Special Article

Roles of Meditation on Alleviation of Oxidative Stress and Improvement of Antioxidant System

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According to MEDLINE/Pubmed search to December 2009, the modulation effects of meditation on oxidative stress have been increasingly investigated for acute, short and long term effects. Both invasive and noninvasive measurements have been utilized. Long term transcendental and Zen meditators have been showed to diminish oxidative stress seen by a reduction of lipid peroxidation and biophoton emission. Glutathione level and activity of antioxidant enzymes (catalase, superoxide dismutase, glutathione peroxidase and glutathione reductase) have been facilitated in Yoga and Sudarshan Kriya practitioners. One year of Tai Chi training has been reported to promote superoxide dismutase activity and lessen lipid peroxidation. Performing diaphragmatic breathing after exhaustive exercise has attenuated oxidative stress faster than control. These data suggest possible roles of meditation and meditation-based techniques on the decrease of oxidative stress which may assist to prevent and/or alleviate deterioration of related diseases. However, further research needs to elucidate the cellular and molecular mechanisms which remain challenge to accomplish.

Keywords: *Meditation, Mind-body intervention, Oxidative stress, Antioxidant, Free radicals*

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In the era of competition and complexity, humans unavoidably have to face both mental and physical stresses. Although biomedical research has been improved in parallel with technology, it seems not to undergo in holistic approach. Various diseases also have been developed and are still incurable. Consequently, complementary and alternative medicines have been sought for improving therapy and quality of life. At present, meditation is of growing interest in both eastern and western countries[1-3]. Numerous clinical studies have demonstrated its therapeutic effects in many diseases[4-7]. Nevertheless, its underlying mechanism still needs to be illuminated. One hypothesis has been considered the attenuation of oxidative stress which has been showed to involve in pathogenesis of many fatal diseases[8,9]. At the moment, scientific research is in progress studying favorable effects of meditation associated with the oxidative stress.

This is the first review about the roles of meditation and meditation-based techniques on oxidative status. Initially, it briefly described an overview of meditation and biomarkers of oxidative stress. Then the last chapter focused on publications corresponding to oxidative status affected by meditation and meditation-based techniques. A literature search was conducted using MEDLINE/Pubmed and the references of received articles. The search included articles published in English up to December 2009, using MeSH tool. Searched terms included, meditation, mind body therapy, oxidative stress, free radicals, reactive species, oxidants and antioxidants in various combinations.

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Meditation and its classification in biomedical research

Meditation, an ancient spiritual practice, is a mind-body technique that helps people in balancing mental, physical as well as emotional prospects which can be practiced by people of any religion or any culture. In terms of history, no one really can specify when meditation originated but it is firstly described in texts about several thousand years B.C[10]. In general, there are two main types of meditation; concentration meditation and mindfulness meditation. The first one involves direct attention on one focus in order to develop deep state of concentration. The latter one is not to focus but rather to observe mind or body perception moment to moment with non-judgment awareness. Finally, the wisdom to comprehend the true nature; impermanence (Anicca), suffering (Dukkha) and non-selfhood (Anatta), will be developed[11]. Most of meditation techniques are employed in Asian countries and took several thousand years to spread to West. Nowadays, meditation is becoming popular in western countries. Articles of Time magazine have revealed meditation as a smart practice in daily life for American people[12] and in military troops[13]. Once Western physicians have tried, they have started to understand the role of mind on health and disease. Meditation health care center has been constructed in school of medicine such as in University of Massachusetts Medical School (The Center for Mindfulness in Medicine), United States of America. Then, this kind of center has been created in other countries, leading into widespread medical investigations.

In the present biomedical researches, Ospina et al[14] broadly divided meditation into five categories; mantra meditation, mindfulness meditation, yoga, Tai Chi and Qigong. First, mantra meditation is composed of transcendental meditation (TM), relaxation response and clinically standardized meditation. They share common characteristics to develop deep concentration by repeating silently or aloud the mantra (a word or phrase). This is so-called concentration meditation of Buddhist meditation. Second, mindfulness meditation is composed of vipassana meditation, Zen meditation, mindfulness-based stress reduction (MBSR) and mindfulness-based cognitive therapy (MBCT). The hallmark of this category is to cultivate mindfulness and wisdom of oneself as previously described. Third, yoga is an ancient Indian system that comprises basic forms of postural movement, meditation, breathing technique and relaxation[15]. Another method named Sudarshan Kriya (SK) is also included in yoga, emphasizing on breathing pattern. Fourth, Tai Chi is the Chinese art for individual health and well being. It involves gentle body movement in continuous sequence, breathing patterns and mental concentration[16,17]. Fifth, Qigong is quite similar to Tai Chi in terms of body movement but relates to breathing attention with meditation basis. However, Qigong emphasizes the concept of Qi flow (flow of internal vital energy) as well[14,18]. Additionally, diaphragmatic breathing (DB) exercise has been categorized in part of mediation too. The technique is to concentrate on inhalation and exhalation. Deep breathing is inhaled through nose into lung by the diaphragm (using abdominal muscles), not by the rib cage expansion. Exhalation is pursed to the lip. This method is generally incorporated in yoga and many types of meditation. The last four methods contribute similar concept of body movement with clear and calm state of meditation. Hence, they could be included into meditation-based technique/movement or meditative movement. To summarize, meditation in area of biomedical study actually can be divided into three broad categories; concentration meditation, mindfulness meditation and meditation-based techniques.

The beneficial effects of meditation and meditative movement on physical body have been revealed. In healthy people, physiological changes are concerned with reduction of heart rate, blood pressure, respiratory rate[19-21], metabolic rate[22,23] and stress hormones[24-26]. As well, meditation enhances parasympathetic nervous system[27], cerebral blood flow[28], cerebral function of attention areas[29,30], and release of dopamine and serotonin[31,32]. Additionally, clinical studies have illustrated its therapeutic effects in many pathological diseases when used in combination with conventional treatment such as cancer[4,33,34], cardiovascular diseases[35-37], diabetes mellitus[5,38], hypertension[6,39] and chronic pain[40]. Nonetheless, cellular and molecular mechanisms still have to be elucidated.

Biomarkers of oxidative stress, oxidants and antioxidant system

Oxidative stress refers to a serious imbalance between oxidant production and antioxidant defenses[41] for which the generation of oxidizing substances is beyond the detoxifying capacity[42], resulting in oxidative damage of target molecules such as DNA, protein and lipid structures[43] (Fig. 1). It has been reported to be involved in the pathogenesis of many diseases, *e.g*, cancer, cardiovascular disease, diabetes mellitus, Alzheimer's disease, Parkinson's disease[8,9]. This part concerns only bioindicators of oxidants and antioxidants. The detailed description of biochemistry is well beyond the scope of this review.

Oxidant measurement as a biomarker of oxidative status

Byproducts of oxidation reaction are regularly measured as indicators of oxidative stress since free radicals themselves are unstable. Reactive species (RS) or oxidants or free radicals are defined as molecules comprising unpaired electron (s) in atomic or molecular orbitals[44]. The common groups of RS are reactive

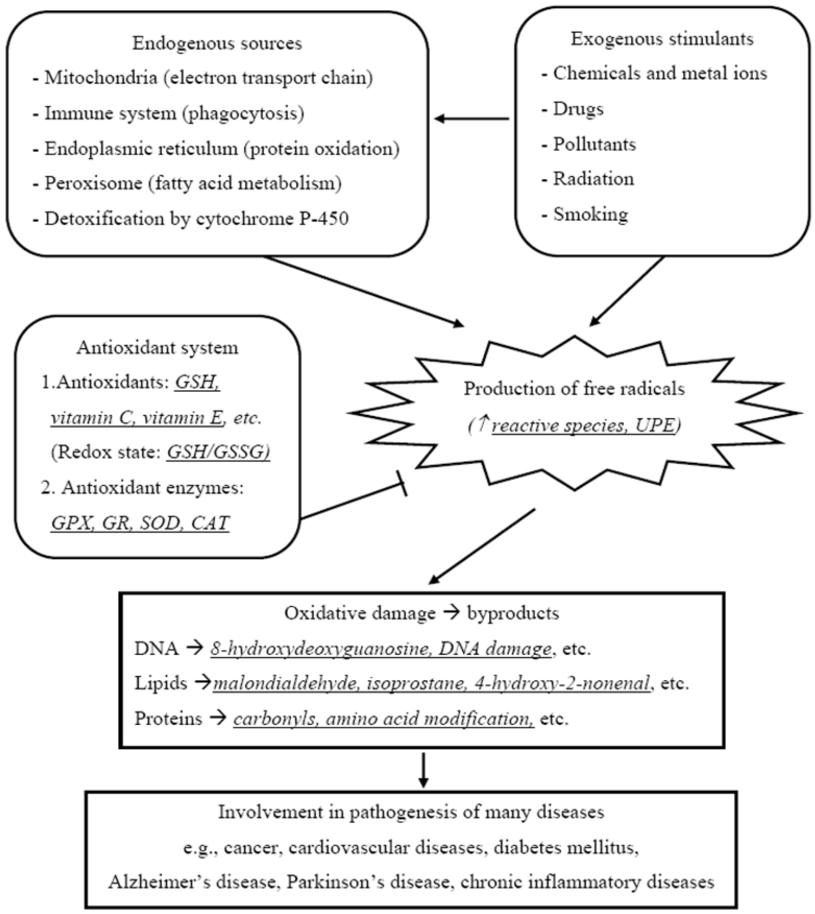

Fig. 1 Oxidative stress, biomarkers (underline) and pathogenesis involvement. Generation of reactive species (RS) is derived from both endogenous and exogenous sources. However, antioxidant system also has been evolved to balance oxidants. Overproduction of RS causes oxidative damage of DNA, lipid and protein structures indicated by byproducts. This damage has been reported to involve in pathogenesis of many diseases. CAT, catalase; GPX, glutathione peroxidase; GR, glutathione reductase; GSH, reduced glutathione; GSSG, oxidized glutathione; SOD, superoxide dismutase; UPE, ultraweak photon emission

oxygen species or ROS (*e.g*, superoxide radicals, hydroxyl radicals and hydrogen peroxide), and reactive nitrogen species or RNS (*e.g*, nitric oxide radicals, nitrogen dioxide radicals and nitrous acid). In normal circumstances, free radicals are endogenously generated in the body from mitochondrial electron transport, immune response, detoxification and protein folding(45). Also, exposure to pollutants, chemicals, radiation, and physical and mental stresses accelerates production of RS(46). To reach ground state, ROS and RNS rapidly donate unpaired electrons to other biological molecules as nucleic acids, lipids and proteins. Consequently, it is difficult to directly quantify free radicals because of their high reactivity and short half-life. Instead, byproducts formed during oxidation are evaluated because they are more stable. ROS, especially hydroxyl radicals, can react with all components of DNA. The common indicators of DNA oxidation are 8-hydroxydeoxyguanosine and the DNA damage(47). Lipids are also sensitive cellular targets of free radicals. Investigation of lipid peroxidation is the oldest determination of oxidative stress. Malondialdehyde (MDA), F2-isoprostanes and 4-hydroxy-2-nonenal (4-HNE) are extensively detected as parameters of lipid peroxidation(44). Reaction of MDA and thiobarbituric acid generates thiobarbituric acid reactive substances (TBARS) which is also applied for MDA evaluation. However, analysis by chromatography is increasingly analyzed and more reliable[48]. Protein oxidation is another process of oxidative damage. Basically, free radicals oxidize amino acids, then, create carbonyls and amino acid modification as biomarkers of protein oxidation[42]. In terms of RNS, nitric oxide (NO) is a major RNS that has been considered as important vasodilator and neutralizer of superoxide radical. However, NO also mediates inflammation and cytotoxic substances. Therefore, RS has been clarified both useful and harmful effects. Overproduction of RS finally originates the destruction of biomolecules, so-called oxidative damage. For this reasons, human body needs the other mechanism to antagonize RS productions, known as the antioxidant system (Fig. 1).

Antioxidant measurement as a biomarker of oxidative status

The antioxidant system is composed of antioxidant enzymes as well as endogenous antioxidants (non-enzyme) and antioxidative enzymes. Antioxidant or free radical scavengers are signified as any substance that delays, prevents or removes oxidative damage to a target molecule[41]. For endogenous antioxidants, the most importance is glutathione or reduced glutathione (GSH)[49]. Total glutathione includes both GSH and oxidized glutathione (GSSG). About ninety eight percent of total glutathione is GSH (g-glutamyl-cysteinylglycine). It is responsible for many crucial biological processes, especially detoxification by either conjugation or acting as a powerful reducing agent. In terms of conjugation, GSH combines with electrophiles into glutathione conjugate for further elimination. This reaction is catalyzed by glutathione S-transferase (GST)[50]. Furthermore, GSH detoxifies hydrogen peroxide and lipid peroxides by catalytic action of glutathione peroxidase (GPX), and form GSSG (so-called oxidized glutathione). Subsequently, reactivity of those RS is abolished or lessened. After that, GSSG is converted back to GSH by glutathione reductase (GR) to maintain redox homeostasis[49]. Hence, these enzymes are determined as biomarkers of antioxidant enzymes. GSH and GSSG levels also are validated as biomarkers of antioxidant and oxidative stress, respectively (Fig. 1). As well, GSH/GSSG ratio is generally calculated to determine oxidative status However, quantification of both GSH and GSSG has to be concerned for artifacts[51]. Additionally, carotenoid, vitamin E and vitamin C are also considered free radical scavengers. Nonetheless, they must be in active forms, and the major source is exogenous from diet. In addition to GST, GPX and GR, the other essential antioxidant enzymes include superoxide dismutase (SOD) and catalase (CAT) (45). SOD catalyzes conversion of superoxide radical to hydrogen peroxide (lesser reactivity) while CAT converts hydrogen peroxide into non-oxidant molecules.

Non-invasive measurement of oxidative stress

Although many biomarkers are provided to measure oxidative status, most of them require the destruction of cell or tissues to derive target specimens. Measurement of ultraweak photon emission (UPE) has been developed to quantify oxidative stress in a non-invasive way[52,53]. Under normal conditions, the human body spontaneously emits biophoton or ultraweak light but cannot be seen by the naked eye or optical detectors. UPE is directly correlated with the consumption of molecular oxygen. Each emitted spectrum is referred to a different oxygen-dependent reaction, *e.g,* lipid and protein peroxidation[53,54]. As a result, measurement of UPE has been implicated in ROS production and oxidative stress[55].

To sum up, the human body regularly initiates free radicals from both endogenous and exogenous sources. Although RS is involved in many physiological phenomena, it also can damage target biomolecules. Thus, the human body has evolved an antioxidant system to balance the reactivity of free radicals. Oxidative status can be estimated via both invasive and non-invasive techniques. Oxidative stress occurs when oxidant production is over the capability of antioxidant mechanisms. It is associated with the pathogenesis of many fatal diseases. Therefore, if any intervention can endogenously reduce oxidative damage or facilitate antioxidant mechanisms, that method would be very worthwhile.

Modulation effects of meditation and meditation-based techniques on oxidative stress

In the past several decades, the studies of meditation and meditation-based techniques have been increasingly interested. The content of this article was arranged following the duration of intervention: acute, short term and long term effects of meditation.

Acute effects of meditation and meditation-based techniques on oxidative status

According to moment published data, Wijk and coworkers[56] presented the shortest time (ten minutes) of meditation affecting oxidative stress (Table 1). They were the first group to measure oxidative status

Table 1. Acute effect of meditation and meditation-based techniques on oxidative status

Study	Intervention group/(n)	Comparison	Result/(evidence suggestion)
Wijk et al, (2005)[56]	ZM (1)	Pre/during/post-meditation	Decreased hand UPE for 46 % after 10 min meditating
	Phi-damped breathing (2)	Pre/during/post-meditation	NSD
	TM (1)	Pre/during/post-meditation	NSD
	TM + breathing (1) (Subjects had experience at least 15 years).	Pre/during/post-meditation (each period was 10 min)	Decreased forehead and hand UPE for 5 % after 10 min meditating and continued reduction along 10 min of post-meditation (Reduction of oxidative stress by ZM and TM+breathing)
Sharma et al (2003)[57]	SK (10) (Subjects carried out SK practice for 5 months).	45 min/0 min of SK	NSD
		65 min/0 min of SK	Significantly increased SOD activity (Improvement of antioxidant system)
Kim et al (2005)[58]	ZM (20) (Subjects had experience at least 4 years).	70 min/0 min of Zen meditation	NSD (serum MDA and NO)
Martarelli et al (2009)[59]	DB (8): DB for 1 hour after exercise-induced oxidative stress Controls (8): Sitting quietly for 1 hour after exercise	DB/controls at 0 min, 90 min, 8 hours and 24 hours after exercise	At 8 and 24 hours, DB group significantly increased biological antioxidant potential and decreased d-reactive oxygen metabolites more than controls. (Alleviation of oxidative stress by DB)

DB, diaphragmatic breathing; min, minute; NO, nitric oxide; MDA, malondialdehyde; NSD, no significant difference, SK, Sudarshan Kriya; SOD, superoxide dismutase; TM, transcendental meditation; UPE, ultraweak photon emission; ZM, Zen meditation in meditators by UPE. Five subjects were long term practitioners with different meditation types. The emission of biophoton was traced from hand and/or head for three periods, ten minutes each; before, during and after meditation. After ten minutes of Zen meditation, forehead UPE was quite the same whereas hand UPE declined up to 46%. The decrease also continued along ten minutes of post-meditation period. In contrast, two subjects of breathing technique and one TM practitioner had no obvious alteration of UPE. One modified TM (TM with breathing combination) showed a slight reduction of hand and forehead UPE (about 5%) after 10 minutes of meditation period (Table 1). Thus, data suggested that meditation could influence human biophoton emission. However, it should be further clarified in larger numbers. In 2003, Sharma et al(57) examined acute effects of SK, yoga branch, on antioxidant system. Firstly, subjects had been trained SK for 5 months (n = 10). Then, total glutathione, CAT and SOD were analyzed at 45 and 65 minutes of SK performance, and compared with 0 minute. None of the parameters indicated significant alteration at 45 minutes. After 65 minutes, total glutathione seemed to elevate but was not statistically significant, whereas, SOD activity exhibited a significant increase. Then, the researchers proposed that SK could produce better status of antioxidants. However, the results should be confirmed in a bigger sample size. In addition, Kim and coworkers studied acute effects of Zen meditation in long term practitioners (over 4 years of experience), at 70 minutes against a 0 minute baseline(58). Nevertheless, no significant alteration was found (by assessing lipid peroxidation and NO) as shown in Table 1. This data was controversy with Wijk et al, (2005). Nevertheless, other oxidative parameters should be confirmed too. In addition to direct influence on oxidative status, exhaustive exercise was also employed to induce oxidative stress. DB, a breathing part of many meditation forms, was declared to encourage the antioxidant system and ease oxidative stress induced by exhaustive exercise(59). After exercising, 8 DB practitioners performed DB for one hour while eight control subjects sat in quiet and comparable environments. At 8 and 24 hours after exercise, DB group demonstrated decline of d-reactive oxygen metabolites and elevation of biological antioxidant potential. In the meantime, oxidative stress in control group stayed still along 24 hours after exercise (Table 1). Thus, lessening of oxidative stress by DB was assumed.

Short term effects of meditation and meditation-based techniques on oxidative status

Yadav and coworkers(60) determined lipid peroxidation of 104 healthy subjects who entered a yoga-based lifestyle modification program for nine days. The program included yoga with nutritional and stress management. At day ten, serum TBARS was significantly decreased when compared with the control before starting the course (Table 2). Sample size and individual baseline comparing were strength of this study. Nevertheless, other oxidative stress markers should be confirmed aside from serum TBARS. Also, alleviation of oxidative stress might have occurred from other factors as nutritional and stress management. The rest of publications investigated short term effects of meditation in periods of months. Sharma et al(57) clarified that five months of SK practice (n = 10) significantly raised total glutathione, CAT and SOD, compared with the control group (n = 14). The baseline levels of CAT and SOD were initially verified to be comparable in both groups. All subjects were in similar living conditions at a Police Training College which was benefit of this study but the sample size should be enlarged. Afterward, Sinha et al(61) investigated six months of yoga practice in 30 Indian Navies in similar habits and environments. Compared to individual baseline, the six-month yoga practitioners significantly elevated blood GSH, GSH/GSSG ratio and total antioxidant status as shown in Table 2. In contrast, control group (routine training for 6 months) declined total antioxidant status and increased GR activity. This could be explained by induction of oxidative stress by routine physical training. Hence, yoga was suggested to ease oxidative stress and improve antioxidant system. Tai Chi, the Chinese martial art exercise, was also inspected. Recently, Goon and colleagues explored oxidative stress profiles after Tai Chi training for 0, 6 and 12 months(62). Interestingly, at six months, DNA damage was elevated and GPX activity increased (n = 25). The outcomes were considered as a mild level of exercise-induced oxidative stress with compensation of GPX activity. Nevertheless, at 12 months, Tai Chi participants (n = 15) presented a significant decrease of plasma MDA and increase of SOD activity (Table 2). In this data, various parameters were determined which advantaged correct interpretation.

Long term effects of meditation and meditative-based techniques on oxidative status

Studies of the long term effects of meditation on oxidative status have been conducted in meditators

Table 2. Short term effect of meditation and meditation-based techniques on oxidative status

Study	Intervention group/(n)	Comparison	Result/(evidence suggestion)
Yadav et al (2005)[60]	Yoga (104) (Subjects entered 9 days-yoga Program).	9 days/own baseline	Significantly decreased serum TBARS (Reduction of oxidative stress)
Sharma et al (2003)[57]	SK (10): SK training for 5-month Controls (14): Routine training, no SK (Subjects were comparable from Police Training College and age-matched).	SK/controls at 5 months	Significantly increased total glutathione and activity of SOD and CAT in SK (Improvement of antioxidant system)
Sinha et al (2007)[61]	Yoga (30): Routine training with yoga practice for 6 months Controls (21): Routine training without Yoga (Both groups were male from Indian Navies and age-matched).	SK/own baseline at 6 months Controls/own baseline at 6 months	Significantly increased GSH, GSH/GSSG ratio and total antioxidant status Significantly decreased total antioxidant status and increased GR activity (Stimulation of antioxidant system and alleviation of stress training by yoga)
Goon et al (2009)[62]	Tai Chi (25) (Sedentary healthy volunteers with age over 45 years).	6 months/own baseline (n =25) 12 months/own baseline (n =15)	Significantly increased DNA damage and GPX activity (induction of oxidative stress) Significantly decreased plasma MDA and increased SOD activity (oxidative stress reduction and antioxidant improvement)

CAT, catalase; DNA, deoxyribonucleic acid; GPX, glutathione peroxidase; GR, glutathione reductase; GSH, reduced glutathione, GSSG, oxidized glutathione; MDA, malondialdehyde; SK, Sudarshan Kriya; SOD, superoxide dismutase; TBARS, thiobarbituric acid reactive substance with experience of more than one year (Table 3). In 2008, Sharma and coworkers[63] compared antioxidant systems of long term practitioners (one hour a day, at least one year) of SK with matched control (n = 42). SK practitioners had higher levels of glutathione, GPX and SOD activities than controls, implying better capacities to neutralize oxidants in SK group. Furthermore, Sharma et al firstly reported a profile of gene expression in long term practice of meditative-based technique. Expression of the GST gene in SK was significantly amplified, correlating with elevation of GSH levels. Therefore, SK practice might help to improve the capability of detoxification. Expression of GPX, CAT and SOD genes of SK tended to elevate as well, but insignificantly. Moreover, Kim et al[58] verified long term effect of Zen meditation (at least 4-year experience) on oxidative stress. Subjects of Zen and control group were healthy and comparable (20 each). Zen practitioners (two to three days per week at least four years) demonstrated a significant diminution of serum MDA and elevation of serum NO over the control group. Thus, they proposed alleviation of oxidative stress by Zen meditation. In addition to Zen meditation, TM was extensively investigated in biomedical research of meditation (Table 3). Schneider et al[64] evaluated lipid peroxides in 20 long term TM practitioners (more than 16.5 years of experience), and in 20 sedentary controls who did not perform any stress management. Plasma TBARS of the meditation group was significantly lesser than the control. Both groups were comparable in age, gender and education. Furthermore, Wijk and colleagues examined the anatomical characterization of UPE in ten long term TM practitioners, who meditated 20 minutes, twice a day for more than ten years (Table 3)[65]. Both study and control participants had verified UPE in 12 anatomical locations of the anterior torso (stomach, heart, right and left abdomen), head (forehead, throat, right and left cheeks) and hand (palms and hands on both left and right sides). Compared to the control group, TM practitioners exhibited a significant decrement of UPE in the area of the stomach, heart, throat, right cheek, forehead and left dorsal hand. Two subjects with regular meditation demonstrated the lowest UPE. Therefore, the authors proposed that persistent meditation could diminish UPE. In order to support this hypothesis, the same group characterized UPE in a bigger sample size of TM practitioners (n = 20). In addition, various techniques of long term meditation were elucidated[66]. Similar to previous reports, long term TM practitioners demonstrated a significant diminution of UPE in the locations of the stomach, heart, throat, right cheek, right and left abdomen (Table 3). The average overall reduction of photon emission in TM practitioners was 27% lower than the control group. In the mean time, 20 long term practitioners of other meditation techniques (OMT) were also evaluated for photon emission. OMT included three Taoists, three Zen meditators, four Christian meditators (praying and contemplation) and ten yoga participants. Compared to control subjects, UPE of OMT was significantly decreased at the throat area with an average lessening of 17%. Hence, this study supported the hypothesis that long term practice of meditation lowers UPE, implying ROS dwelling in a living system. Hence, these results were in concert with modulation effects of meditation on oxidative stress measured by invasive methods.

Miscellaneous findings

In addition to the above articles, some miscellaneous findings were incorporated in this paragraph. Bhattacharya and colleagues[67] reported that yogic breathing technique significantly lessened free radicals and promoted SOD levels (n = 30) when compared to control subjects. However, they did not mention how long practitioners were trained. As well, the full text was unattainable. One article from China mentioned that Qigong could facilitate antioxidant activity but did not reveal the markers used to determine this[68]. Method and duration of experiment were not clearly explained as well (only the abstract was provided). In addition to studying healthy people, Mahapure and coworkers investigated yoga effects on oxidative status in diabetic patients[69]. Compared with control diabetics (anti-diabetic therapy alone), diabetics who also performed yoga had significantly higher levels of SOD after training, suggesting therapeutic assistance in diabetic patients. Additionally, one group of American scientists studied effects of meditation in cell culture. Oxidative stress, rate of cell death and proliferation were assessed before and after biofield therapy (supraphysical energy delivered from meditative masters who had long experience in healing patients). Nonetheless, most investigations had no significant alteration in cell cultures[70-72]. It might be possible that therapeutic effects require coordination of different systems *in vivo*.

Conclusion and future direction

According to MEDLINE/Pubmed data up to December 2009, studies of meditation and meditation-based techniques on oxidative stress have been

Table 3. Long term effect of meditation and meditation-based techniques on oxidative status

Study	Intervention group/(n)	Comparison	Result/(evidence suggestion)
Sharma et al (2008)[63]	SK (42): Long term practice, at least 1 year, 1 hour/day Controls (42): Not performed any exercise and stress management. (Both groups were age, gender, BMI and socioeconomic-matched).	SK/controls	Significantly increased level of total glutathione, and activity of GPX and SOD Significantly elevated GST gene expression (Improvement of antioxidant system)
Kim et al (2005)[58]	ZM (20): Long term practice, at least 4 year, 2-3 day/week, 1 hour/day Controls (20): Not performed any exercise and stress management. (Both groups were comparable in age, gender, BMI, education and diet).	ZM/controls	Significantly decreased serum MDA and increased NO (Reduction of oxidative stress)
Wijk et al (2006)[65]	TM (10): Long term practice, at least 10 years, twice a day, 20 min/time Controls (10): Without experience using any meditation form. (Both groups were age and gender-matched, and did not intake any supplement).	TM/controls	Significantly decreased UPE on area of stomach, heart, throat, right cheek, forehead and left dorsal hand (Reduction of oxidative stress)
Wijk et al (2008)[66]	TM (20): Long term practitioners OMT (20): Long term practitioners of Taoist meditation (3), Zen meditation (3), Christian meditation (3) and yoga (10)	TM/controls	Significantly decreased UPE on area of stomach, heart, throat, right cheek, right and left abdomen (overall reduction was 27%) (Improvement of antioxidant system)
	Controls (20): Without experience using any meditation form (Both groups were age, gender and BMI-matched, and free of medication).	OMT/controls	Significantly decreased UPE on area of throat (overall reduction was 17%) (Improvement of antioxidant system)
Schneider et al (1998)[64]	TM (18): Long term practice, at least 16.5 years Controls (10): Not performed any stress management (Both groups were comparable in age, gender and education).	TM/controls	Significantly decreased plasma TBARS (Reduction of oxidative stress)

BMI; body mass index, GPX, glutathione peroxidase; GST, glutathione S-transferase; MDA, malondialdehyde; NO, nitric oxide; OMT, other meditation types; Sudarshan Kriya; SOD, superoxide dismutase; TBARS, thiobarbituric acid reactive substances; TM, transcendental meditation; UPE, ultraweak photon emission; ZM, Zen meditation growing in interest. Long term TM and Zen meditation have been clarified to reduced oxidative stress, indicated from a decline of MDA level and UPE. Yoga and SK have been clarified to enhance both levels of endogenous antioxidants (glutathione) and activity of antioxidant enzymes; CAT, SOD, GPX and GR. Twelve months of Tai Chi practice also have been showed to promote SOD activity and lessen lipid peroxidation. DB after exhaustive exercise has facilitated attenuation of exercise-induced oxidative stress faster than the control. Therefore, the results suggest reduction of oxidative stress and improvement of the antioxidant system by meditation in various modalities. However, future research should signify cellular and molecular mechanisms. Additionally, inclusion criteria, comparable subjects, study design, reliability of measurement and sample size should be put higher awareness.

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บทบาทของการฝึกสมาธิต่อการลดลงของภาวะเครียดออกซิเดชั่น และการเสริมสร้างระบบต้านอนุมูลอิสระ

จิตรวีณา มหาคีตะ

จากการรวบรวมงานวิจัย ผลของการฝึกสมาธิและเทคนิกที่เกี่ยวข้องต่อภาวะเครียดออกซิเดชั่นและการเสริมสร้างระบบต้านอนุมูลอิสระของร่างกาย จากการศึกษาทั้งผลแบบฉับพลัน แบบระยะสั้นและแบบระยะยาว พบว่าผู้ฝึกสมาธิแบบทรานส์เซนเดนทอลและแบบเซ็นในระยะยาวช่วยบรรเทาการเกิดภาวะเครียดออกซิเดชั่น โดยลดระดับของการเกิดออกซิเดชั่นของไขมัน และโฟตอนชีวภาพ ส่วนโยคะช่วยเพิ่มระดับสารต้านอนุมูลอิสระกลูตาไธโอนและกระตุ้นการทำงานของเอนไซม์ต้านอนุมูลอิสระชนิดคาทาเลส ซุปเปอร์ออกไซด์ดิสมิวเทส กลูตาไธโอนเพอร์ออกซิเดสและกลูตาไธโอนรีดัคเทส การฝึกรำไท้เก๊กตั้งแต่หนึ่งปีพบว่าช่วยลดระดับการเกิดออกซิเดชั่นของไขมันและเพิ่มการทำงานของซุปเปอร์ออกไซด์ดิสมิวเทสได้ ในขณะที่การฝึกหายใจด้วยกระบังลมช่วยลดระดับภาวะเครียดออกซิเดชั่นหลังการออกกำลังกายได้เร็วกว่าปกติ ผลการวิจัยดังกล่าวชี้ให้เห็นถึงผลของการฝึกสมาธิและเทคนิกที่เกี่ยวข้องต่อการช่วยลดระดับภาวะเครียดออกซิเดชั่นและการเสริมสร้างการทำงานของระบบต้านอนุมูลอิสระ ซึ่งวิธีดังกล่าวอาจช่วยป้องกันและบรรเทาอาการของโรคต่างๆ ที่เกี่ยวข้องกับภาวะเครียดออกซิเดชั่นได้ อย่างไรก็ตามควรมีการศึกษากลไกในระดับเซลล์และระดับโมเลกุลต่อไป