mg of vitamin PP; 50 mg of vitamin C; 12.5 mg of vitamin E; 5 mg each of vitamins B-1, B-2 and B-6; 0.8 mg of vitamin A; and 121.7 mg of medical starch. This multivitamin differs from standard commercial multivitamin pills, possesses

doi:10.21010/ajtcam.v14i1.7
good curative effects on chronic metabolic syndromes and produces no chronic toxicity (Tao et al.,2012).

Human trials

The study was performed as a single blind randomized controlled trial in the People's Hospital of Hunan Province and the Hospital of Changsha University of Science and Technology. A group of individuals (volunteers, *n*=76) identified as suffering from various chronic metabolic syndromes or a sub-health condition were selected to participate in human trials. Volunteers were excluded from the study if they had an allergy for nicotinic acid. They were randomly assigned to either the experimental group (*n* = 56) or the control group (*n* = 20). The volunteers in the experimental group received 2 bottles of the multivitamin pills (1 bottle = 100 pills) and the volunteers in the control group received 2 bottles of placebo pills (a pill of the placebo contains 250 mg of medical starch). All the volunteers received feedback forms (see table S1 of additional file 2) and instructions for using the multivitamin or placebo (usage methods and dosage of the multivitamin and the placebo：Oral administration after meals, 1–10 days, 3 times a day, 2 pills each time; 11–30 days, 2 times a day, 2 pills each time; 31–60 days, 2 times a day, 1–2 pills each time. After 60 days, the multivitamin was taken according to the needs of the body). We did not ask the volunteers to undergo any other treatments, except for those with severe hypertension, coronary heart disease, diabetes and infections, nor did we give them any advice concerning diet, lifestyle and exercise. After the allotted multivitamin pills or placebo pills had been taken for a time period of 2 months, the volunteers filled out feedback forms to show their curative effects according to the table S1 of Additional file 2 and Additional file 3. The feedback forms and health examination reports were either returned by the volunteers or collected by us. The effects of the multivitamin on various symptoms or diseases and dysfunctions of the chronic metabolic syndromes were counted and evaluated based on health examination reports and the information provided on the feedback forms regarding curative effects.

The study was approved by the Medical Research Ethics Committee of the Changsha University of Science and Technology, China, and written consents were obtained from all volunteers.

Animal experiments

To explore the mechanisms of the investigated multivitamin in aging process, we also conducted tests on the mouse aging model induced by D-galactose. The aging animal model was integrated with animal model design based on the principle of metabolic disturbance in the aging process. That is, each organ exhibits different degrees of senile symptoms, and, accordingly, aged-related biochemical parameters in the body change by aging. This aging model is the ideal experimental tool for studying metabolic diseases, age-related diseases and anti-aging effects and has been widely used to study the anti-aging action of drugs and functional foods (Lu, et al. 2007; Song, et al. 1999; Zhang, 2007).

Following a 7-day acclimation period, 50 mice were randomly assigned to different groups 1 of 5 (3 dose experimental groups, 1 aging model group, and 1 control group) of 10 mice (5 males; 5 females) each. They were allowed free access to food and water. The mice in the high-medium and low-dose experimental groups and in the aging model group were subcutaneously injected with D-galactose at a dose of 150 mg/kg once daily for 6 weeks, whereas those in the control group were treated with the same volume of physiological saline (0.5 mL). At approximately the same time, the aging mice in the high-medium and low-dose experimental groups were administered multivitamin at doses of 42.32, 21.66, and 10.83 mg/kg BW/day by oral gavage, respectively, every morning, with the mice in the aging model group and the control group receiving the same volume of distilled water (0.4 mL/10 g BW/day). Weekly adjustments were made for BW changes. Following treatment, clinical observations were made. The general condition of all animals was recorded every day. At the initiation of the experiments and at the end of every other week, BWs were measured. Throughout the experiments, food consumption was recorded every day, and the average food consumption per animal was calculated at weekly intervals. At the end of the sixth week, the animals were

doi:10.21010/ajtcam.v14i1.7

euthanized to undergo a gross pathological examination. The brain and liver were then removed from each cadaver for biochemical analysis.

The brain and the liver were homogenised by a method traditionally used in the literature, and the supernatant liquid of the homogenate was removed for biochemical analysis. The MDA content, total superoxide dismutase (T-SOD) activity, cuprum/zinc-superoxide dismutase (Cu/Zn-SOD) activity, GSH-Px activity, MAO activity, and total protein (TP) content were determined with the appropriate biochemical analysis kits (Nanjing Jiancheng Bioengineering Institute, Nanjing, China) and the UV754N ultraviolet spectrophotometer (Shanghai Exact Scientific Instrument, Shanghai, China) in accordance with the respective kit instructions. Thereafter, the effects and mechanisms of this multivitamin in delaying aging were determined based on its impact on the components associated with aging and anti-aging.

Statistical analysis

Data are presented as mean ± SEM. The significance of the difference between the control group and the treated groups for total BWs and food consumption values for mice, content and activity of the components associated with aging and anti-aging in brain and liver was analyzed with Statistical Product and Service Solutions software, version 11.5 (analysis of variance: Student Newman-Keuls). Statistical significance was established at $p < 0.05$.

Results

Human trial results

At the end of human trials, we collected the feedback forms on the curative effects (see Table S2–S44 of Additional file 2) and the health examination reports (see Table S1-S13 of Additional file 4) from the experimental group and the control group. Statistical analyses suggest that the multivitamin can eliminate and/or attenuate 38 types of symptoms or chronic diseases and dysfunctions of the investigated chronic metabolic syndromes (see table 1) and has preventive and curative / adjunctive therapeutic effects on the chronic metabolic syndromes. Chronic metabolic syndromes of the volunteers in the control group did not show any improvement and they looked older (see Fig. S1 of Additional file 5).

Table 1: Effects of the multivitamin on various symptoms and dysfunction of chronic metabolic syndromes (N=56).

Effects of the multivitamin on symptoms or dysfunction of chronic metabolic syndromes	Evaluation				
	A. Cure	B. effect	Substantial	C. Some effect	D. No effect
Improved resistance; prevented cold or rheums		17		12	
provided adjunctive therapy for colds; reduced recovery time for colds		16		13	
Prevented and treated chronic enteritis	1	5		13	
Prevented and treated chronic rhinitis	1	7		16	
Prevented and treated chronic faucitis	1	5		9	
Prevented and treated itchy skin	3	6		4	
Prevented and provided treatment/ adjunctive therapy for intractable skin diseases	2	2			
Prevented and treated anal itching	4	1		1	1
Prevented and treated dandruff and itchy scalp	4	6		7	1
Prevented and treated dizziness	3	3		8	

doi:10.21010/ajtcam.v14i1.7

Enhanced memory		7	1	
Enhanced male sexual function and delayed ejaculation		5	3	
Eliminated pigment spots/ age pigments	2	5	9	
Prevented and treated chest discomfort or chest pain induced by exercise or fast walking	3	3	1	
Prevented and provided treatment/ adjunctive therapy for heart disease		4	5	
Prevented and provided treatment/ adjunctive therapy for hypertension or stabilized blood pressure	1	6	4	1
Provided rehabilitation of lumbar intervertebral disc protrusion sequelae	3	3	4	
Prevented and treated physical weakness and heavy feet or inability to walk	2	3	4	
Prevented and treated gingival bleeding	5	8	8	
Prevented and treated bad breath (halitosis)	4	3	3	
Prevented and treated odontopathy and loose teeth	2	3	2	
Prevented and treated oral cavity ulcers	3	4	5	
Prevented and provided treatment/adjunctive therapy for intractable tinea pedis	1	1	3	1
Prevented and provided treatment/ adjunctive therapy for leuconychia and nail deformities		3	2	1
Prevented and provided treatment/ adjunctive therapy for intractable facial acne		3	1	
Prevented and treated gynecopathy	1		1	
Eliminated skin nodules	1	2	1	
Eliminated dewlaps	1		2	
Increased skin elasticity, reduced skin wrinkles (anti-aging effects)		15	9	
Anti-fatigue		12	8	
Darkened hair and body hair		4		
Prevented and treated hemorrhoids	2			
Prevented and treated chronic tympanitis	1			
Prevented and treated hyperacidity	1	1		
Prevented and treated trigeminal neuralgia		1		
Treated sequelae of lumbar injury		1		
Prevented and treated melancholia		1		
Cerebral hemorrhage sequelae		1		

The results of the animal experiments

The results of the animal experiments indicated that the mice in the aging model group exhibited obvious senility symptoms, such as reduced activity; sparse, dull yellow fur; irritable temperament, and thin dejecta. The appearance, behaviour, urine and fur of mice in the three dose groups were similar to those in the control group. A summary of total

doi:10.21010/ajtcam.v14i1.7

BW (Table S1) and food consumption values (Table S2) is presented in Additional file 6. Contrastive analysis showed no statistically significant changes in food consumption and BW values between the three dose groups and the control group ($p > 0.05$). However, food consumption and BW values of the aging group were significantly lower than those of the dose groups and those of the control group ($p < 0.05$).

The MDA content and MAO activity in the brain and liver of the mice in each group were determined with MDA and MAO kits, respectively. Results are shown in Table 2.

The GSH-Px activity in the brain and liver of the mice in each group were determined with a GSH-Px kit. Results are presented in Table 3.

The T-SOD and CuZn-SOD activity in the brain and liver of the mice in each group were determined with an SOD typing kit. The activity of Mn-SOD equals the activity of T-SOD minus the activity of CuZn-SOD. Results are shown in Table 4 and 5. Contrastive analysis showed that the MDA content and MAO activity of the brain and the liver of the mice in the aging model group were significantly higher than those of the control group ($p < 0.01$), and the GSH-Px activity, T-SOD activity, CuZn-SOD activity, and Mn-SOD activity of the mice in the aging model group was significantly lower than that of the control group ($p < 0.01$). This finding shows that the injection of D-galactose into mice induced changes related to aging and confirmed that the construction of the mouse aging model was successful.

Contrastive analysis showed no statistically significant changes in the MDA content, MAO activity, GSH-Px activity, T-SOD activity, CuZn-SOD activity, and Mn-SOD activity among the three dose groups, nor between the dose groups and the control group ($p > 0.05$); however, they significantly differed ($p < 0.05$) or very significantly differed from those in the aging model group ($p < 0.01$). This finding demonstrates the remarkable anti-aging effect of this multivitamin.

Table 2: Effects of the multivitamin on MDA content and MAO activity of brain and liver of mice in each group (n=10)

Group	MDA (nmol/mgprot)		MAO (U/mgprot)	
	Brain	Liver	Brain	Liver
Low dose	1.36±0.18 $^{\dagger 3, \ddagger 2, \S 3}$	1.34±0.14 $^{\dagger 3, \ddagger 2, \S 3}$	9.16±1.37$^{\dagger 3,\ddagger 1, \S 3}$	2.17±0.22$^{\dagger 3,\ddagger 2, \S 3}$
Medium dose	1.38±0.21 $^{\dagger 3, \ddagger 2, \S 3}$	1.36±0.16 $^{\dagger 3, \ddagger 2, \S 3}$	9.10±1.21$^{\dagger 3,\ddagger 1, \S 3}$	2.06±0.17$^{\dagger 3,\ddagger 2, \S 3}$
High dose	1.55±0.21$^{\dagger 3, \ddagger 1, \S 3}$	1.45 ±0.19 $^{\dagger 3, \ddagger 2, \S 3}$	9.00±1.10$^{\dagger 3,\ddagger 1, \S 3}$	1.98±0.19$^{\dagger 3,\ddagger 2, \S 3}$
Aged model	1.77±0.3$^{\S 2}$	1.82±0.18$^{\S 2}$	10.78±2.12$^{\S 2}$	2.78±0.13$^{\S 2}$
Control	1.30±0.15	1.18±0.15	8.51±1.74	1.88±0.16

† denotes comparison among the three dose groups; $^{\dagger 1}$: $p < 0.05$; $^{\dagger 2}$: $p < 0.01$; $^{\dagger 3}$: $p > 0.05$.

‡ denotes comparison between dose groups and aging model group, $^{\ddagger 1}$: $p < 0.05$; $^{\ddagger 2}$: $p < 0.01$; $^{\ddagger 3}$: $p > 0.05$.

§ denotes comparison between dose groups, aging model groups and control group, $^{\S 1}$: $p < 0.05$; $^{\S 2}$: $p < 0.01$; $^{\S 3}$: $p > 0.05$.

Table 3: Effects of the multivitamin on GSH-Px activity of brain and liver of aging mice (n=10 mice; Unit = U/mgprot)

Group	Brain	Liver
Low dose	162.81±29.21 $^{\dagger 3, \ddagger 2, \S 3}$	436.16±40.47 $^{\dagger 3, \ddagger 1, \S 3}$
Medium dose	169.5127.66 $^{\dagger 3, \ddagger 2, \S 3}$	441.17±37.43 $^{\dagger 3, \ddagger 1, \S 3}$
High dose	171.61±26.29 $^{\dagger 3,\ddagger 2, \S 3}$	437.76±39.05 $^{\dagger 3, \ddagger 1, \S 3}$
Aged model	106.78±7.92$^{\S 2}$	368.30±57.85$^{\S 2}$
Control	187.88±19.88	447.50±60.19

† denotes comparison among the three dose groups; $^{\dagger 1}$: $p < 0.05$; $^{\dagger 2}$: $p < 0.01$; $^{\dagger 3}$: $p > 0.05$.

‡ denotes comparison between dose groups and aging model group; $^{\ddagger 1}$: $p < 0.05$; $^{\ddagger 2}$: $p < 0.01$; $^{\ddagger 3}$: $p > 0.05$.

doi:10.21010/ajtcam.v14i1.7

§ denotes comparison between dose groups, aging model group and control group; §1: $p < 0.05$; §2: $p < 0.01$; §3: $p > 0.05$.

Table 4: Effects of the multivitamin on T-SOD activity, CuZn-SOD activity and Mn-SOD activity of brain of aging mice (n=10 mice; Unit =U/mgprot)

Group	T-SOD	CuZn-SOD	Mn-SOD
Low dose	207.18±31.29 †3, ‡2, §3	159.54±30.03 †3, ‡2, §3	47.64±9.78†3, ‡2, §3
Medium dose	209.16±30.21†3, ‡2, §3	160.34±29.21†3, ‡2, §3	48.82±10.27†3, ‡2, §3
High dose	208.68±31.57†3, ‡2, §3	161.65±28.92†3, ‡2, §3	49.77±11.07†3, ‡2, §3
Aged model	156.65±14.92 §2	121.73±15.87 §2	34.92±10.44 §2
Control	217.37±28.17	161.87±16.97	53.50±12.62

† denotes comparison among the three dose groups; †1: $p < 0.05$; †2: $p < 0.01$; †3: $p > 0.05$.

‡ denotes comparison between dose groups and aging model group; ‡1: $p < 0.05$; ‡2: $p < 0.01$; ‡3: $p > 0.05$.

§ denotes comparison between dose groups, aging model groups and control group; §1: $p < 0.05$; §2: $p < 0.01$; §3: $p > 0.05$.

Table 5: Effects of the multivitamin on T-SOD activity, CuZn-SOD activity and Mn-SOD activity of liver of aging mice (n=10 mice; Unit = U/mgprot).

Group	T-SOD	CuZn-SOD	Mn-SOD
Low dose	117.80±8.62 †3, ‡2, §3	102.60±4.80 †3, ‡2, §3	15.20±7.96 †3, ‡2, §3
Medium dose	119.67±9.03†3,‡2, §3	104.63±5.12†3,‡2, §3	16.04±9.78†3,‡2, §3
High dose	120.13±8.83†3,‡2, §3	103.98±4.16†3, ‡2, §3	17.70±10.08†3,‡2, §3
Aged model	98.93±3.93 §2	87.36±6.86 §2	11.57±6.57 §2
Control	123.72±13.67	104.56±8.73	19.16±10.62

† denotes comparison among the three dose groups; †1: $p < 0.05$; †2: $p < 0.01$; †3: $p > 0.05$.

‡ denotes comparison between dose groups and aging model group; ‡1: $p < 0.05$; ‡2: $p < 0.01$; ‡3: $p > 0.05$.

§ denotes comparison between dose groups, aging model groups and control group; §1: $p < 0.05$; §2: $p < 0.01$; §3: $p > 0.05$.

Discussion

We found that the symptoms and dysfunctions of these chronic metabolic syndromes occurred mainly in metabolically active tissues and organs (e.g., tissues and organs of the cardiovascular system; the digestive system; the skin; teeth and so on). These parts of the body need more energy and more protein so as to maintain normal function and structure. In addition, we found that this multivitamin had poor curative effects or were inefficacious in a few symptoms or chronic diseases of the chronic metabolic syndromes. Upon further investigation, we determined that the main reasons for its poor curative effects or inefficacy were inadequate dosage, shortened duration of multivitamin use or the presence of a secondary disease, because chronic metabolic syndromes is the result of cumulative damage over a period of time caused by long-term subclinical deficiencies in some important nutrients. Therefore, sufficient dose (4–6 pills) and sufficient time are required to achieve a satisfactory therapeutic effect, and that a small dose of the investigated multivitamin (1–3 pills) has preventive effects for these chronic metabolic syndromes, and a high dose (4–6 pills) has curative/ adjunctive therapeutic effects for these chronic metabolic syndromes.

The main reasons of preference for this multivitamin is that it is better than other multivitamins we took into consideration in the causes and Mechanism of chronic metabolic diseases and aging. Our focus was on creating a new multivitamin with suitable proportions of vitamins PP, B-1, B-2 and B-6 and of antioxidant vitamins. This process also involved factoring in the synergistic effects of these components. Specifically, we increased the amount of vitamin PP and B-6 according to their importance in controlling chronic metabolic syndromes and decreased the number of fat-soluble vitamins (vitamins A and E). Therefore, this multivitamin can prevent and provide treatment/ adjunctive therapy for many chronic metabolic diseases and significantly delay aging process.

Why was the multivitamin able to eliminate and attenuate 38 types of symptoms or chronic diseases and dysfunctions of the chronic metabolic syndromes and delay significantly aging? Supplementing with these vitamins can increase the number of coenzymes. An increase in the number of coenzymes may increase the number of active enzymes. An increase in the number of active enzymes may make hundreds of interrelated enzymatic reactions occur more smoothly (Pauling, 1989), accelerate the oxidative decomposition of lipids and saccharides (such as D-galactose) into carbon dioxide and water in the body, prevent the production and accumulation of the components (for example galactitol, MDA, other peroxides and mesostates and so on) associated with metabolic syndromes and aging, and provide a large amount of energy. Studies have shown that improvements in the metabolism of matter–energy and protein are propitious to the synthesis of enzyme proteins (such as GSH-Px, CuZn-SOD, and Mn-SOD)(Li, et al. 2007; Pan, et al.2012; Li, et al.2013), structural proteins and other functional materials in the body and help to maintain the normal structure and function of histiocytes and DNA (Ribeiro, et al. 2007), especially the structure and function of histiocytes that are metabolically active, to prevent the occurrence of metabolic syndromes, especially chronic inflammation (Yang, et al. 2009). These improvements can enhance the regulatory functions of histiocytes on expression of enzymes associated with aging and anti-aging: significantly repressing the expression of the MAO and significantly promoting the expression of anti-oxidases. Studies have shown that repressing the expression of the MAO decelerate the breakdown of monoamine neurotransmitters and improve body's health (Lindley, et al. 2005; Benedetti, et al. 1989; Chen, et al. 2000); that promoting the expression of anti-oxidase (GSH-Px, CuZn-SOD, and Mn-SOD) accelerate the removal of free radicals and peroxides (Li, et al. 2007; Pan, et al.2012; Li, et al.2013). Those active substances (GSH-Px, CuZn-SOD, and Mn-SOD) enhance the anti-aging effects. Studies have shown that improvements in the metabolism of matter–energy and protein are propitious to the ubiquitin proteasome pathway, which is dependent on adenosine triphosphate to accelerate the breakdown of lipofuscin and elimination of age pigments (Shang et al. 2011; Chondrogianni, et al. 2014; Löw, 2011).

In addition to improving substance–energy metabolism, vitamin PP plays a role in expanding blood vessels (Huang, 2003) and improving micro-circulation in the body (we found that microcirculation disturbance may be one of the leading causes of chronic disease in organic tissues), promoting the delivery of nutrients into the microcirculation system, accelerating the effusion of metabolic waste and harmful substances in the microcirculation system, enhancing the abilities of histiocytes to resist various harmful factors and preventing the occurrence of chronic diseases (Huang, 2003; Wu, 2005). Furthermore, the synergistic effects of vitamins PP and B-1 can enhance the stability and regulatory function of the nervous system and the circulatory system, as well as prevent various stress factors from causing arterial vasospasm through neurological reflex and from inducing high blood pressure, thereby effectively controlling cardiovascular disease (Tao, et al. 2013). In conclusion, the optimal metabolism of materials, energy and proteins and microcirculation are the key to preventing chronic metabolic syndromes and to maintaining good health.

By means of their antioxidant effects, vitamins C, E and A in the investigated multivitamin can eliminate peroxides and free radicals and their detrimental effects in the body and, in so doing, promote anti-aging (Cosgrove, et al. 2007).

The main mechanism by which the multivitamin eliminates and attenuate symptoms or chronic diseases and dysfunctions of the chronic metabolic syndromes and delay aging is as follows: Several vitamins in combination

doi:10.21010/ajtcam.v14i1.7
improve the metabolism of materials, energy, and proteins, as well as prevent the formation and accumulation of the components associated with chronic metabolic syndromes and aging, increase the level of antioxidases to eliminate peroxides, free radicals and their harmful effects. Their synergistic effects restore and maintain good health and delay aging. This study provides a theoretical basis and a scientific method for preventing and treating chronic metabolic syndromes, for delaying aging.

Conclusion

The multivitamin can eliminate or attenuate 38 types of symptoms or chronic diseases and dysfunctions of the investigated chronic metabolic syndromes and has significant effects for anti-aging. Supplementing with this multivitamin can prevent and provide treatment/ adjunctive therapy for these chronic metabolic syndromes and delay aging process.

Acknowledgment

This research was supported by the Construct Program of the Key Discipline in Hunan Province.

Conflict of interest: The authors have no conflicts of interest to declare.

Ethical standards: We declare that the experiment complies with the current laws of
the China and the code of ethics of the World Medical Association (Declaration of Helsinki).

Supplementary material
Supplementary file 1: Main factors and mechanism causing chronic metabolic syndromes and aging
Supplementary file 2: Feedback form on the curative effects of the multivitamin.
Supplementary file 3: Evaluation standards of the curative effects of the multivitamin
Supplementary file 4: Health examination reports for volunteers.
Supplementary file 5: A comparison of a man who has been taking the multivitamin and a man who has not.
Supplementary file 6: BW data for mice and food consumption values for experimental mice.

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