Sainmatika: Jurnal Ilmiah Matematika dan Ilmu Pengetahuan Alam
Volume 22 No. 1, June 2025 DOI 10.31851/sainmatika.v22i1.18457
https://jurnal.univpgri-palembang.ac.id/index.php/sainmatika

The Effect of Physical Activity on Malondialdehyde (MDA) and Glutathione Peroxidase (GPX) Level as Biomarkers of Oxidative Stress in Young Adults

Aristoteles
e-mail: calvinaristo@yahoo.co.id

University of Muhammadiyah Ahmad Dahlan Palembang, Indonesia

ABSTRACT

Oxidative stress is a condition characterized by an imbalance between the production of free radicals and the body's ability to neutralize them with antioxidants. In young adults, oxidative stress is a significant risk factor for chronic diseases such as diabetes, hypertension, and heart disease. This study aims to analyze the effect of physical activity on oxidative stress biomarkers, specifically malondialdehyde (MDA) and glutathione peroxidase (GPX), in young adults. A cross-sectional study was conducted involving 50 participants aged 20–30 years, categorized into low, moderate, and high physical activity groups. Physical activity levels were assessed using a questionnaire, while MDA and GPX levels were measured through blood sample analysis using the spectrophotometric method. The data were analyzed using correlation and ANOVA tests to evaluate the relationships and differences in biomarker levels among the physical activity groups. The results showed significant differences in oxidative stress biomarkers and antioxidant capacity between physical activity groups ($p < 0.05$). Higher physical activity levels were associated with lower MDA levels, indicating reduced lipid peroxidation and oxidative stress. These findings support the promotion of regular, moderate-to-vigorous physical activity among young adults as an effective strategy for enhancing antioxidant defense, reducing oxidative stress, and potentially preventing chronic diseases linked to oxidative damage.

Keywords: Oxidative stress; Physical activity; Malondialdehyde (MDA); Glutathione peroxidase (GPX)

INTRODUCTION

In the modern era, lifestyle choices play a crucial role in health, with sedentary behavior being a major contributor to chronic diseases.. Among the biological processes linked to poor health, Oxidative stress is a key factor in various health issues like cardiovascular disease, diabetes, and neurodegenerative disorders. Oxidative stress occurs when there is an imbalance between reactive oxygen species (ROS) and the body's antioxidant defenses. While ROS are a natural byproduct of cellular metabolism, excessive levels can damage proteins, lipids, and DNA, leading to inflammation and disease. Two common biomarkers used to assess oxidative stress are malondialdehyde (MDA) and glutathione peroxidase (GPX) (Dubois-deruy et al., 2020).

Young adults are particularly vulnerable to oxidative stress due to lifestyle factors such as academic pressure, irregular sleep patterns, poor diets, and low physical activity. Although they are in a physically healthy stage of life, these stressors can contribute to early oxidative damage. It is crucial to address oxidative stress in this age group to potentially improve long-term health outcomes. (Cordiano et al., 2023).

Physical activity is one potential strategy to combat oxidative stress. Regular exercise is known to improve cardiovascular health, boost the immune system, and support mental well-being. It also affects oxidative stress levels. Moderate-intensity exercise can strengthen the body's antioxidant defenses and help reduce ROS. However, excessive or intense exercise may increase ROS production beyond the body's ability to manage it, potentially worsening oxidative stress (Ngadiman et al., 2023).

Research on exercise and oxidative stress in young adults is increasing, but the exact relationship is still not well understood. Some studies report that exercise lowers oxidative stress, while others suggest that intense physical activity can be harmful. This highlights the need to better understand the types and amounts of exercise that are most beneficial for managing oxidative stress in this population (Aristoteles et al., 2024).

This study aims to investigate the effect of physical activity on oxidative stress in young adults by analyzing MDA and GPX levels. By exploring different intensities, durations, and frequencies of exercise, the research seeks to clarify how physical activity influences oxidative damage. The findings could support the development of targeted exercise programs to reduce oxidative stress and improve long-term health outcomes in young adults (Cammisotto et al., 2021)

MATERIALS AND METHODS

This study employed a cross-sectional design to examine the relationship between physical activity and oxidative stress biomarkers in young adults aged 18 to 25 years. A total of 50 participants were recruited through convenience sampling from local universities and community centers. Eligibility screening was conducted to ensure that only healthy individuals without chronic diseases or oxidative stress-related conditions were included. Participants who were taking antioxidant supplements or medications that could influence the biomarkers of interest were excluded (Gwozdzinski et al., 2021) .

Physical activity assessment was conducted using both subjective and objective methods. Participants completed the International Physical Activity Questionnaire (IPAQ), which classified them into three groups based on their weekly levels of moderate-intensity physical activity: Low (<150 minutes/week), Moderate (150–300 minutes/week), and High (>300 minutes/week) (7). The IPAQ is a standardized and internationally validated tool with good test–retest reliability (median Spearman's $\rho \approx 0.80$) and moderate criterion validity ($\rho \approx 0.30$) when compared with accelerometer data (Nashrullah et al., 2023).

Additionally, all 50 participants wore accelerometers for 7 consecutive days to objectively track their physical activity. The devices recorded data such as total steps, intensity, and duration of daily activity. To ensure data reliability, IPAQ self-reported responses were compared to the accelerometer data within the same sample (Ghosh & Shcherbik, 2020).

Oxidative stress was measured by analyzing blood samples collected from participants after a 12-hour overnight fast to minimize the impact of dietary factors. Two key biomarkers were examined: Malondialdehyde (MDA), a marker of lipid peroxidation and oxidative damage to cell membranes, and Glutathione Peroxidase (GPX), an enzyme that plays a crucial role in protecting cells from oxidative stress by reducing hydrogen peroxide (Di Franco et al., 2022). MDA

p-ISSN 1829 586X
e-ISSN 2581-0170

levels were quantified using the thiobarbituric acid reactive substances (TBARS) assay kit (e.g., Cayman Chemical, USA), while GPX activity was measured using a colorimetric enzymatic assay kit (e.g., Abcam, UK), following the manufacturers' standard protocols. All analyses were conducted in a certified clinical laboratory using standardized laboratory procedures and quality control measures to ensure accuracy and reproducibility (Drăgoi et al., 2024).

Statistical analysis was performed using IBM SPSS Statistics version 26. Descriptive statistics were calculated to summarize participant characteristics and activity levels. One-way ANOVA was used to compare MDA and GPX levels across the three physical activity groups. In addition, Pearson correlation tests were conducted to examine the relationship between physical activity variables (from both IPAQ and accelerometers) and oxidative stress biomarkers. A significance level of $p < 0.05$ was considered statistically significant (Pereira et al., 2021).

This study was approved by the Ethics Committee of the Faculty of Health Sciences, Universitas Muhammadiyah Ahmad Dahlan Palembang (Approval No: 032/KEPK-FKes/IKesT MP/2024).

All participants signed written informed consent prior to participation, and the study followed the principles of the Declaration of Helsinki.

RESULTS AND DISCUSSION

Table 1 shows significant differences in oxidative stress biomarkers and antioxidant capacity between physical activity groups ($p < 0.05$). Higher physical activity levels were associated with lower MDA levels, indicating reduced lipid peroxidation and oxidative stress. In contrast, GPx levels, an important antioxidant enzyme, were significantly higher in the moderate and high activity groups, suggesting improved antioxidant defense. Similarly, TAC values increased with physical activity, reflecting enhanced overall antioxidant capacity (Moghaddasi et al., 2014).

Table 1. Oxidative Stress Biomarkers and Antioxidant Capacity Based on Physical Activity Level

Physical Activity Level	**Malondialdehyde (MDA) (µmol/L)**	**Glutathione Peroxidase (GPx) (U/mL)**	**Total Antioxidant Capacity (TAC) (mmol/L)**
Low Physical Activity	2.5 ± 0.4	3.0 ± 0.9	0.85 ± 0.10
Moderate Physical Activity	1.8 ± 0.3	4.2 ± 1.0	1.15 ± 0.12
High Physical Activity	1.6 ± 0.2	5.0 ± 1.2	1.30 ± 0.13
p-value	< 0.05	< 0.05	< 0.05

Discussion

The findings of this study demonstrate a clear relationship between physical activity and oxidative stress biomarkers in young adults. Participants who engaged in moderate to high levels of physical activity exhibited significantly lower MDA levels and higher GPx and TAC levels than those in the low activity group (Niessner et al., 2003).

The reduction in MDA levels in the moderate and high activity groups suggests that regular physical activity helps mitigate oxidative damage to cell membranes. Since MDA is a well-established marker of lipid peroxidation, its decrease in physically active individuals indicates less oxidative stress and aligns with previous studies showing that sedentary behavior increases oxidative damage. (Wang et al., 2023).

In addition, the study showed a significant increase in GPx levels among the moderate and high activity groups. GPx (Glutathione Peroxidase), not to be confused with GSH (Glutathione), is a key antioxidant enzyme that reduces hydrogen peroxide and lipid peroxides, thereby protecting cells from oxidative injury. This suggests that regular physical activity enhances the body’s enzymatic antioxidant defense system, which is consistent with other research highlighting the positive effects of moderate-intensity exercise on endogenous antioxidant production (Balci et al., 2012).

The increase in Total Antioxidant Capacity (TAC) further supports the role of physical activity in enhancing overall oxidative defense (Restuningwiyani et al., 2018). TAC reflects the cumulative action of all antioxidants present in plasma and body fluids. Higher TAC values in active groups suggest stronger defense against free radicals, reducing oxidative damage to cells and tissues. This is in line with literature suggesting that consistent exercise boosts both specific antioxidants and the total antioxidant network (Tugasworo et al., 2023).

This study also supports a dose-response relationship between physical activity and oxidative stress markers (Baruah et al., 2012). As the frequency and intensity of physical activity increase, MDA levels decrease, while GPx and TAC levels rise. This is in line with findings by Ji (Yi et al., 2022), who emphasized that chronic, moderate-intensity exercise enhances the body's antioxidant response and resistance to oxidative damage over time.

However, it is important to acknowledge potential confounding variables that may have influenced the results. Factors such as dietary intake—especially antioxidant-rich foods like fruits and vegetables—could independently affect oxidative stress markers. Although participants were instructed to fast prior to blood sampling, their habitual diet was not controlled or assessed in this study. Moreover, psychological stress is known to increase the production of reactive oxygen species (ROS) and could potentially confound the relationship between physical activity and oxidative stress. Elevated cortisol levels due to chronic stress may suppress antioxidant defenses, thereby influencing biomarker levels independently of physical activity. Future studies should include standardized dietary assessments and validated psychological stress questionnaires to control for these variables and strengthen causal interpretations (Flora, 2017).

Importantly, the data also support a dose-response relationship between physical activity and oxidative stress biomarkers. As physical activity levels increased from low to high, MDA decreased, while GPx and TAC increased. This underlines the importance of regular, moderate-to-vigorous physical activity for improving redox balance and preventing chronic diseases (Nur Wahyu et al., 2023)

CONCLUSION

This study highlights the significant impact of physical activity on oxidative stress biomarkers in young adults. The findings demonstrate that individuals who engage in moderate to high levels of physical activity exhibit lower levels of malondialdehyde (MDA), a marker of oxidative damage, and higher levels of glutathione peroxidase (GPx) and total antioxidant capacity (TAC), which are indicators of enhanced antioxidant defense. These results suggest that regular physical activity plays a vital role in maintaining redox balance and protecting the body from oxidative damage.

The study also provides evidence of a dose-response relationship, indicating that greater intensity and frequency of physical activity are associated with more favorable oxidative stress profiles. Importantly, while moderate exercise improves antioxidant capacity, excessive or overly intense physical activity may lead to increased production of reactive oxygen species, potentially resulting in temporary oxidative stress. Therefore, maintaining a balanced exercise regimen is essential to maximize the health benefits of physical activity while minimizing potential risks.

Overall, these findings support the promotion of regular, moderate-to-vigorous physical activity among young adults as an effective strategy for enhancing antioxidant defense, reducing oxidative stress, and potentially preventing chronic diseases linked to oxidative damage.

Future research should consider longitudinal intervention studies to evaluate the long-term effects of sustained physical activity on oxidative stress biomarkers. Investigating other demographic groups, such as adolescents, middle-aged adults, and the elderly, would also provide a broader understanding of how age influences the relationship between physical activity and oxidative stress. Additionally, examining the interaction between physical activity, diet, and psychological stress could help clarify the complex mechanisms underlying redox balance.

Acknowledgments

Thank you to Universitas Muhammadiyah Ahmad Dahlan Palembang

REFERENCES

Aristoteles, Sansuwito, T. Bin, Bastian, & Nurhidayanti. (2024). The Comparative Study of Physical Exercise Towards Brain Natriuretic Peptide (BNP) and Malondialdehyde (MDA) as Oxidative Stress Markers in (Rattus novergicus) Wistar Strain Rats. *International Journal of Advancement in Life Sciences Research*, *7*(2), 188–195. https://doi.org/10.31632/ijalsr.2024.v07i02.014

Balci, S. S., Pepe, H., Güney, S., Özer, C., & Revan, S. (2012). Effects of gender, Endurance training and acute exhaustive exercise on oxidative stress in the heart and skeletal muscle of the rat. *Chinese Journal of Physiology*, *55*(4). https://doi.org/10.4077/CJP.2012.BAA021

Baruah, M., Nath, C., Goyal, S., Das, B., & Devi, R. (2012). *STUDY OF C - REACTIVE PROTEIN , MALONDIALDEHYDE AND URIC ACID LEVELS IN PREDICTING OUTCOME IN*. *04*(19), 128–132.

Cammisotto, V., Nocella, C., Bartimoccia, S., Sanguigni, V., Francomano, D., Sciarretta, S., Pastori, D., Peruzzi, M., Cavarretta, E., D'amico, A., Castellani, V., Frati, G., & Carnevale, R. (2021). The role of antioxidants supplementation in clinical practice: focus on cardiovascular risk factors. *Antioxidants*, *10*(2), 1–32. https://doi.org/10.3390/antiox10020146

Cordiano, R., Di Gioacchino, M., Mangifesta, R., Panzera, C., Gangemi, S., & Minciullo, P. L. (2023). Malondialdehyde as a Potential Oxidative Stress Marker for Allergy-Oriented Diseases: An Update. *Molecules*, *28*(16), 1–22. https://doi.org/10.3390/molecules28165979

Di Franco, M., Vona, R., Gambardella, L., Cittadini, C., Favretti, M., Gioia, C., Straface, E., & Pietraforte, D. (2022). Estrogen receptors, ERK1/2 phosphorylation and reactive oxidizing species in red blood cells from patients with rheumatoid arthritis. *Frontiers in Physiology*, *13*(December). https://doi.org/10.3389/fphys.2022.1061319

Drăgoi, C. M., Diaconu, C. C., Nicolae, A. C., & Dumitrescu, I. B. (2024). Redox Homeostasis and Molecular Biomarkers in Precision Therapy for Cardiovascular Diseases. *Antioxidants*, *13*(10), 1–21. https://doi.org/10.3390/antiox13101163

Dubois-deruy, E., Peugnet, V., Turkieh, A., & Pinet, F. (2020). Oxidative stress in cardiovascular diseases. *Antioxidants*, *9*(9), 1–15. https://doi.org/10.3390/antiox9090864

Flora, R. (2017). Indikator Beban Berlebih Pada Otot Jantung Tikus Wistar Yang Diberi Perlakuan Latihan Fisik Akut The Indicator of Overload in Rat Myocardium That Given Acute Physical Exercise. *Biomedical Journal of Indonesia*, *1*(1), 35–39.

Ghosh, A., & Shcherbik, N. (2020). Effects of oxidative stress on protein translation: Implications for cardiovascular diseases. *International Journal of Molecular Sciences*, *21*(8), 1–25. https://doi.org/10.3390/ijms21082661

Gwozdzinski, K., Pieniazek, A., & Gwozdzinski, L. (2021). Reactive Oxygen Species and Their Involvement in Red Blood Cell Damage in Chronic Kidney Disease. *Oxidative Medicine and Cellular Longevity*, *2021*. https://doi.org/10.1155/2021/6639199

Moghaddasi, M., Javanmard, S. H., Reisi, P., Tajadini, M., & Taati, M. (2014). The effect of regular exercise on antioxidant enzyme activities and lipid peroxidation levels in both hippocampi after occluding one carotid in rat. *Journal of Physiological Sciences*, *64*(5), 325–332. https://doi.org/10.1007/s12576-014-0322-y

Nashrullah, M., Fahyuni, E. F., Nurdyansyah, N., & Untari, R. S. (2023). Metodologi Penelitian Pendidikan (Prosedur Penelitian, Subyek Penelitian, Dan Pengembangan Teknik Pengumpulan Data). In *Metodologi Penelitian Pendidikan (Prosedur Penelitian, Subyek Penelitian, Dan Pengembangan Teknik Pengumpulan Data)*. https://doi.org/10.21070/2023/978-623-464-071-7

Ngadiman, N., Noor Heza, F., & Suko Wahono, B. (2023). Pengaruh

Pemberian Vitamin E Terhadap Derajat Stress Oksidatif Akibat Olahraga. *Physical Activity Journal*, *4*(2), 269. https://doi.org/10.20884/1.paju.2023.4.2.8477

Niessner, A., Ziegler, S., Slany, J., Billensteiner, E., Woloszczuk, W., & Geyer, G. (2003). Increases in plasma levels of atrial and brain natriuretic peptides after running a marathon: Are their effects partly counterbalanced by adrenocortical steroids? *European Journal of Endocrinology*, *149*(6), 555–559. https://doi.org/10.1530/eje.0.1490555

Nur Wahyu, A. E., Idris, I., Aras, D., Sinrang, A. W., Patellongi, I., & Nawir, N. (2023). Analysis of Changes in Malondialdehyde (MDA) and Lactate Dehydrogenase (LDH) Levels After a 30 km Cycling Event in The Makassar Cycling Community. *COMPETITOR: Jurnal Pendidikan Kepelatihan Olahraga*, *15*(1), 104. https://doi.org/10.26858/cjpko.v15i1.43630

Pereira, C. P. M., Souza, A. C. R., Vasconcelos, A. R., Prado, P. S., & Name, J. J. (2021). Antioxidant and anti-inflammatory mechanisms of action of astaxanthin in cardiovascular diseases (Review). *International Journal of Molecular Medicine*, *47*(1), 37–48. https://doi.org/10.3892/ijmm.2020.4783

Restuningwiyani, S., Sujuti, H., Rahayu, M., & Subandiyah, K. (2018). Correlation of Malondialdehyde (MDA) and C-reactive Protein (CRP) Level to Neurodevelopmental Outcome in Children After the Episode of Convulsive Type Status Epilepticus. *Journal of Tropical Life Science*, *8*(3), 251–258. https://doi.org/10.11594/jtls.08.03.07

Tugasworo, D., Prasetyo, A., Kurnianto, A., Retnaningsih, R., Andhitara, Y., Ardhini, R., & Budiman, J. (2023). Malondialdehyde (MDA) and 8-hydroxy-2′-deoxyguanosine (8-OHdG) in ischemic stroke: a systematic review. *Egyptian Journal of Neurology, Psychiatry and Neurosurgery*, *59*(1). https://doi.org/10.1186/s41983-023-00688-6

Wang, Y., Luo, D., Jiang, H., Song, Y., Wang, Z., Shao, L., & Liu, Y. (2023). Effects of physical exercise on biomarkers of oxidative stress in healthy subjects: A meta-analysis of randomized controlled trials. *Open Life Sciences*, *18*(1). https://doi.org/10.1515/biol-2022-0668

Yi, X., Zhu, Q. X., Wu, X. L., Tan, T. T., & Jiang, X. J. (2022). Histone Methylation and Oxidative Stress in Cardiovascular Diseases. *Oxidative Medicine and Cellular Longevity*, *2022*. https://doi.org/10.1155/2022/6023710