The role of yoga exercise as a therapy in reducing oxidative stress: a systematic review

El papel del yoga como terapia para reducir el estrés oxidativo: una revisión sistemática

Authors

Akhmad Syarif [1]
Kukuh Wurdianto [1]
Silvia Arianti [1]
Baskoro Nugroho Putro [2]
Junian Cahyanto Wibawa [3]
Novadri Ayubi [4]
Muhammad Muhyi [5]

[1]Universitas PGRI Palangkaraya (Indonesia)
[2]Universitas Sebelas Maret (Indonesia)
[3]STKIP PGRI Trenggalek (Indonesia)
[4]Universitas Negeri Surabaya (Indonesia)
[5]Universitas PGRI Adi Buana Surabaya (Indonesia)

Corresponding author:
Junian Cahyanto Wibawa
juniancahyanto96@stkippgritrenggalek.ac.id

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Abstract

Background: Increased oxidative stress results from both exposure to and the body's generation of free radicals. It is well recognized that exercise lowers oxidative stress. Nevertheless, nothing is known about how yoga affects oxidative stress.
Research objectives: This study sought to ascertain how yoga practice affected the reduction of malondialdehide levels, which are an indicator of oxidative stress.
Methods: For this study, a number of journal databases, including Pubmed, Web of Science, and Science Direct, were searched. The study considered a number of factors, including studies conducted between 2015 and 2025 on yoga and malondialdehide in humans. The systematic review excluded articles that did not meet the inclusion criteria; for example, those that used animals not used in research. A total of 165 publications were found using databases from Web of Science, Science Direct, and Pubmed. The need for this systemic shift is discussed in ten carefully selected, peer-reviewed papers. Preferred Reporting Systematics and Meta-analysis (PRISMA) was used to create the standard operating procedure for this study.
Results: It is clear from the findings of this thorough investigation that yoga practice can lower malondialdehide levels in people.
Conclusion: Human malondialdehide levels have been demonstrated to decrease after yoga activity. So, this can be a therapy to reduce free radical levels in the body.

Keywords

Physical exercise; yoga; malondialdehide; oxidative stress.

Resumen

Antecedentes: El aumento del estrés oxidativo se debe tanto a la exposición como a la generación de radicales libres por parte del cuerpo. Es bien sabido que el ejercicio reduce el estrés oxidativo. Sin embargo, se desconoce cómo el yoga afecta al estrés oxidativo.
Objetivos de la investigación: Este estudio buscó determinar cómo la práctica de yoga afecta la reducción de los niveles de malondialdehido, un indicador de estrés oxidativo.
Métodos: Para este estudio, se realizaron búsquedas en diversas bases de datos de revistas científicas, como PubMed, Web of Science y Science Direct. El estudio consideró diversos factores, incluyendo estudios realizados entre 2015 y 2025 sobre yoga y malondialdehido en humanos. La revisión sistemática excluyó los artículos que no cumplían los criterios de inclusión; por ejemplo, aquellos que utilizaban animales no utilizados en la investigación. Se encontraron 165 publicaciones utilizando bases de datos de Web of Science, Science Direct y PubMed. La necesidad de este cambio sistémico se analiza en diez artículos cuidadosamente seleccionados y revisados por pares. Se utilizó el método de reporte preferente y metaanálisis (PRISMA) para crear el procedimiento operativo estándar de este estudio.
Resultados: Los hallazgos de esta exhaustiva investigación demuestran claramente que la práctica de yoga puede reducir los niveles de malondialdehido en las personas.
Conclusión: Se ha demostrado que los niveles de malondialdehido en humanos disminuyen después de la actividad de yoga. Por lo tanto, esta puede ser una terapia para reducir los niveles de radicales libres en el cuerpo.

Palabras clave

Ejercicio físico; yoga; malonaldehído; estrés oxidativo.

Introduction

The body's ability to handle reactive oxygen species and reactive nitrogen species produced during oxidative and nitrosative stress, important processes closely related to physical activity. Cellular signaling, control, and balance maintenance all depend on this process (Toledo, 2023). Exercise-induced oxidative stress can have either positive or negative consequences on the body, depending on the length, intensity, and health of the individual (Lu et al., 2021). Regular exercise can create a momentary state of exhaustion, which increases the body's capacity for regeneration and leads to overcompensation in the biological systems. Specifically, structural damage to muscle cells from any vigorous action requiring six metabolic equivalents per minute or more is considered soreness and inflammation during exercise. This increases free radical levels, impairs immune function, and removes proteins from the bloodstream, among other negative effects.

Numerous clinical indications of this process, such as immunosuppression and inflammation, make people more vulnerable to infection (Zhou et al., 2022). In this case, the body might not be able to adjust to the physical workload effectively if there is a prolonged imbalance between the work and recovery phases. Overtraining can lead to situations that are detrimental to both physical performance and health, and when these conditions arise, the body produces reactive oxygen species (ROS) (Zhou et al., 2022). In this instance, free radicals are crucial are produced during aerobic cellular metabolism and serve as regulatory mediators in signaling cascades. Oxidative stress is a result of an imbalance between the production of reactive oxygen species and adequate antioxidant defenses (Pingitore et al., 2015). Numerous pathophysiological states, including aging, exercise, inflammation, and cardiovascular disease, are associated with these detrimental circumstances, neurodegenerative illnesses, and cancer, and they can cause damage to cellular and tissue components (Pingitore et al., 2015).

Specifically, exercise and oxidative stress have a complex relationship that varies depending on the kind and intensity of the activity, and length of exercise (Toledo, 2023). Regular, moderate exercise seems to improve health and reduce oxidative stress. It is impossible to overestimate the part that oxidative and nitrosative stress play in the emergence of conditions including cancer, diabetes, neurodegenerative illnesses, and cardiovascular disease. These stressors are dual in nature, having the capacity to be both regulating and harmful at low concentrations. By modifying inflammation, apoptosis, and mitochondrial function, the impact of reactive oxygen species (ROS) and reactive nitrogen species (RNS) on health and disease is intricate. The etiology of a number of diseases, including rheumatoid arthritis, metabolic syndrome, atherosclerosis, and Alzheimer's disease, has been connected to elevated ROS levels brought on by oxidative stress (Klran et al., 2023). Numerous chronic illnesses, including cancer, infections, neurological diseases, and cardiovascular disease, are also associated with oxidative stress (Verhaegen et al., 2022).

Overproduction of ROS can alter a cell's composition and functionality, resulting in chronic degenerative diseases and aging (Leyane et al., 2022). However, antioxidant treatments may reduce oxidative stress and its impact on cardiovascular health (Islam, 2022). It has been demonstrated that antioxidants lessen the negative effects of oxidative stress on the body, promoting better health and lowering the risk of illness (Panda et al., 2022). Exercise is also believed to help prevent the buildup of ROS in addition to antioxidants. Yoga is a science that teaches people how to lead healthy lives. When incorporated into daily life, yoga is effective. A person's physical, mental, emotional, and spiritual well-being are all impacted by yoga. Yoga is a science that influences the subconscious in addition to self-awareness (Kapil et al., 2023). Yoga, which has its roots in India and dates back thousands of years, covers every facet of holistic living and wellness. Yoga, the world's oldest personal development practice, is good for the body,mind, and spirit.

A deep understanding of human nature and what it takes for individuals to live in harmony with their environment can be found in ancient yoga (Kapil et al., 2023). It has been demonstrated that yoga meditation, a straightforward and approachable kind of meditation, has beneficial and enduring physiological and psychological impacts on individuals of all ages (Usmani et al, 2025). It functions by connecting the individual with the universal life consciousness and subtly regulating the body's energy. A person's physical, mental, emotional, and spiritual well-being have all been reported to improve with frequent Sahaja yoga meditation practice (Usmani et al., 2025).

It has been demonstrated that regular yoga and meditation practice improves blood lipid profiles in both healthy people and diabetes patients (Sengupta, 2012). By lowering oxidative stress and free radicals, yoga and meditation improve diabetics' antioxidant defense systems. Nitric oxide and superoxide dismutase levels in the blood are markedly elevated as a result, while malondialdehyde (MDA) levels are markedly decreased (Hegde et al., 2011). However, the underlying mechanism of yoga physical exercise in reducing MDA levels is still not completely clear. Therefore, the aim of this study will be to examine in depth how yoga reduces MDA levels as a marker of oxidative stress.

Materials and method

Study Design

In order to find systematic review investigations, the researchers searched extensively via journal databases such as Pubmed, Web of Science, and Science Direct. These search engines are regarded as the greatest in the world for gathering publications with substantial impact and solid scientific foundations. Duplicate articles are removed using this first search method. Using previously established inclusion and exclusion criteria, the search results were further filtered.

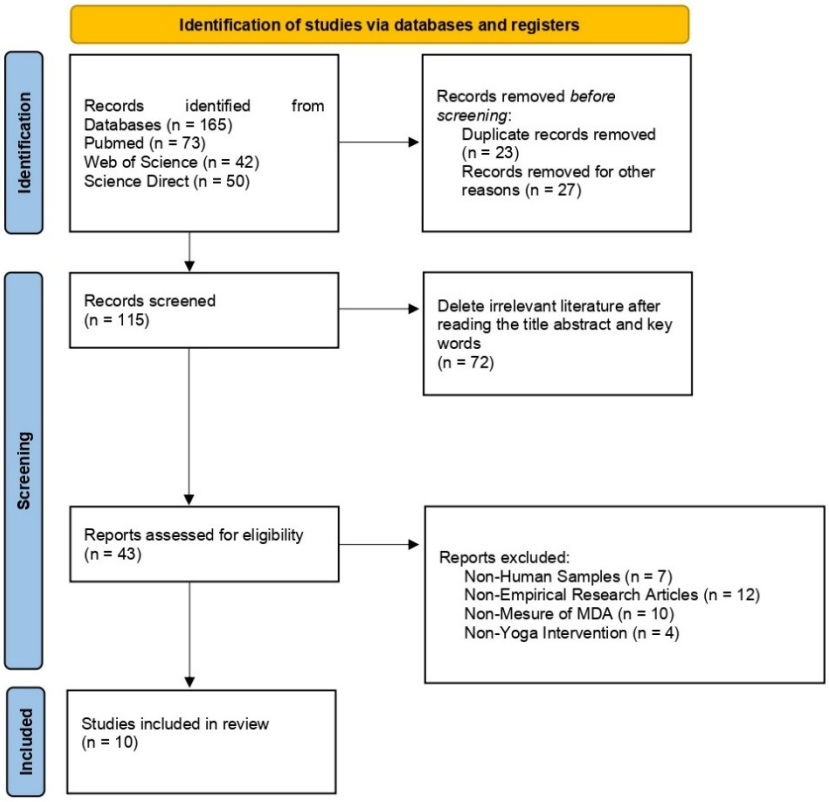
Eligibility Criteria

Publications published between 2015 - 2025 that discussed yoga practice and its effects on MDA levels were reviewed to determine the inclusion criteria for the study. In addition, journals that did not comply with scientific validity guidelines or were not listed in reliable search indexes such as Web of Science, Pubmed, or Science Direct were excluded from the study.

Procedure

The Mendeley information database now includes the titles, abstracts, and full texts of confirmed and authorized publications. The Pubmed, Web of Science, and Science Direct search databases were used to locate 165 papers for the first section of this study. In the second step, 115 scientific papers were assessed for their relevance to the research analysis issue and for how well their titles and abstracts followed the researcher's instructions. Forty-three articles were available for the third round of processing. Next, depending on the topic's general applicability to the issue at hand, we carried out an analysis. Non-human samples, markers that were not MDA, papers that were not original experiments, and therapies that were not physical exercises like yoga were among the subjects of articles that did not meet our inclusion criteria and were therefore not included in our analysis. In the final phase, ten papers that met the inclusion criteria were carefully assessed, selected, and analyzed for this systematic review. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) evaluation standard operating procedure was used to examine this study, as illustrated in Figure 1. PRISMA flowchart for the article selection procedure.

Figure 1. PRISMA flowchart of the article selection process



Results

Table 1 is a summary of the study design and intervention:

Table 1. Results of Yoga Exercises in Reducing Oxidative Stress

Author	Sample Characteristics	Study Design	Intervention	Results
(Usmani et al., 2025)	Four groups control without yoga, control with yoga, diabetic without yoga, and diabetic with yoga were created from 60 healthy control individuals and patients with diabetes mellitus and diabetes with hypertension.	Randomized Controlled Trial	For six months, yoga is done. Navi Mumbai as well as International Sahaja, Mumbai's hub for yoga, meditation, and research.	MDA levels in the diabetes group significantly decreased after practicing yoga.
(Pinku Mani Talukdar, Preethi V. Reddy Bhargav et al., 2024)	Thirty-three people have significant depression. Participants in this study were 32-year-old MDD patients who were split into two groups: the control group (n=17) and the yoga group (n=16).	Randomized Controlled Trial	Intervention Using a general yoga module that was validated for depression, patients with MDD in the yoga group practiced yoga for 12 weeks, with each session lasting 52 minutes. Patients finished 48–72 yoga sessions in total (4–6 sessions per week for 12 weeks), with 16 of those sessions being done directly under a yoga instructor's supervision.	MDA levels in the group receiving yoga intervention significantly decreased.
(Nikam, Patil, Nimbal, & Nikam, 2019)	In this study, 200 individuals with diabetes mellitus between the ages of 45 and 60 were split into two groups: 100 were in the yoga group and 100 were in the control group.	Randomized Controlled Trial	Throughout the six months of the intervention, yoga was practiced.	MDA levels in the group receiving yoga intervention significantly decreased.

Table 1. Results of Yoga Exercises in Reducing Oxidative Stress

Author	Sample Characteristics	Study Design	Intervention	Results
(AYu & Panova, 2020)	Participants in this study included 97 mildly hypertensive patients, ages 33, who were split into two groups: the yoga group and the control group.	Randomized Controlled Trial	Six days a week, the yoga intervention group of patients with mild hypertension was instructed to perform the 30-minute morning yoga exercise known as "Nadi Shodhan Pranayama," which involves forcing air through one nostril. For three months, yoga was practiced.	MDA levels in the group receiving yoga intervention significantly decreased.
(Canda & Verma, 2016)	A pretest and posttest were administered to 100 healthy male participants, ages 20 to 25.	Randomized Controlled Trial	Yoga is practiced twice a day for three months, lasting sixty minutes per session.	Following the yoga exercise intervention, MDA levels significantly decreased.
(Cheung et al., 2018)	Twenty participants, ages 49 to 75, were split into two groups for this study: the intervention group and the control group.	Randomized Controlled Trial	For 12 weeks, the yoga practice was taught in group settings with 60-minute sessions twice a week. At baseline, twelve weeks, and six months after the intervention, participants were evaluated.	Following a yoga intervention, MDA levels dramatically dropped.
(Ha, Kim, & Baek, 2015)	In this study, twenty female patients with shoulder discomfort who were 22 years of age or older were split into two groups: the yoga group (n = 10) and the control group (n = 10).	Randomized Controlled Trial	The yoga workout lasted 50 minutes, which included a five-minute warm-up, a 40-minute main exercise, and a five-minute cool-down. For 16 weeks, the subjects engaged in yoga three times a week.	MDA levels significantly decreased in the yoga intervention group.
(Karthiga et al., 2022)	234 participants in all were split into two groups for this study: the control group (n = 113) and the yoga treatment group (n = 121).	Randomized Controlled Trial	At the Advanced Center for Yoga Therapy Education and Research, certified yoga instructors taught the participants how to do yoga. To guarantee that the participants fully understood the yoga techniques, five introductory sessions were held. After that, they performed yoga twice a day at home (between 6 and 7 am and 6 and 7 pm). Beginning in the 16th week of pregnancy and continuing until the 36th week, the yoga protocol was practiced.	MDA levels in the group receiving yoga intervention significantly decreased..
(Babita & , Menon, Rajkumar, 2020)	The study involved 95 participants who were split into two groups: the control group (n = 45) and the yoga therapy group (n = 40).	Randomized Controlled Trial	For three months, the treatment group did yoga for fifty minutes each day under the supervision of a certified yoga instructor, following a set of yoga poses.	The MDA levels in the yoga group significantly dropped.
(Agarwal, Saxena, & Naz, 2015)	Participants in this study included 100 hypertension patients and 100 individuals between the ages of 20 and 60. They were split into two groups: the control group and the yoga treatment group.	Randomized Controlled Trial	For three months of treatment, a yoga exercise intervention was conducted.	Following the yoga exercise, MDA levels significantly decreased.

Discussion

This study sought to ascertain whether yoga practice may lower MDA levels, which are an indicator of oxidative stress. According to this study's findings, it is established that yoga practice has been proven to reduce MDA levels. The results of previous studies showed that patients with diabetes mellitus who were given Yoga intervention for 6 months were proven to be able to significantly reduce MDA levels (Usmani et al., 2025). Other research results prove that 52 minutes of yoga practice per session carried

out for 12 weeks can significantly reduce MDA levels (Pinku Mani et al., 2024). Yoga exercises in patients with diabetes mellitus carried out for 6 months have been proven to be significant in reducing MDA levels after intervention (Nikam et al., 2019). So it is known for sure that in patients with diabetes, yoga has a great impact on reducing MDA levels. So it is highly recommended as a therapy, especially for patients with diabetes mellitus.

In addition to diabetes mellitus patients, yoga also has an impact on hypertension patients. The results showed that yoga practice of 30 minutes per session, 6 sessions per week and carried out for 3 months of treatment had a significant impact on reducing MDA levels (AYu & Panova, 2020). Other research results showed that yoga performed on healthy people for 60 minutes per session 2x a week for 3 months had a significant impact on reducing MDA levels (Canda & Verma, 2016). Other results showed that a yoga program implemented through group-based classes for 60 minutes twice a week for 12 weeks was proven to be able to significantly reduce MDA levels (Cheung et al., 2018). Other research results also prove that yoga exercises consisting of a five-minute warm-up, 40-minute main exercise, and a five-minute cool-down, with a total session of 50 minutes. In addition, it was also done three times a week for 16 weeks, proven to be able to significantly reduce MDA levels after the intervention (Ha et al., 2015).

The results of other studies show that yoga exercises for pregnant women performed at 16 to 36 weeks of pregnancy have been shown to significantly reduce MDA levels (Karthiga et al., 2022). Other research results showed that yoga performed for 50 minutes every day for 3 months was also effective in reducing MDA levels after intervention (Babita & , Menon, Rajkumar, 2020). The results of other studies also prove the same thing, namely that there is a significant decrease in MDA levels in hypertension patients who have done yoga for 3 months (Agarwal et al., 2015). So it can be concluded based on the analysis that has been done, it has been proven that with yoga exercise, MDA levels have decreased. However, what is the underlying mechanism? We will try to provide an in depth discussion of the stages and mechanisms of yoga exercise in reducing MDA levels.

Physiological Concept of Yoga Exercise Lowers Malondialdehyde Levels

It is well known that following yoga meditation alone, the levels of these antioxidants steadily rose in both healthy individuals and diabetics with hypertension, suggesting better health outcomes. Following yoga meditation alone, MDA levels, a measure of lipid peroxidation, dropped in both healthy people and diabetics with high blood pressure (Usmani et al., 2025). It is well known that yoga has been shown to raise the body's antioxidant levels, which in turn lowers the body's levels of free radicals. Yoga lowers blood pressure by improving the balance of the autonomic nervous system and increasing the activity of the parasympathetic nervous system (Pal et al., 2012). However, we must comprehend the physiological idea that takes place when the body engages in physical activity before we can go any farther. Exercise causes the body's ROS levels to rise, but it also raises endogenous antioxidant levels, which controls the body's defensive mechanism (Lu et al., 2021). An imbalance between the body's greater amounts of free radicals and antioxidants causes oxidative stress, which happens during physical activity (Kawamura et al., 2020). The body can achieve a stable state of health in various ways, including through physical activity. In addition, it improves cardiovascular function and increases cardiac output, which in turn improves the metabolic system to support the musculoskeletal system (Sylviana et al., 2019). Increased ATP synthesis in mitochondria and maximum oxygen absorption are two effects of aerobic exercise that can improve oxidative capacity and lessen muscular exhaustion after exercise (van der Zwaard et al, 2021).

Research result (Souissi et al., 2020) demonstrates that following physical activity, MDA levels rise. Endogenous antioxidants are important enzymes such as glutathione peroxidase (GPX), superoxide dismutase (SOD), and catalase (CAT). These antioxidants function to support the body's defense mechanisms against free radicals, and also increase with the increase in free radicals during physical activity. SOD, an endogenous antioxidant, uses glutathione peroxidase and catalase to transform H2O2 into H2O (Cho et al, 2022). First proposed in 1985, the mechanism and idea of oxidative stress refers to the imbalance between oxidants and antioxidants that causes harm to cells (Ayubi et al., 2024). At first, it was understood that oxygen was utilized by living cells and could cause redox reactions (Ayubi et al., 2024). Extensive research on the connection between oxidants and antioxidants in metabolism has been spurred by this theory (Lorenzen et al, 2021). Numerous cellular organ dysfunctions will be brought on by elevated ROS in the body. Oxidation reactions, such as the process of absorbing oxygen into energy

in the mitochondria, occur in the human respiratory chain and also cause an increase in ROS (Pisoschi et al., 2021). Cellular physiology is impacted by cellular adaptation, which happens continuously in a variety of contexts, including changing nutrition, antigens, immunity, stressors, and oxygen concentrations (Sies & Jones, 2020).

It has been demonstrated that physical activity raises oxidative stress by raising MDA levels. A study of untrained men divided into two groups and given either moderate-intensity or high-intensity exercise revealed that the group receiving the high-intensity exercise intervention had the highest MDA levels (Cho et al., 2022). Another study conducted on 20 men divided into trained and untrained groups. The results showed that the untrained or rarely exercising group had the highest MDA levels after 30 minutes of aerobic exercise on an ergometer (Algul et al, 2018). Given its extensive distribution in human tissues, SOD may play a significant role in shielding the organism from oxidative stress brought on by free radicals (Ayubi et al., 2024). It has been demonstrated that physical activity increases SOD, glutathione, and catalase (Powers et al., 2020). There are three different isoforms of the SOD enzyme, and each one needs a transition metal to activate at its active site (Fetherolf et al., 2017). Following endurance activity, the data indicated elevated SOD levels (Azizbeigi et al., 2014). One of the main antioxidant enzymes that is present outside of cells is plasma SOD, also known as EC SOD (Xu et al., 2022). One of the main antioxidant enzymes that is present outside of cells is plasma SOD, also known as EC SOD (Xu et al., 2022). The body, on the other hand, achieves a dynamic equilibrium between the oxidation and antioxidant systems by reducing or eliminating oxidative byproducts through a sequence of metabolic events (Powers et al., 2020). According to an early 2019 study, high-intensity exercise can change antioxidant levels, which in turn impacts redox-related physiological processes (Souza et al., 2019). So it has been proven that yoga practice is one of the best therapies in improving human health status by lowering MDA levels. This is important to understand to provide scientific information about the importance of doing yoga and the important impacts it has on improving the health of the human body.

Strenght and Limitations

This systematic review's strength is that it only looked at randomized controlled trials, which are the most trustworthy kind of scientific evidence because there is no chance of an ambiguous causal association. Furthermore, the samples were collected with a focus on humans with yoga interventions to ensure that all data were consistent and not mixed with samples from other categories, such as those involving animals.

The lack of discussion and debate on the underlying process of decreasing MDA levels and how Yoga practice reduces MDA levels in humans through physiological studies is a limitation that we face. Thus, this study is considered important to provide further information on how Yoga practice can reduce MDA levels and how the underlying mechanisms are theoretical and scientific. Based on the findings of the study, Yoga becomes an alternative exercise to reduce oxidative stress.

Conclusions

Based on the results of the research analysis that has been done, yoga practice has been proven to be significant in reducing MDA levels as a sign of oxidative stress. This decrease is triggered by an increase in SOD levels as an endogenous antioxidant that naturally functions to reduce MDA levels, thereby reducing oxidative stress. Other types of exercise are still unclear, such as high-intensity exercise in affecting MDA levels, so this could be a recommendation for further research to prove it.

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Authors' and translators' details:

Akhmad Syarif	syarifroeslan2018@gmail.com	Author
Kukuh Wurdianto	kwpalangkaraya@gmail.com	Author
Silvia Arianti	silvia.aryati1985@gmail.com	Author
Baskoro Nugroho Putro	baskoro.np@staff.uns.ac.id	Author
Junian Cahyanto Wibawa	juniancahyanto96@stkippgritrenggalek.ac.id	Author
Novadri Ayubi	novadriayubi@unesa.ac.id	Author
Muhammad Muhyi	muhyi@unipasby.ac.id	Translator