PERBEDAAN PENGARUH AKTIVITAS DI RUANG TERBUKA DAN RUANG TERBUKA BERPOLUSI SERTA PEMBERIAN ANTIOKSIDAN TERHADAP INFLAMASI DAN *MITOCHONDRIAL BIOGENESIS* PARU-PARU

DISERTASI

diajukan untuk memenuhi sebagian syarat untuk memperoleh gelar Doktor Pendidikan dalam Bidang Pendidikan Olahraga

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ABSTRAK

Lucky Angkawidjaja Roring. 2024. Perbedaan Pengaruh Aktivitas di Ruang Terbuka dan Ruang Terbuka Berpolusi serta Pemberian Antioksidan terhadap Inflamasi dan *Mitochondrial Biogenesis* Paru-Paru. Promotor: Prof. Dr. Amung Ma'mun, M.Pd. Ko-Promotor: Prof. dr. Hamidie Ronald Daniel Ray., M.Pd., Ph.D. Anggota: Dr. Eng. Beta Paramita, S.T., M.T.

Penelitian dilatarbelakangi oleh pentingnya aktivitas di ruang terbuka sebagai salah satu upaya memelihara dan meningkatkan kesehatan. Aktivitas di ruang terbuka khususnya di area perkotaan memiliki risiko yang ditimbulkan oleh polusi udara. Pemberian antioksidan diharapkan dapat memiliki pengaruh terhadap inflamasi dan *mitochondrial biogenesis* paru-paru sebagai akibat paparan polusi udara. Tujuan penelitian adalah menguji perbedaan pengaruh aktivitas di ruang terbuka dan ruang terbuka berpolusi serta pemberian antioksidan terhadap proses inflamasi dan *mitochondrial biogenesis* paru-paru. Penelitian menggunakan pendekatan kuantitatif dengan metode eksperimen dan desain *True Experimental* serta *Randomized Posttest-only Control Group Design*. Subjek penelitian menggunakan tikus jantan galur Wistar berusia 8 – 12 minggu. Hasil penelitian menunjukkan: 1) Aktivitas berpengaruh signifikan terhadap IL-6 tetapi tidak signifikan terhadap NF-κB jaringan paru-paru; 2) Aktivitas juga berpengaruh signifikan terhadap biomaker *mitochondrial biogenesis* PGC-1α dan TOM20, namun tidak berpengaruh signifikan terhadap COXIV*;* 3) Polusi udara secara parsial tidak berpengaruh signifikan terhadap IL-6 dan NF-κB**,** namun ketika berinteraksi dengan pemberian ekstrak daun *Moringa oleifera*, polusi berpengaruh signifikan terhadap IL-6 jaringan paru-paru; 4) Secara parsial, polusi berpengaruh signifkan pada TOM20 namun tidak berpengaruh signifikan terhadap PGC-1α dan COX IV jaringan paru-paru; 5) Pemberian ekstrak daun *Moringa oleifera* berpengaruh signifikan terhadap IL-6 namun tidak berpengaruh signifikan terhadap NF-κB jaringan paru-paru; 6) Secara parsial, pemberian ekstrak daun *Moringa oleifera* tidak berpengaruh signifikan terhadap PGC-1α, TOM20, dan COX IV jaringan paru-paru. Namun ketika berinteraksi dengan aktivitas dan polusi, pemberian ekstrak daun *Moringa oleifera* berpengaruh signifikan terhadap TOM20 jaringan paru-paru. Penelitian ini berimplikasi dalam mendukung paradigma "*Development Through Sport*", menjadi dasar *policy brief* untuk meningkatkan kesadaran kualitas udara dan membantu pengembangan kurikulum dan program olahraga yang efektif.

Kata Kunci: Aktivitas, Antioksidan, Inflamasi, *Mitochondrial Biogenesis,* Polusi, Paru-Paru, Ruang Terbuka

ABSTRACT

Lucky Angkawidjaja Roring. 2024. Differences in the Effect of Activities in Open Space and Polluted Open Space and Antioxidant Administration on Pulmonary Inflammation and Mitochondrial Biogenesis. Promoter: Prof. Dr. Amung Ma'mun, M.Pd. Co-Promoter: Prof. dr. Hamidie Ronald Daniel Ray, M.Pd., Ph.D. Member: Dr. Eng. Beta Paramita, S.T., M.T.

The study was based on the importance of physical activity in open spaces as an effort to maintain and improve health. Activity in open spaces, especially in urban areas, has risks posed by air pollution. Antioxidant administration is expected to have an influence on inflammation and mitochondrial biogenesis of the lungs as a result of exposure to air pollution. The purpose of the study was to examine the difference in the effect of activity in open space and polluted open space as well as antioxidant administration on the inflammatory process and pulmonary mitochondrial biogenesis. The study used a quantitative approach with experimental methods and True Experimental design and Randomized Posttest-only Control Group Design. The research subjects used male Wistar rats aged 8-12 weeks. The results showed: 1) Activity has a significant effect on IL-6 but not significant on NF-κB of lung tissue; 2) Activity also has a significant effect on mitochondrial biogenesis biomakers PGC-1α and TOM20, but has no significant effect on COXIV; 3) Air pollution partially has no significant effect on IL-6 and NF-κB, but when interacting with the administration of Moringa oleifera leaf extract, pollution has a significant effect on IL-6 in pulmonary tissue; 4) Partially, pollution has a significant effect on TOM20 but has no significant effect on PGC-1α and COX IV in lung tissue; 5) The administration of Moringa oleifera leaf extract has a significant effect on IL-6 but no significant effect on NF-κB in lung tissue; 6) Partially, the administration of Moringa oleifera leaf extract has no significant effect on PGC-1α, TOM20, and COX IV in pulmonary tissue. However, when interacting with activity and pollution, the administration of Moringa oleifera leaf extract has a significant effect on TOM20 of lung tissue. This research has implications in supporting the "Development Through Sport" paradigm, informing policy briefs to raise air quality awareness and assisting the development of effective sports curricula and programs.

Keywords: Activity, Antioxidant, Inflammation, Lung Mitochondrial Biogenesis, Open Space, Pollutions

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DAFTAR GRAFIK

1) Dalam penelitian ini, aktivitas fisik di luar perlakuan tidak dapat dikendalikan dan dimonitor secara ketat sehingga memungkinkan tikus beraktivitas secara bervariasi. Kondisi ini dapat berpengaruh terhadap volume aktivitas fisik setiap tikus baik pada kelompok aktivitas maupun tanpa aktivitas.
2) Penelitian ini menggunakan sampel tiap kelompok sebanyak lima subjek. Meskipun secara teoretik ukuran sampel lima memenuhi syarat menurut Federer namun sampel kecil ini menyebabkan ketidakstabilan hasil dalam uji statistika.
3) Aktivitas dengan intensitas sedang pada penelitian ini hanya menggunakan *treadmill.*
4) Subjek penelitian menggunakan tikus Wistar jantan yang pada beberapa kondisi memiliki keterbatasan dengan partisipan sesungguhnya yang diukur yakni manusia.
5) Penelitian masih melibatkan sampel yang terbatas, pemantauan jangka pendek, serta penggunaan teknologi pemantauan paru-paru yang relatif sederhana.

DAFTAR PUSTAKA

Abdel-Salam, Mahmoud M.M. Outdoor and indoor factors influencing particulate matter and carbon dioxide levels in naturally ventilated urban homes. Journal of the Air & Waste Management Association Volume 71, 2021 - Issue 1. https://doi.org/10.1080/10962247.2020.1834009.

Abohashem, S., Osborne, M. T., Dar, T., Naddaf, N., Abbasi, T., Ghoneem, A., Radfar, A., Patrich, T., Oberfeld, B., Tung, B., Fayad, Z. A., Rajagopalan, S., & Tawakol, A. (2021). A leucopoietic-arterial axis underlying the link between ambient air pollution and cardiovascular disease in humans. *European heart journal, 42*(7), 761-772. https://doi.org/10.1093/eurheartj/ehaa982

Aghasafari, P., George, U., & Pidaparti, R. (2019). A review of inflammatory mechanisms in airway diseases. *Inflammation Research, 68*, 59-74. https://doi.org/10.1007/s00011-018-1191-2

Ahmad, K. A., Yuan Yuan, D., Nawaz, W., Ze, H., Zhuo, C. X., Talal, B., ... & Qilong, D. (2017). Antioxidant therapy for management of oxidative stress induced hypertension. *Free radical research*, *51*(4), 428-438. https://doi.org/10.1080/10715762.2017.1322205

Ahmed, A. U. (2011). An overview of inflammation: mechanism and consequences. *Frontiers in Biology, 6*, 274-281. https://doi.org/10.1007/s11515-011-1123-9.

Akira, S., Uematsu, S., & Takeuchi, O. (2006). Pathogen recognition and innate immunity. *Cell, 124*(4), 783-801. https://doi.org/10.1016/j.cell.2006.02.015

Alawi, C. M., Ray, H. R. D., & Rusdiana, A. (2022). The Effect of Outdoor Sports and Green Outdoors on Lung Inflammation. *JUARA: Jurnal Olahraga*, *7*(1), 178-187. https://doi.org/10.33222/juara.v7i1.1418

Alessio, H. M., Hagerman, A. E., Fulkerson, B. K., Ambrose, J. E. S. S. I. C. A., RICE, R. E., & WILEY, R. L. (2000). Generation of reactive oxygen species after exhaustive aerobic and isometric exercise. *Medicine & Science in Sports & Exercise, 32*(9), 1576-1581. https://doi.org/10.1097/00005768-200009000-00008

Allardt, E. (1967). Basic approaches in comparative sociological research and the study of sport. International Review of Sport Sociology, 2(1), 89-107. https://doi.org/10.1177/101269026700200107

Alper, S., & Janssen, W. J. (2018). *Lung innate immunity and inflammation: Methods and protocols.* Humana Press. https://doi.org/10.1007/978-1-4939-8570-8

Amli, M.S., Yuliarto, B, Nugraha. (2015). Desain dan Pembuatan Sistem Pengukuran Kualitas Udara Menggunakan Mikrokontroler. *J.Oto.Ktrl.Inst (J.Auto.Ctrl.Inst)* Vol 7 (1), 2015 ISSN: 2085-2517-1

Andersen, L. B., Schnohr, P., Schroll, M., & Hein, H. O. (2000). All-cause mortality associated with physical activity during leisure time, work, sports, and

cycling to work. Archives of *Internal Medicine, 160*(11), 1621-1628. https://doi.org/10.1001/archinte.160.11.1621

Anderson, S., Bankier, A. T., Barrell, B. G., de Bruijn, M. H., Coulson, A. R., Drouin, J., Eperon, I. C., Nierlich, D. P., Roe, B. A.. Sanger, F., Schreier, P. H., Smith, A. J. H, Staden, R., & Young, I. G. (1981). Sequence and organization of the human mitochondrial genome. Nature, 290(5806), 457-465. https://doi.org/10.1038/290457a0

Andriani, N., Sujuti, H., & Winarsih, S. (2016). Efek Ekstrak Etanol Daun Kelor (*Moringa oleifera*) terhadap Nuclear Factor Kappa Beta (NF-kB) Aktif dan Apoptosis Cell Line Kanker MCF-7. *Majalah Kesehatan, 3*(4), 204–212. https://majalahfk.ub.ac.id/index.php/mkfkub/article/view/112

Aneja, V. P., Schlesinger, W. H., & Erisman, J. W. (2008). Farming pollution. *Nature Geoscience, 1*(7), 409-411. https://doi.org/10.1038/ngeo236

Anwar, F., Latif, S., Ashraf, M., & Gilani, A. H. (2007). *Moringa oleifera*: A food plant with multiple medicinal uses. *Phytotherapy Research, 21*(1), 17-25. https://doi.org/10.1002/ptr.2023

Arias-Pérez, R. D., Taborda, N., Gómez, D. M., Narvaez, J. F., Porras, J., & Hernandez, J. C. (2020). Inflammatory effects of particulate matter air pollution. *Environmental Science and Pollution Research*, 1-15. https://doi.org/10.1007/s11356-020-10574-w

Atan, T., & Akyol, P. (2012). Comparison of Respiratory Functions of Athletes *Engaged in Different Sports Branches, 14*(3), 76–81.

Atkinson, R. W., Fuller, G. W., Anderson, H. R., Harrison, R. M., & Armstrong, B. (2010). Urban ambient particle metrics and health: a time-series analysis. *Epidemiology*, 501-511. https://www.jstor.org/stable/25680581

Badan Pengendalian Dampak Lingkungan. (1998). P*edoman Teknis Perhitungan dan Pelaporan serta Informasi Indeks Standar Pencemar Udara*. Jakarta: Bapedal.

Baker, B. M., Lithgow, G., & Schartz, G. (2007). TOM20: A key regulator of mitochondrial protein import. *Biochimica et Biophysica Acta, 1763*(2), 557-561.

Balmes, J. R., Arjomandi, M., Bromberg, P. A., Costantini, M. G., Dagincourt, N., Hazucha, M. J., Hollenbeck-Pringle, D., Rich, D. Q., Stark, P., & Frampton, M. W. (2019). Ozone effects on blood biomarkers of systemic inflammation, oxidative stress, endothelial function, and thrombosis: The Multicenter Ozone Study in oldEr Subjects (MOSES). *PloS one, 14*(9), e0222601. https://doi.org/10.1371/journal.pone.0222601

Bangun, Sabaruddin, Y. (2013). Analisis Sport Development Index Kota Tebing Tinggi Sumatera Utara Tahun 2012**.** *Gladi Jurnal Ilmu Keolahragaan* 07 (02) 2013, 800-810. https://doi.org/10.21009/GJIK.072.05

Barn, P., Fong, D., & Kosatsky, T. (2016). Carbon monoxide detectors: A powerful, underused way to protect lives. *British Columbia Medical Journal, 58*(1), 49-

49. https://bcmj.org/bccdc/carbon-monoxide-detectors-powerful-underused-way-protect-lives?inline=true

Barnes, P. J. (2013). Exhaled breath condensate: A new approach to monitoring lung inflammation. In P. Montuschi, *New perspectives in monitoring lung inflammation: Analysis of exhaled breath condensate* (pp. 1-10). CRC Press.

Barnes, D. L. & Connor, B. (2014). *Managing Dust on Unpaved Roads and Airports.* INE/AUTC 14.14 Report Num. 4000096.

Batalioto, C., Pauletti, C., Buffon, D., Dragunski, D., & Lindino, C. (2022). Aminpentacyanoferrate as a Carbon Monoxide Indicator. *Revista Tecnológica*. https://doi.org/10.4025/revtecnol.v30i1.57459.

Belfont Scientific. (2018). *Belfont Smokerlyzer Manual Book*. England: Belfont Scientific Ltd.

Bhanwra, R. K., Tyagi, S., Singh, N., & Barthwal, R. C. (2014). Effect of *Moringa oleifera* Linn. on inflammatory markers in hyperlipidemic rats: A randomized controlled trial. *Pharmacological Research, 86*, 48–55.

Bhatnagar, A., Sharma, J. N., & Pandey, M. C. (2015). Antioxidant and anti-inflammatory activity of *Moringa oleifera* leaf extract: An in vitro and in vivo study. *Journal of Complementary and Integrative Medicine, 12*(3), 232–238.

Bowatte, G., Lodge, C. J., Knibbs, L. D., Lowe, A. J., Erbas, B., Dennekamp, M., & Dharmage, S. C. (2017). Traffic-related air pollution exposure is associated with allergic sensitization, asthma, and poor lung function in middle age. *Journal of Allergy and Clinical Immunology, 139*(1), 122-129. https://doi.org/10.1016/j.jaci.2016.05.046

Bowler, R. P., Crapo, J. D., & Oxidative Stress in Airway Disease. (2002). *American Journal of Respiratory and Critical Care Medicine, 166*(12), S4-S9. https://doi.org/10.1164/rccm.2206010

Brand, Serge., Ebner, Katarina., Mikoteit, Thorsten., Lejri, Imane, Gerber,. Markus, Beck, Johannes, Holsboer-Trachsler, Edith., and Eckert, Anne. (2020). Influence of Regular Physical Activity on Mitochondrial Activity and Symptoms of Burnout—An Interventional Pilot Study. J Clin Med. 2020 Mar; 9(3): 667. doi: 10.3390/jcm9030667

Breton, C. V., Song, A., Xiao, J., Kim, S.-J., Mehta, H., Wan, J., . . . Cohen, P. (2019). Effects of air pollution on mitochondrial function, mitochondrial DNA methylation, and mitochondrial peptide expression. *Mitochondrion, 46*, 22-29. https://doi.org/10.1016/j.mito.2019.04.001.

Brierley, Elizabeth Jane., Johnson, M.A., James, Oliver., Turnbull, D.M. (1996). Effects of physical activity and age on mitochondrial function. QJM: monthly journal of the Association of Physicians 89(4):251-8. DOI: 10.1093/qjmed/89.4.251

Brunekreef, B., & Holgate, S. T. (2002). Air pollution and health. *The lancet, 360*(9341), 1233-1242. https://doi.org/10.1016/S0140-6736(02)11274-8

Bryda, Elizabeth C. (2013) The Mighty Mouse: The Impact of Rodents on Advancesin Biomedical Research. *Missouri Medicine.The Journal of the Missouri State Medical Association.*

Bryman, Alan. (2012). *Social Research Method*. New York: Oxford University Press, Inc.

Buettner, G. R. (2011). The pecking order of free radicals and antioxidants: lipid peroxidation, α-tocopherol, and ascorbate. *Archives of biochemistry and biophysics, 300*(2), 535-543. https://doi.org/10.1006/abbi.1993.1074

Byard, R. W. (2019). Carbon monoxide–the silent killer. *Forensic Science, Medicine and Pathology, 15*(1), 1-2. https://doi.org/10.1007/s12024-018-0040-5

Cabre, H. E., Gordon, A. N., Patterson, N. D., & Smith-Ryan, A. E. (2022). Evaluation of pre-workout and recovery formulations on body composition and performance after a 6-week high-intensity training program. *Frontiers in Nutrition*, *9*, 1016310. https://doi.org/10.3389/fnut.2022.1016310

Carlisle, A. J., & Sharp, N. C. C. (2001). Exercise and outdoor ambient air pollution. *British Journal of Sports Medicine, 35*(4), 214-222. https://doi.org/10.1136/bjsm.35.4.214

Carlsen, M. H., Halvorsen, B. L., Holte, K., Bøhn, S. K., Dragland, S., Sampson, L., Willey, C., Senoo, H., Umezono, Y., Sanada, C., Barikmo, I., Berhe, N., Willet, W. C., Phillips, K. M., Jacobs Jr., D. R., & Blomhoff, R. (2010). The total antioxidant content of more than 3100 foods, beverages, spices, herbs and supplements used worldwide. *Nutrition journal, 9*(1), 1-11. https://doi.org/10.1186/1475-2891-9-3

Carlsten, C., Brauer, M., & Brinkman, F. S. (2017). Fine particulate matter constituents associated with cardiovascular hospitalizations and mortality in patients with coronary artery disease. *Environmental Health Perspectives, 125*(7), 117007. https://doi.org/10.1289/EHP1637

Carr, Stephen, et al. (1992). *Public Space*. Australia: Cambridge University.

Carraway, M. S., Suliman, H. B., Kliment, C., Welty-Wolf, K. E., Oury, T. D., & Piantadosi, C. A. (2008). Mitochondrial biogenesis in the pulmonary vasculature during inhalational lung injury and fibrosis. *Antioxidants & redox signaling, 10*(2), 269-276. https://doi.org/10.1089/ars.2007.1910

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public health reports, 100(2), 126. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1424733/

Chalip, L. (2006). Towards social leverage of sport events. *Journal of sport & tourism, 11*(2), 109-127. https://doi.org/10.1080/14775080601155126

Chan, Y. L., Wang, B., Chen, H., Ho, K. F., Cao, J., Hai, G., Jalaludin, B., Herbert, C., Thomas, P. S., Saad, S., & Oliver, B. G. G. (2019). Pulmonary inflammation induced by low-dose particulate matter exposure in mice.

American Journal of Physiology-Lung Cellular and Molecular Physiology, 317(3), L424-L430. https://doi.org/10.1152/ajplung.00232.2019

Chen, H., Yang, S., & Guo, Y. (2020). The impact of air pollution on mitochondrial biogenesis and function. *Environmental Toxicology and Pharmacology, 77*(103588).

Chen, L., Deng, H., Cui, H., Fang, J., Zuo, Z., Deng, J., Li, Y., Wang, X., & Zhao, L. (2018). Inflammatory responses and inflammation-associated diseases in organs. *Oncotarget, 9*(6), 7204. https://doi.org/10.18632%2Foncotarget.23208

Chen, T. M., Kuschner, W. G., Gokhale, J., & Shofer, S. (2007). Outdoor air pollution: nitrogen dioxide, sulfur dioxide, and carbon monoxide health effects. *The American journal of the medical sciences*, *333*(4), 249-256. https://doi.org/10.1097/MAJ.0b013e31803b900f

Chennaoui, M., Drogou, C., & Gomez-Merino, D. (2008). Effects of physical training on IL-1beta, IL-6 and IL-1ra concentrations in various brain areas of the rat.. European cytokine network, 19 1, 8-14 . https://doi.org/10.1684/ecn.2008.0115.

Cheung, K., Daher, N., Kam, W., Shafer, M. M., Ning, Z., Schauer, J. J., & Sioutas, C. (2011). Spatial and temporal variation of chemical composition and mass closure of ambient coarse particulate matter (PM10–2.5) in the Los Angeles area. *Atmospheric environment,* 45(16), 2651-2662. https://doi.org/10.1016/j.atmosenv.2011.02.066

Chew, S., & et al. (2020). Urban air particulate matter induces mitochondrial dysfunction in human olfactory mucosal cells. *Particle and Fibre Toxicology, 17*(18). https://doi.org/10.1186/s12989-020-00352-4

Chow, J. C., Liu, C. S., Cassmassi, J., Watson, J. G., Lu, Z., & Pritchett, L. C. (1992). A neighborhood-scale study of PM10 source contributions in Rubidoux, California. Atmospheric Environment. Part A. *General Topics, 26*(4), 693-706. https://doi.org/10.1016/0960-1686(92)90181-J

Clayton, G. C. (1996). The R Coronae borealis stars. *Publications of the Astronomical Society of the Pacific, 108*(721), 225. https://doi.org/10.1086/133715

Coalter, F. (2007). *A wider social role for sport: Who's keeping the score?*. New York: Routledge.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences (2nd ed.).* New York: Routledge.

Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., Horton, E. S., Castorino, K., & Tate, D. F. (2016). Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. Diabetes care, 39(11), 2065. https://doi.org/10.2337%2Fdc16-1728

Cottin, V., Wollin, L., Fischer, A., Quaresma, M., Stowasser, S., & Harari, S. (2019). Fibrosing interstitial lung diseases: Knowns and unknowns.

European Respiratory Review, 28(151), 1-9. http://doi.org/10.1183/16000617.0100-2018

Daba, M. (2016). Miracle tree: A review on multi-purposes of *Moringa oleifera* and its implication for climate change mitigation. *Journal of Earth Science & Climatic Change, 7*(8), 1-5. https://doi.org/10.4172/2157-7617.1000366

Dalrymple, S. A., Slattery, R., Aud, D. M., Krishna, M., Lucian, L. A., & Murray, R. (1996). Interleukin-6 is required for a protective immune response to systemic escherichia coli infection. *Infection and Immunity, 64*(8), 3231-3235. https://doi.org/10.1128%2Fiai.64.8.3231-3235.1996

Das, S., Pal, D., & Sarkar, A. (2021). Particulate matter pollution and global agricultural productivity. *Sustainable Agriculture Reviews 50: Emerging Contaminants in Agriculture*, 79-107. https://doi.org/10.1007/978-3-030-63249-6_4

Dauchet, L., Hulo, S., Cherot-Kornobis, N., Matran, R., Amouyel, P., Edmé, J. L., & Giovannelli, J. (2018). Short-term exposure to air pollution: associations with lung function and inflammatory markers in non-smoking, healthy adults. *Environment international*, *121*, 610-619. https://doi.org/10.1016/j.envint.2018.09.036

Devarakonda, S., Sevusu, P., Liu, H., Liu, R., Iftode, L., & Nath, B. (2013, August). Real-time air quality monitoring through mobile sensing in metropolitan areas. *In Proceedings of the 2nd ACM SIGKDD international workshop on urban computing* (pp. 1-8). https://doi.org/10.1145/2505821.2505834

Devkota, S., & Bhusal, K. K. (2020). *Moringa oleifera*: A miracle multipurpose tree for agroforestry and climate change mitigation from the Himalayas-A review. *Cogent Food & Agriculture, 6*(1), 1-8. https://doi.org/10.1080/23311932.2020.1805951.

Dunn, D. (2006). *Energy Systems: Part 1.* In: Nutrition & Health Online Magazine. NHOmag.com Inc.

Eime, R., Harvey, J., & Charity, M. (2020). Sport participation settings: where and 'how'do Australians play sport?. BMC Public Health, 20, 1-9. https://doi.org/10.1186/s12889-020-09453-3

El-Fadel, M., & Hashisho, Z. (2001). Vehicular emissions in roadway tunnels: a critical review. *Critical Reviews in Environmental Science and Technology, 31*(2), 125-174. https://doi.org/10.1080/20016491089190

Emtner, M., Herala, M., Stålenheim, G., & Kiviloog, J. (2011). Comparisons of lung function and exercise capacity in children with asthma, during ergometer and treadmill exercise testing. *Acta Paediatrica, 100*(6), 871-876. https://doi.org/10.1111/j.1651-2227.2011.02131.x

Esteki-Uoregani, A. A., Valipour Dehnou, V., Kargarfard, M., & Ghahramanlou, E. (2019). The Effect of Endurance Training in Air Pollution on the Expression of Muscle Tissue Mitochondria PGC-1α and MEF2C Genes in Wistar Male Rats. *Journal of Isfahan Medical School*, *37*(521), 303-309. https://doi.org/10.22122/jims.v37i521.11619

Fahey, J. W. (2005). *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties: Part 1. *Trees for Life Journal, 1*(5), 1-15. https://doi.org/10.1201/9781420039078.ch12

Fang, G. C., Chang, C. N., Wu, Y. S., Wang, V., Fu, P. P. C., Yang, D. G., ... & Chu, C. C. (2000). The study of fine and coarse particles, and metallic elements for the daytime and night-time in a suburban area of central Taiwan, Taichung. *Chemosphere, 41*(5), 639-644. https://doi.org/10.1016/S0045-6535(99)00507-X

Fard, Masoumeh Tangestani., Arulselvan, Palanisamy., Karthivashan, Govindarajan., Adam, Siti Khadijah., Fakurazi, Sharida. (2015). Bioactive Extract from *Moringa oleifera* Inhibits the Pro-inflammatory Mediators in Lipopolysaccharide Stimulated Macrophages Pharmacogn Mag. 2015 Oct; 11(Suppl 4): S556–S563. doi: 10.4103/0973-1296.172961

Ferreira, M. L., Sherrington, C., Smith, K., Carswell, P., Bell, R., Bell, M., Nascimento, D. P., Pereira, L. S. M., & Vardon, P. (2019). Physical activity improves strength, balance and endurance in adults aged 40-65 years: A systematic review. *Journal of Physiotherapy, 65*(3), 143-154. https://doi.org/10.1016/S1836-9553(12)70105-4

Fisher-Wellman, K., & Bloomer, R. J. (2009). Acute exercise and oxidative stress: A 30 year history. *Dynamic Medicine*, *8*(1), 1–25. https://doi.org/10.1186/1476-5918-8-1

Foster, D., Linehan, C., Kirman, B., Lawson, S., & James, G. (2010, October). Motivating physical activity at work: using persuasive social media for competitive step counting. In Proceedings of the 14th international academic MindTrek conference: envisioning future media environments (pp. 111-116). https://doi.org/10.1145/1930488.1930510

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to Design and Evaluate Research in Education (8th ed.).* New York: Mc Graw HIll.

Fuller, R., Landrigan, P. J., Balakrishnan, K., Bathan, G., Bose-O'Reilly, S., Brauer, M., Caravanos, J., Chiles, T., Cohen, A., Corra, L., Cropper, M., Ferror, G., Hanna, J., Hanrahan, D., Hu, H., Hunter, D., Janata, G., Kupka, R., Lanphear, B.,... & Yan, C. (2022). Pollution and health: a progress update. *The Lancet Planetary Health, 6*(6), e535-e547. https://doi.org/10.1016/S2542-5196(22)00090-0

Gallo, J., Goodman, S. B., Konttinen, Y. T., & Raska, M. (2012). Particle Disease: Biologic Mechanisms of Periprosthetic Osteolysis in Total Hip Arthroplasty. *Innate Immunity, 19*(2), 213–224. https://doi.org/10.1177/1753425912451779.

Gasperi, V., Ceci, R., Tantimonaco, M., Talamonti, E., Battista, N., Parisi, A., Florio, R., Sabatini, S., Rossi, A., & Maccarrone, M. (2014). The fatty acid amide hydrolase in lymphocytes from sedentary and active subjects.. Medicine and science in sports and exercise, 46 1, 24-32 . https://doi.org/10.1249/MSS.0b013e3182a10ce6.

Gehling, W., Dellinger, B. (2013). Environmentally persistent free radicals and their lifetimes in PM 2.5. Environ. Sci. Technol., 47, pp. 8172-8178, 10.1021/es401767

Giacco F, Brownlee M. Oxidative Stress and Diabetic Complications. (2010). *Circ Res* [serial online].

Giles, L. V., & Koehle, M. S. (2014). The health effects of exercising in air pollution. *Sports Medicine*, *44*(2), 223–249. https://doi.org/10.1007/s40279-013-0108-z

Giles, L. V., & Koehle, M. S. (2014). The health effects of exercising in air pollution. *Sports Medicine*, *44*, 223-249. https://doi.org/10.1007/s40279-013-0108-z

Gillis, J. L., & Pavlidis, S. (2014). The effects of exercise on airway inflammation in asthma. *Immunology and Cell Biology, 92*(8), 697-703. https://doi.org/10.1038/icb.2014.61

Gleeson, M. (2007). Immune function in sport and exercise. Journal of Applied Physiology, 103(2), 693-699. https://doi.org/10.1152/japplphysiol.00008.2007 .

Gomes, E. C., & Florida-James, G. (2014). Lung inflammation, oxidative stress and air pollution. In *Lung Inflammation*. InTechOpen. https://doi/org/10.5772/58252

Gomes, E. C., Stone, V., & Florida-James, G. D. (2017). Impact of heat and pollution on oxidative stress and CC16 secretion after 8 km run. *European Journal of Applied Physiology, 117*(11), 2207-2216. https://doi/org/10.1007/s00421-017-3720-4

Gomez-Cabrera, M. C., Domenech, E., Romagnoli, M., Arduini, A., Borras, C., Pallardo, F. V., Sastre, J & Viña, J. (2008). Oral administration of vitamin C decreases muscle mitochondrial biogenesis and hampers training-induced adaptations in endurance performance. *The American journal of clinical nutrition, 87*(1), 142-149. https://doi.org/10.1093/ajcn/87.1.142

Gopalakrishnan, L., Doriya, K., & Kumar, D. S. (2016). *Moringa oleifera*: A review on nutritive importance and its medical application. *Food Science and Human Wellness, 5*(2), 1-29. https://doi.org/10.1016/j.fshw.2016.04.001

Granata, C., Jamnick, N. A., & Bishop, D. J. (2018). Training-induced changes in mitochondrial content and respiratory function in human skeletal muscle. *Sports Medicine, 48*(8), 1809-1828. https://doi.org/10.1007/s40279-018-0936-y

Granata, C., Oliveira, R. S., Little, J. P., Renner, K., & Bishop, D. J. (2016). Mitochondrial adaptations to high-volume exercise training are rapidly reversed after a reduction in training volume in human skeletal muscle. *The FASEB journal, 30*(10), 3413-3423. https://doi.org/10.1096/fj.201500100R

Hahad, O., Kuntic, M., Frenis, K., Chowdhury, S., Lelieveld, J., Lieb, K., Daiber, A., & Muenzel, T. (2021). Physical Activity in Polluted Air—Net Benefit or

Harm to Cardiovascular Health? A Comprehensive Review. *Antioxidants*, *10*(11), 1787. https://doi.org/10.3390/antiox10111787

Hake, R, R. (1999). Analyzing Change/Gain Scores. *AREA-D American Education Research Association's Division.D, Measurement and Research Methodology.*

Haldar, R., & Kosankar, S. (2017). *Moringa oleifera*: The miracle tree. *International Journal of Advance Research, Ideas and Innovations in Technology, 3*(6), 966-970. Retrieved from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.ijariit.com/manuscripts/v3i6/V3I6-1400.pdf

Halliwel, B. (2002). Food-Derived Antioxidants: How to Evaluate Their Importance in Food and In Vivo. In E. Cadenas., & L. Packer, *Handbook of Antioxidants, Second Edition Revised and Expanded*. New York: Marcel Dekker.

Halliwell B, Gutteridge JMC. (2007). Free radicals in biology and medicine. 4th eds. New York: Oxford.

Han, Y., Wang, Y., Li, W., Chen, X., Xue, T., Chen, W., Fan, Y., Xinghua, Q., & Zhu, T. (2019). Susceptibility of prediabetes to the health effect of air pollution: a community-based panel study with a nested case-control design. *Environmental Health, 18*(1), 1-9. https://doi.org/10.1186/s12940-019-0502-6

Hancox, R. J., Poulton, R., Ely, M., Welch, D., Taylor, D. R., McLachlan, C. R., & Greene, J. M. (2005). Effects of cannabis on lung function: a population-based cohort study. *European Respiratory Journal, 35*(1), 42-47. https://doi.org/10.1183/09031936.00016609

Handschin, C., & Spiegelman, B. M. (2008). The role of exercise and PGC-1α in inflammation and chronic disease. *Nature*, *454*(7203), 463-469. https://doi.org/10.1038/nature07206

Have, C. (2022). What is pulmonary fibrosis? *NIH Publication: National Heart, Lung, and Blood Institute*, 1-2. Retrieved from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.nhlbi.nih.gov/sites/default/files/publications/WhatIsPulmonaryFibrosis.pdf

Heppner, P.P., Wampold, B.E., Kivlighan, D.M. (2008). *Research Design in Counseling (Research Statistics, and Program Evaluation*. 3rd eds. California: Thomson Brooks/Cole.

Hieu, N. T., & Lee, B. K. (2010). Characteristics of particulate matter and metals in the ambient air from a residential area in the largest industrial city in Korea. *Atmospheric Research, 98*(2-4), 526-537. https://doi.org/10.1016/j.atmosres.2010.08.019

Hind, K., & Dolmage, T. E. (2017). Outdoor airway hyperresponsiveness and the effects of training outdoors compared with indoors in a recreational and a competitive winter sport. *Respiratory medicine, 132*, 115-121. https://doi.org/10.1016/j.rmed.2017.09.010

Hogg, J. C., & Timens, W. (2008). The pathology of chronic obstructive pulmonary disease. *The Annual Review of Pathology: Mechanisms of Disease*, 435-459. https://doi.org/10.1146/annurev.pathol.4.110807.092145

Holloszy, J. O., & Booth, F. W. (1976). Biochemical adaptations to endurance exercise in muscle. *Annual review of physiology*, *38*(1), 273-291. https://doi.org/10.1146/annurev.ph.38.030176.001421

Hood, D. A. (2009). Mechanisms of exercise-induced mitochondrial biogenesis in skeletal muscle. *Applied Physiology, Nutrition, and Metabolism*, *34*(3), 465-472. https://doi.org/10.1139/H09-045

Hood, D. A., Memme, J. M., Oliveira, A. N., Triolo, M., & Reidy, P. T. (2019). Kinesiology and mitochondrial turnover. Exercise and sport sciences reviews, 47(4), 208-217.

Hoppeler, H. (2003). Exercise-induced ultrastructural changes in skeletal muscle. International journal of sports medicine, 24(08), 528-532. https://doi.org/10.1055/s-2008-1025758

Hull IV, R. B., & Michael, S. E. (1995). Nature-based recreation, mood change, and stress restoration. *Leisure Sciences, 17*(1), 1-14. https://doi.org/10.1080/01490409509513239

Islam, Z., Islam, S. R., Hossen, F., Mahtab-ul-Islam, K., Hasan, M. R., & Karim, R. (2021). *Moringa oleifera* is a prominent source of nutrients with potential health benefits. *International Journal of Food Science*, 1-11. https://doi.org/10.1155/2021/6627265

Idah Rosidah, Sri Ningsih, Tiya Novita Renggani, Kurnia Agustini, Julham Efendi (2020) Profil Hematologi Tikus (Rattus Norvegicus) Galur Sprague-Dawley Jantan Umur 7 Dan 10 Minggu, Jurnal Bioteknologi & Biosains Indonesia, Volume 7 Nomor 1, ISSN 2548 – 611x

Jackson, A. W., Morrow, J.R., Hill, D. W., & Dishman, R. K. (2004). Physical Activity for Health and Fitness. Human Kinetics.

Jacobsen, K. R., Kalliokoski, O., Hau, J., Abelson, K. S. P. (2006). The effects of chronic psychosocial stress on heart rate and heart rate variability in rodents: A review. *Physiology & Behavior,* 1-10.

Janssens, W., Bouillon, R., Claes, B., Carremans, C., Lehouck, A., Buysschaert, I., Coolen, J., Mathieu, C., Decramer, M., & Lambrechts, D. (2010). Vitamin D deficiency is highly prevalent in COPD and correlates with variants in the vitamin D-binding gene. *Thorax, 65*(3), 215-220. https://doi.org/10.1136/thx.2009.120659

Ji, L. L. (2008). Modulation of skeletal muscle antioxidant defense by exercise: Role of redox signaling. *Free Radical Biology and Medicine, 44*(2), 142-152. https://doi.org/10.1016/j.freeradbiomed.2007.02.031

John, J. A., & Shahidi, F. (2010). Phenolic compounds and antioxidant activity of Brazil nut (Bertholletia excelsa). *Journal of functional foods, 2*(3), 196-209. https://doi.org/10.1016/j.jff.2010.04.008

Jornayvaz, F. R., & Shulman, G. I. (2010). Regulation of mitochondrial biogenesis. *Essays in biochemistry*, *47*, 69-84. https://doi.org/10.1042/bse0470069

Joseph, A. M., Adhihetty, P. J., Buford, T. W., Wohlgemuth, S. E., Lees, H. A., Nguyen, L. M. D., Aranda, J. M., Sandesara, B. D., Pahor, M., Manini, T. M., Marzetti, E., & Leeuwenburgh, C. (2012). The impact of aging on mitochondrial function and biogenesis pathways in skeletal muscle of sedentary high-and low-functioning elderly individuals. *Aging cell, 11*(5), 801-809. https://doi.org/10.1111/j.1474-9726.2012.00844.x

Kamiya Biomedical Company. (2007). *Superoxide Dismutase (SOD) Colorimetric Activity Kit For use with serum, plasma, cells, tissues, and erythrocyte lysates*. Seattle: Kamiya Biomedical Company.

Kampa, M., & Castanas, E. (2008). Human health effects of air pollution. *Environmental pollution, 151*(2), 362-367. https://doi.org/10.1016/j.envpol.2007.06.012

Kaplan, S. (1985). Cognition and affect in environmental learning. *Children's Environments Quarterly, 2*(3), 19-21. https://www.jstor.org/stable/41514562

Karagulian, F., Belis, C., Dora, C., Prüss-Ustün, A., Bonjour, S., Adair-Rohani, H., & Amann, M. (2015). Contributions to Cities' Ambient Particulate Matter (PM): a Systematic Review of Local Source Contributions at Global Level. *Atmospheric Environment,* 120, 475-483. https://doi.org/10.1016/J.ATMOSENV.2015.08.087.

Kelly, F. J., & Fussell, J. C. (2012). Size, source and chemical composition as determinants of toxicity attributable to ambient particulate matter. *Atmospheric environment, 60*, 504-526. https://doi.org/10.1016/j.atmosenv.2012.06.039.

Kelor. (2024, Aug. 3). Retrieved from Wikipedia. https://id.wikipedia.org/wiki/Kelor.

Kim, K. H., Kabir, E., & Kabir, S. (2015). A review on the human health impact of airborne particulate matter. *Environment international, 74*, 136-143. https://doi.org/10.1016/j.envint.2014.10.005

Kioumourtzoglou, M. A., Schwartz, J. D., Weisskopf, M. G., Melly, S. J., Wang, Y., Dominici, F., & Zanobetti, A. (2016). Long-term PM2. 5 exposure and neurological hospital admissions in the northeastern United States. *Environmental health perspectives, 124*(1), 23-29. https://doi.org/10.1289/ehp.1408973

Kirschvink, N., Fievez, L., Bougnet, V., Art, T., Degand, G., Smith, N., Marlin, D., Roberts, C., Harris, P., & Lekeux, P. (2002). Effect of nutritional antioxidant supplementation on systemic and pulmonary antioxidant status, airway inflammation and lung function in heaves-affected horses. *Equine Veterinary Journal*, *34*(7), 705-712. https://doi.org/10.2746/042516402776250298

Kochi, C., Ahmad, S., & Salim, S. (2023). The effects of air pollution toxicants on the mitochondria. In M. R. Oliveira, *Mitochondrial intoxication* (pp. 147-166). Academic Press Elsevier Inc.

Kohl, H. W., Craig, C. L., Lambert, E. V., Inoue, S., Alkandari, J. R., Leetongin, G., & Kahlmeier, S. (2012). Physical Activity 5 The pandemic of physical inactivity : global action for. *The Lancet*, *380*(9838), 294–305. https://doi.org/10.1016/S0140-6736(12)60898-8.

Kollanus, V., Prank, M., Gens, A., Soares, J., Vira, J., Kukkonen, J., Sofiev, M., Salonen, R. O., & Lanki, T. (2017). Mortality due to vegetation fire–originated PM2. 5 exposure in Europe—assessment for the years 2005 and 2008. *Environmental health perspectives, 125*(1), 30-37. https://doi.org/10.1289/EHP194

Koohsari, M. J., Mavoa, S., Villanueva, K., Sugiyama, T., Badland, H., Kaczynski, A. T., Owen, N., & Giles-Corti, B. (2015). Public open space, physical activity, urban design and public health: Concepts, methods and research agenda. Health & place, 33, 75-82. https://doi.org/10.1016/j.healthplace.2015.02.009

Kowaltowski AJ, de Souza-Pinto NC, Castilho RF, Vercesi AE. (2009). Mitochondria and reactive oxygen species. *Free Radic. Biol. Med.* 47(4), 333–343.

Kramer, A. (2020). An Overview of the Beneficial Effects of Exercise on Health and Performance. In J. Xiao, Physical Exercise for Human Health. Singapura: Springer. https://doi.org/10.1007/978-981-15-1792-1_1

Kreuz, S. (2016). Oxidative Stress and Oxygen Radicals/Oxidative Stress in Health and Disease, *8*, 843–862.

Kubistova, A., Horacek, J., & Novak, T. (2012). Increased interleukin-6 and tumor necrosis factor alpha in first episode schizophrenia patients versus healthy controls. *Psychiatria Danubina, 24*, 153-156. Retrieved from https://pubmed.ncbi.nlm.nih.gov/22945211/.

Kumar, A., Kumar, S., & Kumari, A. (2023, June). Carbon Monoxide Concentration in Atmosphere—A Review. *In IRC-SET 2022: Proceedings of the 8th IRC Conference on Science, Engineering and Technology*, August 2022, Singapore (pp. 97-109). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-19-7222-5_9

Kumar, P., Hama, S., Nogueira, T., Abbass, R. A., Brand, V. S., de Fatima Andrade, M., Asfaw, A., Aziz, K. H., Cao, S., El-Gendy, A., Islam, S., Jeba, F., Khare, M., Mamuya, S. H., Martinez, J., Meng, M., Morawska, L., Muula A. A., Nagendra, S. M. S., … & Salam, A. (2021). *In-car particulate matter exposure across ten global cities. Science of the total environment, 750*, 141395. https://doi.org/10.1016/j.scitotenv.2020.141395

Kurtzman, J., & Zauhar, J. (2003). A wave in time-The sports tourism phenomena. Journal of Sport Tourism, 8(1), 35-47. https://doi.org/10.1080/14775080306239

Larsen, S., Nielsen, J., Hansen, C. N., Nielsen, L. B., Wibrand, F., Stride, N., Schroder, H. D., Boushel, R., Helge, J. W., Dela, F., & Hey-Mogensen, M. (2012). Biomarkers of mitochondrial content in skeletal muscle of healthy young human subjects. *The Journal of physiology, 590*(14), 3349-3360. https://doi.org/10.1113/jphysiol.2012.230185

Lee, C., & Moudon, A. (2004). Physical Activity and Environment Research in the Health Field: Implications for Urban and Transportation Planning Practice and Research. *Journal of Planning Literature, 19,* 147-181. https://doi.org/10.1177/0885412204267680.

Lestari, Irene, Bagyo Yanuwiadi, Soemarno. (2013). Suitability Analysis of Green Open Space (Gos) Model Based On Area Characteristics in Kupang City, Indonesia. *The International Journal Of Engineering And Science (IJES)* Volume 2 Issue 6 Pages 81-91 2013.

Li, G., Fang, C., Wang, S., & Sun, S. (2016). The effect of economic growth, urbanization, and industrialization on fine particulate matter (PM2. 5) concentrations in China. *Environmental science & technology, 50*(21), 11452-11459. https://doi.org/10.1021/acs.est.6b02562

Li, J., Zhou, C., Xu, H., Brook, R. D., Liu, S., Yi, T., Wang, Y., Feng, B., Zhao, M., Wang, X., Zhao, Q., Chen, J., Song, X., Wang, T., Liu, S., Zhang, Y., Wu, R., Gao, J., Pan, B., … & Huang, W. (2019). Ambient air pollution is associated with HDL (high-density lipoprotein) dysfunction in healthy adults. *Arteriosclerosis, Thrombosis, and Vascular Biology, 39*(3), 513-522. https://doi.org/10.1161/ATVBAHA.118.311749

Li, L., Wang, L., Sun, L., Zhang, Y., Jiang, G., Chen, J., & Liu, B. (2018). Chronic exposure to fine particulate air pollution induces macrophage tolerance via downregulation of NF-κB signaling. *Toxicology Letters, 301*, 12–21.

Li, N., Sioutas, C., Cho, A., Schmitz, D., Misra, C., Sempf, J., Wang, M., Oberley, T., Froiner, J., & Nel, A. (2003). Ultrafine particulate pollutants induce oxidative stress and mitochondrial damage. *Environmental health perspectives*, *111*(4), 455-460. https://doi.org/10.1289/ehp.6000

Li, R., Li, S., Pan, M., Chen, H., Liu, X., Chen, G., Chen, R., Yin, S., Hu, K., Mao, Z., Huo, W., Wang, X., Yu, S., Guo, Y., Hou, J., & Wang, C. (2021). Physical activity counteracted associations of exposure to mixture of air pollutants with mitochondrial DNA copy number among rural Chinese adults. *Chemosphere*, *272*, 129907. https://doi.org/10.1016/j.chemosphere.2021.129907

Li, S., Li, W., Wu, X., Xu, H., & Huang, Y. (2019). The effects of air pollution on mitochondrial function and mitochondrial dynamics in rats. Environmental Pollution, 254(Pt B), 112971. https://doi.org/10.1016/j.envpol.2019.07.029

Li, W., Dorans, K. S., Wilker, E. H., Rice, M. B., Ljungman, P. L., Schwartz, J. D., Coull, B. A., Koutrakis, P., Gold, D. R., Keaney, Jr., J. F., Vasan, R. S., Benjamin, E. J., & Mittleman, M. A. (2019). Short-term exposure to ambient air pollution and circulating biomarkers of endothelial cell activation: The

Framingham Heart Study. *Environmental research, 171*, 36-43. https://doi.org/10.1016/j.envres.2018.10.027

Li, W., Dorans, K. S., Wilker, E. H., Rice, M. B., Ljungman, P. L., Schwartz, J. D., Coull, B. A., Koutrakis, P., Gold, D. R., Keaney, Jr., J. F., Vasan, R. S., Benjamin, E. J., & Mittleman, M. A. (2017). Short-term exposure to ambient air pollution and biomarkers of systemic inflammation: the Framingham Heart Study. *Arteriosclerosis, thrombosis, and vascular biology, 37*(9), 1793-1800. https://doi.org/10.1161/ATVBAHA.117.309799

Li, Y., Zhao, J., Yin, Y., Li, K., Zhang, C., & Zheng, Y. (2022). The role of IL-6 in fibrotic diseases: Molecular and cellular mechanisms. *International Journal of Biological Sciences, 18*(14), 5405-5414. https://doi.org/10.7150/ijbs.75876

Lim, A. Y., Chen, Y. C., Hsu, C. C., Fu, T. C., & Wang, J. S. (2022). The effects of exercise training on mitochondrial function in cardiovascular diseases: A systematic review and meta-analysis. *International Journal of Molecular Sciences*, *23*(20), 12559. https://doi.org/10.3390/ijms232012559

Lin, C. C., Chen, S. J., Huang, K. L., Hwang, W. I., Chang-Chien, G. P., & Lin, W. Y. (2005). Characteristics of metals in nano/ultrafine/fine/coarse particles collected beside a heavily trafficked road. *Environmental Science & Technology, 39*(21), 8113-8122. https://doi.org/10.1021/es048182a

Lin, Y., Ramanathan, G., Zhu, Y., Yin, F., Rea, N. D., Lu, X., Tseng, C., Faull, K. F., Yoon, A. J., Jerrett, M., Zhu, T., Qiu, X., & Araujo, J. A. (2019). Pro-oxidative and proinflammatory effects after traveling from Los Angeles to Beijing: a biomarker-based natural experiment. *Circulation, 140*(24), 1995-2004. https://doi.org/10.1161/CIRCULATIONAHA.119.042054

Liu, B., Li, L., Sun, L., Wang, L., Zhang, Y., Li, M., & Chen, J. (2019). Ozone exposure induces heme oxygenase-1 expression and reduces macrophage inflammatory response. *Environmental Toxicology and Pharmacology, 66*, 103–109.

Liu, B., Zhang, Y., Sun, L., Li, L., Wang, L., & Chen, J. (2016). Chronic exposure to fine particulate air pollution reduces the inflammatory response of macrophages in mice. *Environmental Health and Preventive Medicine, 23*(1), 70–77.

Liu, J., Chen, X., Qiu, X., Zhang, H., Lu, X., Li, H., Chen, W., Zhang, L., Que, C., & Zhu, T. (2021). Association between exposure to polycyclic aromatic hydrocarbons and lipid peroxidation in patients with chronic obstructive pulmonary disease. *Science of The Total Environment, 780*, 146660. https://doi.org/10.1016/j.scitotenv.2021.146660

Liu, L., Poon, R., Chen, L., Frescura, A. M., Montuschi, P., Ciabattoni, G., Wheeler, A., & Dales, R. (2009). Acute effects of air pollution on pulmonary function, airway inflammation, and oxidative stress in asthmatic children. *Environmental health perspectives*, *117*(4), 668-674. https://doi.org/10.1289/ehp11813

Liu, T., Zhang, L., Joo, D., & Sun, S.-C. (2017). NF-KB signaling in inflammation. *Signal Transduction and Targeted Therapy, 2*(17023), 1-8. https://doi.org/10.1038/sigtrans.2017.23

Liu, Y., Wei, Y., Zhang, Y., Ma, Z., Zhang, H., He, F., & Chen, L. (2021). Exercise attenuates lung inflammation induced by PM2.5 via modulation of miR-21 in mice. *Science of the Total Environment, 759*, 144434. https://doi.org/10.1016/j.scitotenv.2020.144434

Liu, Z., Gong, F., Tian, L., Yan, J., Li, K., Tan, Y., Han, J., Zhao, Y., Li, D., Xi, Z., & Liu, X. (2022). Acute exercise in ozone-polluted air induces apoptosis in rat quadriceps femoris muscle cells via mitochondrial pathway. *Sports Medicine and Health Science*, *4*(3), 190-197. https://doi.org/10.1016/j.smhs.2022.06.003

Loy, J. W. (1968). The nature of sport: A definitional effort. Quest, 10(1), 1-15. https://doi.org/10.1080/00336297.1968.10519640

Lunec J, Herbert K, Blount S, Griffiths HR, Emery P. (1994). 8-Hydroxydeoxyguanosine: a marker of oxidative DNA damage in systemic lupus erythematosus. FEBS Lett. 348(2), 131–138.

Maeda, K., Mehta, H., Drevets, D., & Coggeshall, K. (2010). IL-6 increases B-cell IgG production in a feed-forward proinflammatory mechanism to skew hematopoiesis and elevate myeloid production. *Blood, 115*(23), 4699-4706. https://doi.org/10.1182/blood-2009-07-230631

Mahler, H. R., & Tzagoloff, A. (1973). Biogenetic Autonomy Of Mitochondri. *CRC Critical Reviews in Biochemistry*, *1*(3), 381-460. https://doi.org/10.3109/10409237309105439

Maksum, A, dkk. (2004). *Panduan Pelaksanaan Pengkajian Sport Development Index (SDI).* Jakarta: Proyek Pengembangan dan keserasian kebijakan Olahraga Direktorat Jenderal Olahraga Departemen Pendidikan Nasional Kerjasama Pusat Studi Olahraga Lembaga Pendidikan UNESA.

Mann, J. K., Lutzker, L., Holm, S. M., Margolis, H. G., Neophytou, A. M., Eisen, E. A., Costello, S., Tyner, T., Holland, N., Tindula, G., Prunicki, M., Nadeau, K., Noth, E. M., Lurmann, F., Hammond, S. K., & Balmes, J. R. (2021). Traffic-related air pollution is associated with glucose dysregulation, blood pressure, and oxidative stress in children. *Environmental research, 195*, 110870. https://doi.org/10.1016/j.envres.2021.110870

McAllister, M. J., Basham, S. A., Smith, J. W., Waldman, H. S., Krings, B. M., Mettler, J. A., Butawan, M. B., & Bloomer, R. J. (2018). Effects of environmental heat and antioxidant ingestion on blood markers of oxidative stress in professional firefighters performing structural fire exercises. *Journal of Occupational and Environmental Medicine*, *60*(11), e595-e601. https://doi.org/10.1097/JOM.0000000000001452

McKleroy, W., & Lyn-Kew, K. (2018). 500 million alveoli from 30,000 feet: A brief primer on lung anatomy. In S. Alper, & W. J. Janssen, *Lung innate immunity and inflammation* (pp. 3-16). Humana Press. https://doi.org/10.1007/978-1-4939-8570-8_1

Mead, M. I., Popoola, O. A. M., Stewart, G. B., Landshoff, P., Calleja, M., Hayes, M., Baldovi, J. J., McLeod, M. W., Hodgson, T. F., Dicks, J., Lewis, A., Cohen, J., Baron, R., Saffell, J. R., & Jones, R. L. (2013). The use of electrochemical sensors for monitoring urban air quality in low-cost, high-density networks. *Atmospheric Environment*, 70, 186-203. https://doi.org/10.1016/j.atmosenv.2012.11.060

Medzhitov, R. (2010). Inflammation 2010: New adventures of an old flame. *Cell, 140*, 771-776. https://doi.org/10.1016/j.cell.2010.03.006

Mehta, S., Shin, H., Burnett, R., North, T., & Cohen, A. J. (2013). Ambient particulate air pollution and acute lower respiratory infections : a systematic review and implications for estimating the global burden of disease, 69–83. https://doi.org/10.1007/s11869-011-0146-3

Menshikova, Elizabeth V., Ritov, Vladimir B., Fairfull, Liane., Ferrell, Robert E., Kelley, David E., and Goodpaster, Bret H. (2006). Effects of Exercise on Mitochondrial Content and Function in Aging Human Skeletal Muscle. J Gerontol A Biol Sci Med Sci. 2006 Jun; 61(6): 534–540. doi: 10.1093/gerona/61.6.534

Michailidis, Y., Karagounis, L. G., Terzis, G., Jamurtas, A. Z., Spengos, K., Tsoukas, D., Chatzinikolaou, A., Mandalidis, D., Stefanetti, R. J., Papassotiriou, I., Athanasopoulos, S., Hawley, J. A., Russell, A. P., & Fatouros, I. G. (2013). Thiol-based antioxidant supplementation alters human skeletal muscle signaling and attenuates its inflammatory response and recovery after intense eccentric exercise. *The American journal of clinical nutrition, 98*(1), 233-245. https://doi.org/10.3945/ajcn.112.049163

Minakshi, J., Kumari, N., Kumar, R., Kumar, A., Rani, B., Phogat, D., . . . Kumar, P. (2021). Moringa (*Moringa oleifera* L.): An underutilized and traditionally valued tree holding remarkable potential. *Journal of Horticultural Sciences, 16*(1), 1-19. https://doi.org/10.24154/JHS.2021.v16i01.001

Mirowsky, J. E., Carraway, M. S., Dhingra, R., Tong, H., Neas, L., Diaz-Sanchez, D., Cascio, W., Case, M., Crooks, J., Hauser, E. R., Dowdy, Z. E., Kraus, W. E., & Devlin, R. B. (2017). Ozone exposure is associated with acute changes in inflammation, fibrinolysis, and endothelial cell function in coronary artery disease patients. *Environmental health, 16*(1), 1-10. https://doi.org/10.1186/s12940-017-0335-0

Moldoveanu, B., Otmishi, P., Jani, P., Walker, J., Sarmiento, X., Guardiola, J., Yu, J. (2009). Inflammatory mechanisms in the lung. *Journal of Infl ammation Research, 2*, 1-11. Retrieved from https://pubmed.ncbi.nlm.nih.gov/22096348/.

Moldoveanu, G. A., & Papangelakis, V. G. (2016). An overview of rare-earth recovery by ion-exchange leaching from ion-adsorption clays of various origins. *Mineralogical Magazine, 80*(1), 63-76. https://doi.org/10.1180/minmag.2016.080.051

MØller, P., & Loft, S. (2010). Oxidative damage to DNA and lipids as biomarkers of exposure to air pollution. *Environmental Health Perspectives*, *118*(8), 1126–1136. https://doi.org/10.1289/ehp.0901725

Monge, M. E., D'Anna, B., Mazri, L., Giroir-Fendler, A., Ammann, M., Donaldson, D. J., & George, C. (2010). Light changes the atmospheric reactivity of soot. *Proceedings of the National Academy of Sciences*, 107(15), 6605-6609. https://doi.org/10.1073/pnas.0908341107

Monn, C., & Becker, S. (1999). Cytotoxicity and induction of proinflammatory cytokines from human monocytes exposed to fine (PM2. 5) and coarse particles (PM10–2.5) in outdoor and indoor air. *Toxicology and applied pharmacology, 155*(3), 245-252. https://doi.org/10.1006/taap.1998.8591

Mun, Hansol., Li, Mengying., Jung, Juchul. (2022). Spatial-Temporal Characteristics and Influencing Factors of Particulate Matter: Geodetector Approach. Land 2022, 11(12), 2336; https://doi.org/10.3390/land11122336

Muñoz, M. A., Valdez, M., Campos-Almazán, M., & Flores-Herrera, O. (2018). Streptozotocin-induced adaptive modification of mitochondrial supercomplexes in liver of wistar rats and the protective effect of *Moringa oleifera* lam. *Biochemistry Research International, 5*, 1-15. https://doi.org/10.1155/2018/5681081

Mytton, Oliver T, Nick Townsend, Harry Rutter, Charlie Foster. (2012). Green space and physical activity: An observational study using Health Survey for England data. *Health Place. 2012* Sept; 18(5): 1034-1041. doi: 10.1016/j.healthplace.2012.06.003

Naseem, S., Iqbal, R., & Munir, T. (2016). Role of interleukin-6 in immunity: A review. *International Journal of Life Sciences Research, 4*(2), 268-274. Retrieved from https://www.researchgate.net/publication/307965149_Role_of_interleukin-6_in_immunity_A_Review.

Nassan, F. L., Wang, C., Kelly, R. S., Lasky-Su, J. A., Vokonas, P. S., Koutrakis, P., & Schwartz, J. D. (2021). Ambient PM2. 5 species and ultrafine particle exposure and their differential metabolomic signatures. *Environment international, 151*, 106447. https://doi.org/10.1016/j.envint.2021.106447

Ndahimana, D., & Kim, E. K. (2017). Measurement methods for physical activity and energy expenditure: a review. Clinical nutrition research, 6(2), 68-80. https://doi.org/10.7762/cnr.2017.6.2.68

Ness, P. (2001). The Concept of Risk in Biomedical Research Involving Human Subjects. *Bioethics, 15*(4), 364-370.

Ni, Y., Tracy, R. P., Cornell, E., Kaufman, J. D., Szpiro, A. A., Campen, M. J., & Vedal, S. (2021). Short-term exposure to air pollution and biomarkers of cardiovascular effect: a repeated measures study. *Environmental Pollution, 279*, 116893. https://doi.org/10.1016/j.envpol.2021.116893

Nieman, D. C., Henson, D. A., Austin, M. D., & Sha, W. (2011). Upper respiratory tract infection is reduced in physically fit and active adults. *British Journal of Sports Medicine, 45*(12), 987-992. https://doi.org/10.1136/bjsports-2010-082719

Nieman, D. C., Wentz, L. M., & Dixit, V. D. (2019). Exercise immunology: Protection against viral respiratory infections and immunosenescence. *Immunology and Cell Biology, 97*(4), 382-389. https://doi.org/10.1111/imcb.12223

Nikhil, S., Agarwal, A. K., Eastwood, P., Gupta, T., & Singh, A. P. (2018). Introduction to Air Pollution and Its Control. In N. Sharma., A. K. Agarwal., P. Eastwood., T. Gupta., & A. P., Singh, Air Pollution and Control (pp. 3-7). Singapura: Springer.

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry and Urban Greening*, *4*(3–4), 115–123. https://doi.org/10.1016/j.ufug.2006.01.007

Oeckinghaus, A., & Ghosh, S. (2009). The NF-kB family of transcription factors and its regulation. *Cold Spring Harbor Perspective in Biology, 1*(4), 1-14. https://doi.org/10.1101/cshperspect.a000034

Ole, H., Matthew, S. J., & Situs B. M. Evan. (2021). Air Pollution Sources, Statistics, and Health Effects: Introduction. In M. E. Goodsite., M. S. Johnson., & O. Hertel, Air Pollution Sources, Statistics and Health Effects (pp. 1-3). New York: Springer. https://doi.org/10.1007/978-1-4939-2493-6_911-3.

Owen N., Humpel N., Leslie E., Bauman A., Sallis J.F. (2004). Understanding environmental influences on walking: review and research agenda. *American Journal of Preventive Medicine. 2004;27(1):67–76*.

Paravicini, T. M., & Touyz, R. M. (2008). NADPH oxidases, reactive oxygen species, and hypertension: clinical implications and therapeutic possibilities. *Diabetes Care*, *31 Suppl 2*. https://doi.org/10.2337/dc08-s247

Parola, M., & Pinzani, M. (2019). Pathophysiology of organ and tissue fibrosis. *Molecular Aspects of Medicine, 65*(1), 1. https://doi.org/10.1016/j.mam.2019.02.001

Pascoe, M. A., Robertson, C. F., & Burgess, J. A. (2013). Airway inflammation in children: relationships with asthma and exercise. *Medicine and Science in Sports and Exercise, 45*(2), 217-224. https://doi.org/10.1249/MSS.0b013e31826c9f37

Pascoe, M. A., Robertson, C. F., & Burgess, J. A. (2013). Airway inflammation in children: relationships with asthma and exercise. *Medicine and Science in Sports and Exercise, 45*(2), 217-224. https://doi.org/10.1249/MSS.0b013e31826c9f37

Pasqua, L. A., Damasceno, M. V., Cruz, R., Matsuda, M., Martins, M. G., Lima-Silva, A. E., Bertuzzi, R. (2018). Exercising in air pollution: The cleanest versus dirtiest cities challenge. *International Journal of Environmental Research and Public Health*, *15*(7). https://doi.org/10.3390/ijerph15071502

Patintingan, C. G., Louisa, M., Juniantito, V., Arozal, W., Hanifah, S., Wanandi, S., & Thandavar, R. (2023). *Moringa oleifera* leaves extract ameliorates doxorubicin-induced cardiotoxicity via its mitochondrial biogenesis

modulatory activity in rats. *Journal of Experimental Pharmacology, 15*, 307-319.

Pearce, M., Saunders, D. H., Allison, P., & Turner, A. P. (2018). Indoor and outdoor context-specific contributions to early adolescent moderate to vigorous physical activity as measured by combined diary, accelerometer, and GPS. Journal of Physical Activity and Health, 15(1), 40-45. https://doi.org/10.1123/jpah.2016-0638

Pecchi, E., Dallaporta, M., Jean, A., Thirion, S., & Troadec, J.-D. (2009). Prostaglandins and sickness behavior: Old story, new insights. *Physiology & Behavior, 97*, 279-292. https://doi.org/10.1016/j.physbeh.2009.02.040

Pedersen, B.K., & Febbraio, M.A. (2008). Muscle as an endocrine organ: focus on muscle-derived interleukin-6. Physiological Reviews, 88(4), 1379-1406. https://doi.org/10.1152/physrev.90100.2007

Peel, J. L., Tolbert, P. E., Klein, M., Metzger, K. B., Flanders, W. D., Todd, K., ... & Frumkin, H. (2005). Ambient air pollution and respiratory emergency department visits. *Epidemiology,* 164-174. https://www.jstor.org/stable/20486023

Pemerintah Indonesia. (2020). Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia Nomor P.14/MENLHK/SETJEN/KUM.1/7/2020 tentang Indeks Standar Pencemaran Udara. Jakarta.

Peng, Z., Deng, W., & Tenorio, R. (2017). Investigation of indoor air quality and the identification of influential factors at primary schools in the North of China. Sustainability, 9(7), 1180. https://doi.org/10.3390/su9071180

Petersen, A. M., & Pedersen, B. K. (2005). The anti-inflammatory effect of exercise. Journal of applied physiology, 98(4), 1154-1162. https://doi.org/10.1152/japplphysiol.00164.2004

Picard, M., & Turnbull, D. M. (2013). Linking the metabolic state and mitochondrial DNA in chronic disease, health, and aging. Diabetes, 62(3), 672-678. https://doi.org/10.2337%2Fdb12-1203

Piggin, J., & Bairner, A. (2014). The global physical inactivity pandemic : an analysis of knowledge production, (April 2015), 37–41. https://doi.org/10.1080/13573322.2014.882301.

Pinho, R. A., Andrades, M. E., Oliveira, M. R., Pirola, A. C., Zago, M. S., Silveira, P. C., Dal-Pizzol, F., & Moreira, J. C. F. (2006). Imbalance in SOD/CAT activities in rat skeletal muscles submitted to treadmill training exercise. *Cell Biology International, 30*(10), 848-853. https://doi.org/10.1016/j.cellbi.2006.03.011

Plummer, L. E., Smiley-Jewell, S., & Pinkerton, K. E. (2012). Impact of air pollution on lung inflamation and the role of toll-like receptors. *International Journal of Interferon, Cytokine and Mediator Research, 4*(1), 43-57. https://doi.org/10.2147/IJICMR.S29352

Pope III, C. A., Bhatnagar, A., McCracken, J. P., Abplanalp, W., Conklin, D. J., & O'Toole, T. (2016). Exposure to fine particulate air pollution is associated with endothelial injury and systemic inflammation. *Circulation research, 119*(11), 1204-1214. https://doi.org/10.1161/CIRCRESAHA.116.309279

Prockop, L. D., & Chichkova, R. I. (2007). Carbon monoxide intoxication: an updated review. *Journal of the neurological sciences, 262*(1-2), 122-130. https://doi.org/10.1016/j.jns.2007.06.037

Prunicki, M., Cauwenberghs, N., Ataam, J. A., Movassagh, H., Kim, J. B., Kuznetsova, T., Wu, J. C., Maecker, H., Haddadh, F., & Nadeau, K. (2020). Immune biomarkers link air pollution exposure to blood pressure in adolescents. *Environmental Health, 19*, 1-17. https://doi.org/10.1186/s12940-020-00662-2

Psilander, N., Frank, P., Flockhart, M., & Sahlin, K. (2013). Exercise with low glycogen increases PGC-1α gene expression in human skeletal muscle. *European journal of applied physiology, 113*, 951-963. https://doi.org/10.1007/s00421-012-2504-8

Qin, F., Cui, S., Dong, Y., Xu, M., Wang, Z., Qu, C., & Zhao, J. (2021). Aerobic exercise ameliorates particulate matter-induced lung injury in aging rats. *Environmental Pollution, 280,* 116889. https://doi.org/10.1016/j.envpol.2021.116889

Rabinovich, R. A., Ardite, E., Troosters, T., Carbo, N., Alonso, A., Gonzalez-de-Suso, J. M., ... & Barberà, J. A. (2006). Reduced muscle redox capacity after endurance training in patients with chronic obstructive pulmonary disease. *American Journal of Respiratory and Critical Care Medicine, 173*(4), 373-379. https://doi.org/10.1164/rccm.200506-919OC

Radak, Z., Chung, H. Y., & Goto, S. (2008). Systemic adaptation to oxidative challenge induced by regular exercise. *Free Radical Biology and Medicine, 44*(2), 153-159. https://doi.org/10.1016/j.freeradbiomed.2007.01.029

Radak, Z., Zhao, Z., Goto, S., & Koltai, E. (2011). Age-associated neurodegeneration and oxidative damage to lipids, proteins and DNA. *Molecular aspects of medicine, 32*(4-6), 305-315. https://doi.org/10.1016/j.mam.2011.10.010

Rajbhar, Y. P., Rajbhar, G., PL, R., Shukla, S., & Kumar, M. (2018). Grow moringa (*Moringa oleifera*), the miracle tree on the earth. *Horticulture International Journal, 2*(4), 166-172. https://doi.org/10.15406/hij.2018.02.00047

Rasbach, K. A., & Schnellmann, R. G. (2007). Signaling of mitochondrial biogenesis following oxidant injury. Journal of Biological Chemistry, 282(4), 2355-2362. https://doi.org/10.1074/jbc.M608009200

Ravipati, A. S., Zhang, L., Koyyalamudi, S. R., Jeong, S. C., Reddy, N., Bartlett, J., Smith, P. T., Shanmugam, K., Münch, G., Wu, M. K., Satyanarayanan, M., & Vysetti, B. (2012). Antioxidant and anti-inflammatory activities of selected Chinese medicinal plants and their relation with antioxidant content. *BMC Complementary and Alternative Medicine*, *12*(1), 1-14. https://doi.org/10.1186/1472-6882-12-173

Razis, A. F., Ibrahim, M. D., & Kntayya, S. B. (2014). Health benefits of *Moringa oleifera*. *Asian Pacific Journal of Cancer Prevention, 15*(20), 8571-8576. https://doi.org/10.7314/APJCP.2014.15.20.8571

Redei, E., Udell, M., Solberg-Woods, L., & Chen, H. (2022). The Wistar Kyoto Rat: A Model of Depression Traits. *Current Neuropharmacology*. https://doi.org/10.2174/1570159X21666221129120902.

Riches, D. W., & Martin, T. R. (2018). Overview of innate lung immunity and inflammation. In S. Alper, & W. J. Jansen, *Lung innate immunity and inflammation: Methods and protocols* (pp. 17-33). Humana Press. https://doi.org/10.1007/978-1-4939-8570-8_2

Riedler, J., Braun-Fahrländer, C., Eder, W., Schreuer, M., Waser, M., Maisch, S., Carr, D., Schierl, R., Nowak, D., & von Mutius, E. (2001). Exposure to farming in early life and development of asthma and allergy: a cross-sectional survey. *The Lancet, 358*(9288), 1129-1133. https://doi.org/10.1016/S0140-6736(01)06252-3

Riggs, D. W., Zafar, N., Krishnasamy, S., Yeager, R., Rai, S. N., Bhatnagar, A., & O'Toole, T. E. (2020). Exposure to airborne fine particulate matter is associated with impaired endothelial function and biomarkers of oxidative stress and inflammation. *Environmental research, 180*, 108890. https://doi.org/10.1016/j.envres.2019.108890

Rimbaud, S., Sanchez, H., Garnier, A., Fortin, D., Bigard, X., Veksler, V., & Ventura-Clapier, R. (2009). Stimulus specific changes of energy metabolism in hypertrophied heart. *Journal of molecular and cellular cardiology*, *46*(6), 952-959. https://doi.org/10.1016/j.yjmcc.2009.01.013

Riso, P., Klimis-Zacas, D., Del Bo', C., Martini, D., Campolo, J., Vendrame, S., Moller, P., Loftm S., Maria, R. D., & Porrini, M. (2013). Effect of a wild blueberry (Vaccinium angustifolium) drink intervention on markers of oxidative stress, inflammation and endothelial function in humans with cardiovascular risk factors. *European journal of nutrition, 52*, 949-961. https://doi.org/10.1007/s00394-012-0402-9

Ristow, M., Zarse, K., Oberbach, A., Klöting, N., Birringer, M., Kiehntopf, M., Stumvoll, M., Kahn, C. R., & Blüher, M. (2009). Antioxidants prevent health-promoting effects of physical exercise in humans. *Proceedings of the National Academy of Sciences, 106*(21), 8665-8670. https://doi.org/10.1073/pnas.0903485106

Ritchie, Hannah, & Roser, Max (2018). Urbanization. *Our World in Data, https://ourworldindata.org/urbanization.*

Rockey, D. C., Bell, D., & Hill, J. A. (2015). Fibrosis - A common pathway to organ injury and failure. *The New England Journal of Medicine, 372*(12), 1138-1149. https://doi.org/10.1056/NEJMra1300575

Rockwood, J. L., Anderson, B., & Casamatta, D. A. (2013). Potential uses of *Moringa oleifera* and an examination of antibiotic efficacy conferred by M. oleifera seed and leaf extracts using crude extraction techniques available to underserved indigenous populations. *International Journal of Phytotherapy*

Research, 3(2), 61-71. Retrieved from https://www.semanticscholar.org/paper/POTENTIAL-USES-OF-Moringa-oleifera-AND-AN-OF-BY-M.-Rockwood-Anderson/d5e658f9d9afb7fb3253709999c564ae63567aaa.

Roderique, J. D., Josef, C. S., Feldman, M. J., & Spiess, B. D. (2015). A modern literature review of carbon monoxide poisoning theories, therapies, and potential targets for therapy advancement. *Toxicology, 334*, 45-58. https://doi.org/10.1016/j.tox.2015.05.004

Romanello, V., & Sandri, M. (2016). Mitochondrial quality control and muscle mass maintenance. *Frontiers in physiology*, *6*, 422. https://doi.org/10.3389/fphys.2015.00422

Romberg, K., & Nordström, A. (2017). Outdoor activities and long-term lung function among Swedish women. Respiratory Medicine, 130, 36-41. https://doi.org/10.1016/j.rmed.2017.07.012

Roy, A., Gong, J., Thomas, D. C., Zhang, J., Kipen, H. M., Rich, D. Q., Eckel, S. P. (2014). The cardiopulmonary effects of ambient air pollution and mechanistic pathways: A comparative hierarchical pathway analysis. *PLoS ONE*, *9*(12), 1–18. https://doi.org/10.1371/journal.pone.0114913

Rundle, A., Hoepner, L., Hassoun, A., Oberfield, S., Freyer, G., Holmes, D., Reyes, M., Quinn, J., Camann, D., Perera, F., & Whyatt, R. (2012). Association of childhood obesity with maternal exposure to ambient air polycyclic aromatic hydrocarbons during pregnancy. *American journal of epidemiology*, *175*(11), 1163-1172. https://doi.org/10.1093/aje/kwr455

Safdar, A., Little, J. P., Stokl, A. J., Hettinga, B. P., Akhtar, M., & Tarnopolsky, M. A. (2011). Exercise increases mitochondrial PGC-1α content and promotes nuclear-mitochondrial cross-talk to coordinate mitochondrial biogenesis. Journal of Biological Chemistry, 286(12), 10605-10617. https://doi.org/10.1074/jbc.m110.211466

Saha, S. K., Lee, S. Bin, Won, J., Choi, H. Y., Kim, K., Yang, G. M., … Cho, S. G. (2017). Correlation between oxidative stress, nutrition, and cancer initiation. *International Journal of Molecular Sciences*, *18*(7). https://doi.org/10.3390/ijms18071544

Saito, F., Tasaka, S., Inoue, K.-I., Miyamoto, K., Nakano, Y., Ogawa, Y., Yamada, W., Shiraishi, Y., Hasegawa, N., Fujishima, S., Takano, H., & Ishizaka, A. (2008). Role of interleukin-6 in bleomycin-induced lung inflammatory changes in mice. *American Journal of Respiratory Cell and Molecular Biology, 38*(5), 566-571. https://doi.org/10.1165/rcmb.2007-0299OC

Samet, J. M., Hatch, G. E., Horstman, D., Steck-Scott, S., Arab, L., Bromberg, P. A., Levine, M., McDonnell, W. F., & Devlin, R. B. (2001). Effect of antioxidant supplementation on ozone-induced lung injury in human subjects. *American journal of respiratory and critical care medicine*, *164*(5), 819-825. https://doi.org/10.1164/ajrccm.164.5.2008003

Saraiva, M., & O'Garra, A. (2010). The Regulation of IL-10 Production by Immune Cells. *Nature Reviews Immunology, 10,* 170-181. https://doi.org/10.1038/nri2711.

Savin, I. A., Zenkova, M. A., & Sen'kova, A. V. (2022). Pulmonary fibrosis as a result of acute lung inflammation: Molecular mechanisms, relevant in vivo models, prognostic and therapeutic approaches. *International Journal of Molecular Sciences, 23*(23), 1-42. https://doi.org/10.3390/ijms232314959

Scandalios, J. G. (2005). Oxidative stress: molecular perception and transduction of signals triggering antioxidant gene defenses. *Brazilian journal of medical and biological research*, *38*, 995-1014. https://doi.org/10.1590/S0100-879X2005000700003

Schäppi, G. F., Monn, C., Wüthrich, B., & Wanner, H. U. (1996). Direct determination of allergens in ambient aerosols: methodological aspects. *International archives of allergy and immunology, 110*(4), 364-370. https://doi.org/10.1159/000237329

Schins, R. P., Lightbody, J. H., Borm, P. J., & Shi, T. (2004). Inflammatory effects of coarse and fine particulate matter in relation to chemical and biological constituents. *Toxicology and Applied Pharmacology, 195*(1), 1-11. https://doi.org/10.1016/j.taap.2003.10.002

Schlesinger, R. B., Kunzli, N., Hidy, G. M., Gotschi, T., & Jerrett, M. (2006). The health relevance of ambient particulate matter characteristics: coherence of toxicological and epidemiological inferences. *Inhalation toxicology, 18*(2), 95-125. https://doi.org/10.1080/08958370500306016

Sen, S., Chakraborty, R., Sridhar, C., Reddy, Y. S. R., & De, B. (2010). Free radicals, antioxidants, diseases and phytomedicines: current status and future prospect. *Int J Pharm Sci Rev Res, 3*(1), 91-100. https://www.scienceopen.com/document?vid=0549fca9-b4f5-4f44-9250-f3b08348da7d

Sengupta, P. (2013). The Laboratory Rat: Relating Its Age With Human's. *International Journal of Preventive Medicine, 4*(6), 624-30. PMCID: PMC3733029.

Seo, D. Y., Lee, S. R., Kim, N., Ko, K. S., Rhee, B. D., & Han, J. (2016). Age-related changes in skeletal muscle mitochondria: the role of exercise. *Integrative medicine research*, *5*(3), 182-186. https://doi.org/10.1016/j.imr.2016.07.003

Serasanambati, M., & Chilakapati, S. R. (2016). Function of nuclear factor kappa B (NF-KB) in human diseases: A review. *South Indian Journal of Biological Sciences, 2*(4), 368-387. https://doi.org/10.22205/sijbs/2016/v2/i4/103443

Sharma, J., Parsai, K., Raghuwanshi, P., Ali, S. A., Tiwari, V., Bhargava, A., & Mishra, P. K. (2021). Emerging role of mitochondria in airborne particulate matter-induced immunotoxicity. *Environmental pollution, 270*, 116242. https://doi.org/10.1016/j.envpol.2020.116242

Sharma, K., Chandra, A., Hasija, Y., & Saini, N. (2021). MicroRNA-128 inhibits mitochondrial biogenesis and function via targeting PGC-1α and NDUFS4. *Mitochondrion, 60*, 160-169. https://doi.org/10.1016/j.mito.2021.08.008

Siddhuraju, P., & Becker, K. (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. *Journal of agricultural and food chemistry, 51*(8), 2144-2155. https://doi.org/10.1021/jf020444+

Simpson, R. J., Kunz, H., Agha, N., & Graff, R. (2015). Exercise and the regulation of immune functions. *Progress in Molecular Biology and Translational Science, 135*, 355-380. https://doi.org/10.1016/bs.pmbts.2015.08.001

Singh, K., & Tripathi, D. (2021). *Particulate matter and human health*. Environmental Health.

Song, L.M., Y. Zhang, & Y. Zhou. 2007. The relationship between the thermocline and the catch rate of Thunnus obesus in the tropical areas of the Indian Ocean. In: Anonymous (Ed.). *IOTC Proceeding-WPTT-14- rev1*. 13 pp.

Sorriento, D., Di Vaia, E., & Iaccarino, G. (2021). Physical exercise: a novel tool to protect mitochondrial health. *Frontiers in physiology*, *12*, 660068. https://doi.org/10.3389/fphys.2021.660068

Squadrito, G. L., Cueto, R., Dellinger, B., & Pryor, W. A. (2001). Quinoid redox cycling as a mechanism for sustained free radical generation by inhaled airborne particulate matter. *Free Radical Biology and Medicine, 31*(9), 1132-1138. https://doi.org/10.1016/S0891-5849(01)00703-1

Sreelatha, S., & Padma, P. R. (2009). Antioxidant activity and total phenolic content of *Moringa oleifera* leaves in two stages of maturity. *Plant foods for human nutrition, 64*, 303-311. https://doi.org/10.1007/s11130-009-0141-0

Srimuruganandam, B., & Nagendra, S. S. (2012). Source characterization of PM10 and PM2. 5 mass using a chemical mass balance model at urban roadside. *Science of the total environment*, 433, 8-19. https://doi.org/10.1016/j.scitotenv.2012.05.082

Srirangan, S., & Choy, E. H. (2010). The role of interleukin 6 in the pathophysiology of rheumatoid arthritis. *Therapeutic Advances in Musculoskeletal Disease, 2*(5), 247-256. https://doi.org/10.1177%2F1759720X10378372

Stotland, A., & Gottlieb, R. A. (2015). Mitochondrial Quality Control: Easy Come, Easy Go. *Biochimica et Biophysica Acta (BBA): Molecular Cell Research, 1853*(10), 2802-2811. https://doi.org/10.1016/j.bbamcr.2014.12.041.

St-Pierre J, Buckingham JA, Roebuck SJ, Brand MD. (2002) Topology of superoxide production from different sites in the mitochondrial electron transport chain. *J. Biol. Chem*. 277(47), 44784–44790.

Stanek, L. W., Brown, J. S., Stanek, J., Gift, J., & Costa, D. L. (2011). Air pollution toxicology—a brief review of the role of the science in shaping the current

understanding of air pollution health risks. *Toxicological Sciences, 120*(suppl_1), S8-S27. https://doi.org/10.1093/toxsci/kfq367

Starkie, R., Ostrowski, S.R., Jauffred, S., & Febbraio, M. (2003). Exercise and IL-6 infusion inhibit endotoxin-induced TNF-alpha production in humans. The FASEB Journal, 17(8), 884-886. https://doi.org/10.1096/fj.02-0670fje

Statista (2024), Share of the urban population in Indonesia from 2014 to 2023, https://www.statista.com/statistics/761113/share-of-urban-population-indonesia/#statisticContainer

Sterling, E., & Glassco, M. (2009). Field studies in the United States and United Kingdom of the effectiveness of mechanical ventilation systems on indoor air quality in hospitality venues where smoking is allowed in relation to outdoor air conditions. *ASHRAE Transactions*, 115, 729. https://proquest.com/openview/5c6f16a376c07f4c8932ebf0f0f99ba2/1?pq-origsite=gscholar&cbl=34619

Stohs, S. J., & Hartman, M. J. (2015). Review of the safety and efficacy of *Moringa oleifera*. *Phytotherapy Research*, 796-804. https://doi.org/10.1002/ptr.5325

Strobel, N. A., Peake, J. M., Matsumoto, A. Y. A., Marsh, S. A., Coombes, J. S., & Wadley, G. D. (2011). Antioxidant supplementation reduces skeletal muscle mitochondrial biogenesis. *Med Sci Sports Exerc, 43*(6), 1017-24. https://doi.org/10.1249/MSS.0b013e318203afa3

Suarez, C. A. (2012). Diagnosis and control of particulate matter: Total suspended particles PM10 breathable fraction. *Luna Azul, 34*, 195-213. Retrieved from http://www.scielo.org.co/scielo.php?pid=S1909-24742012000100012&script=sci_abstract.

Sumaryanto. 2005. Sport Development Index sebagai Parameter dalam mengukur Pembangunan Olahraga Indonesia.Yogyakarta: makalah, Disajikan dalam rangka kegiatan FONI Di kantor PORA Pemkot Yogyakarta tanggal 24 Desember 2005.

Sun, Q., Zhang, Y., Wang, D., Sun, L., Li, L., Chen, J., & Liu, B. (2015). Ozone exposure induces anti-inflammatory response through activation of Nrf2 signaling in macrophages. *Toxicology Letters, 238*(2), 118–125.

Sun, S.-C. (2012). The noncanonical NF-KB pathway. *Immunol Rev, 246*(1), 125-140. https://doi.org/10.1111/j.1600-065X.2011.01088.x

Sun, S.-C., & Liu, Z.-G. (2011). A special issue on NF-KB signaling and function. *Cell Research, 21*(1), 1-2. https://doi.org/10.1038/cr.2011.1.

Taherkhani, S., Suzuki, K., & Ruhee, R. T. (2021). A brief overview of oxidative stress in adipose tissue with a therapeutic approach to taking antioxidant supplements. *Antioxidants*, *10*(4), 594. https://doi.org/10.3390/antiox10040594

Tanaka, T., Narazaki, M., & Kishimoto, T. (2014). IL-6 in inflammation, imunity, and disease. *Cold Spring Harbor Perspectives in Biology, 6*(10), 1-16. https://doi.org/10.1101/cshperspect.a016295

Tareq, Z., Razzaq, A., Al-madfai, Z., Saeed, G. T., & Ch, M. B. B. (2016). The

Effect of Training and Sport Type on Pulmonary Function Parameters among Iraqi Soccer and Futsal Players, *3*(5), 27–30. https://doi.org/10.9790/6737-03052730

Tecer, L. H., Süren, P., Alagha, O., Karaca, F., & Tuncel, G. (2008). Effect of meteorological parameters on fine and coarse particulate matter mass concentration in a coal-mining area in Zonguldak, Turkey. *Journal of the Air & Waste Management Association, 58*(4), 543-552. https://doi.org/10.3155/1047-3289.58.4.543

Thacker, E. L. (2006). Lung inflammatory responses. *Veterinary Research, 37*(3), 469-486. https://doi.org/10.1051/vetres:2006011

Thompson, J. E. (2018). Airborne particulate matter: Human exposure & health effects. *Journal of Occupational and Environmental Medicine, 60*(5), 392-423. https://doi.org/10.1097/JOM.0000000000001277

Thong-Ngern, P. (2015). *Moringa a superfood!*

Tjong, A., Assa, Y. A., & Purwanto, D. S. (2021). Kandungan antioksidan pada daun kelor (*Moringa oleifera*) dan potensi sebagai penurun kadar kolesterol darah. *eBiomedik, 9*(2), 248-254. https://doi.org/10.35790/ebm.9.2.2021.33452

Tomaszewska, I. M., Mosiewicz, J., Chciałowski, A., & Podgórski, J. K. (2014). Influence of physical effort on selected indicators of inflammation in bronchoalveolar lavage fluid in horses. *Polish Journal of Veterinary Sciences, 17*(4), 593-599. https://doi.org/10.2478/pjvs-2014-0082

Tsai, J. H., Lin, K. H., Chen, C. Y., Ding, J. Y., Choa, C. G., & Chiang, H. L. (2007). Chemical constituents in particulate emissions from an integrated iron and steel facility. *Journal of hazardous materials, 147*(1-2), 111-119. https://doi.org/10.1016/j.jhazmat.2006.12.054

Tsiloulis, T., & Watt, M. J. (2015). Exercise and the regulation of adipose tissue metabolism. Progress in molecular biology and translational science, 135, 175-201. https://doi.org/10.1016/bs.pmbts.2015.06.016

Uchiyama, T., Takahashi, H., Endo, H., Sakai, E., Hosono, K., Nagashima, Y., & Nakajima, A. (2012). IL-6 plays crucial roles in sporadic colorectal cancer through the cytokine networks including CXCL7. *Journal of Cancer Therapy, 3*(6A), 874-879. https://doi.org/10.4236/jct.2012.326112

Ulrich, R. S. (1981). Natural versus urban scenes: Some psychophysiological effects. *Environment and behavior, 13*(5), 523-556. https://doi.org/10.1177/0013916581135001

Uyainah, A.Z., Zulkifli Amin, Feisal Thufeilsyah. (2014). Spirometry. *Ina J Chest Crit and Emerg Med*. Vol. 1, No. March - May 2014.

Valavanidis, A., Fiotakis, K., & Vlachogianni, T. (2008). Airborne particulate matter and human health: toxicological assessment and importance of size and composition of particles for oxidative damage and carcinogenic mechanisms. *Journal of Environmental Science and Health, Part C*, *26*(4), 339-362. https://doi.org/10.1080/10590500802494538

Vallero, D. A. (2008). Fundamental of Air Pollution: Fourth Edition. California: Elsevier.

Venkataraman, C. (1999). Comparison of particle lung doses from the fine and coarse fractions of urban PM-10 aerosols. *Inhalation toxicology, 11*(2), 151-169. https://doi.org/10.1080/089583799197221

Veras, M. M., Costa, N. D. S. X., Fajersztajn, L., & Saldiva, P. H. N. (2015). Impacts of Air Pollution on Reproductive Health. In S. S., Nadarur, & J. W. Hollingsworth, Air Pollution and Health Effects (pp. 25-50). London: Springer-Verlag.

Vongsak, B., Sithisarn, P., Mangmool, S., Thongpraditchote, S., Wongkrajang, Y., & Gritsanapan, W. (2013). Maximizing total phenolics, total flavonoids contents and antioxidant activity of *Moringa oleifera* leaf extract by the appropriate extraction method. *Industrial crops and products, 44*, 566-571. https://doi.org/10.1016/j.indcrop.2012.09.021

Vuori, I. M. (2001). Health benefits of physical activity with special reference to interaction with diet. Public health nutrition, 4(2b), 517-528. https://doi.org/10.1079/PHN2001137

Wadley, G. D., & McConell, G. K. (2010). High-dose antioxidant vitamin C supplementation does not prevent acute exercise-induced increases in markers of skeletal muscle mitochondrial biogenesis in rats. *Journal of Applied Physiology*, *108*(6), 1719-1726. https://doi.org/10.1152/japplphysiol.00127.2010

Wadley, G. D., & McConell, G. K. (2010). High-dose antioxidant vitamin C supplementation does not prevent acute exercise-induced increases in markers of skeletal muscle mitochondrial biogenesis in rats. Journal of Applied Physiology, 108(6), 1719-1726. https://doi.org/10.1152/japplphysiol.00127.2010

Wallace, D. C. (1999). Mitochondrial diseases in man and mouse. Science, 283(5407), 1482-1488. https://doi.org/10.1126/science.283.5407.1482

Walsh, N. P., & Gleeson, M. (2011). Position statement. Part one: Immune function and exercise. Exercise immunology review, 17, 6-63. https://pubmed.ncbi.nlm.nih.gov/21446352/

Walton-Fisette, J.L. & Wuest, D.A. (2015). Foundations of Physical Education, Exercise Science, and Sport, Nineteenth Edition. New York: Mc-Graw Hill.

Wang, B., Chan, Y., Anwer, A., & Saad, S. (2021). Traffic-related air pollution induces mitochondrial oxidative stress and transgenerational mitochondrial dysfunction. *ERS International Congress 2021*. https://doi.org/10.1183/13993003.congress-2021.PA829

Wang, H., Dai, X., Wu, J., Wu, X., & Nie, X. (2019). Influence of urban green open space on residents' physical activity in China. BMC public health, 19(1), 1-12. https://doi.org/10.1186/s12889-019-7416-7

Wang, J., Liao, B., Wang, C., Zhong, O., Lei, X., & Yang, Y. (2022). Effects of Antioxidant Supplementation on Metabolic Disorders in Obese Patients from

Randomized Clinical Controls: A Meta-Analysis and Systematic Review. *Oxidative Medicine and Cellular Longevity*, *2022*. https://doi.org/10.1155/2022/7255413

Ward, P. A. (2003). Acute lung injury: how the lung inflammatory response works. *European Respiratory Journal, 22*, 22-23. http://doi.org/10.1183/09031936.03.00000703a

Weichenthal, S., Hatzopoulou, M., & Goldberg, M. S. (2014). Exposure to traffic-related air pollution during physical activity and acute changes in blood pressure, autonomic and microvascular function in women: A cross-over study. *Particle and Fibre Toxicology*, *11*(1), 1–16. https://doi.org/10.1186/s12989-014-0070-4

Werdhasari, Asri. (2014). Peran Antioksidan bagi Kesehatan.. *Jurnal Biotek Medisiana Indonesia* . Vol.3.2.2014: 59-68.

Wiium, N., & Säfvenbom, R. (2019). Participation in organized sports and self-organized physical activity: Associations with developmental factors. International journal of environmental research and public health, 16(4), 585. https://doi.org/10.3390/ijerph16040585.

Wijsenbeek, M., & Cottin, V. (2020). Spectrum of fibrotic lung diseases. *The New England Journal of Medicine, 383*(10), 958-968. https://doi.org/10.1056/NEJMra2005230

Wilson, M., & Wynn, T. (2009). Pulmonary fibrosis: Pathogenesis, etiology and regulation. *Mucosal Immunology, 2*(2), 103-121. https://doi.org/10.1038/mi.2008.85

Wilson, W. E., & Suh, H. H. (1997). Fine particles and coarse particles: concentration relationships relevant to epidemiologic studies. *Journal of the Air & Waste Management Association, 47*(12), 1238-1249. https://doi.org/10.1080/10473289.1997.10464074

Witkop, J. J. (2019). Role of antioxidant supplementation and exercise regimen in handling oxidative stress from natural PM2. 5 exposure due to boreal forest fire. University of Alaska Fairbanks. https://www.proquest.com/openview/c06caa7b18d9576c213123223f3ada48/1?pq-origsite=gscholar&cbl=18750&diss=y

Wong, J., Magun, B. E., & Wood, L. J. (2016). Lung inflammation caused by inhaled toxicants: a review. *International journal of chronic obstructive pulmonary disease,* 1391-1401. https://www.tandfonline.com/doi/full/10.2147/COPD.S106009

Woo, P. C., Lau, S. K., Huang, Y., & Yuen, K. Y. (2009). Coronavirus diversity, phylogeny and interspecies jumping. *Experimental Biology and medicine, 234*(10), 1117-1127. https://doi.org/10.3181/0903-MR-94

World Health Organisation. (2009). Global Health Risks. *WHO Library Cataloguing-in-Publication Data Global*, *1*, 62.

World Health Organization. (2003). Health and Development Through Physical Activity and Sport. *World Health Organization*, *3*(2), 1–11. Retrieved from

http://apps.who.int/iris/bitstream/10665/67796/1/WHO_NMH_NPH_PAH_03.2.pdf.

World Health Organization. (2012). Health in the green economy: health co-benefits of climate change mitigation-transport sector. World Health Organization.

World Health Organization. (2024). Physical Activity. Retrieved from https://www.who.int/news-room/fact-sheets/detail/physical-activity

World Health Organization. (2020) Who Guidelines On Physical Activity and Sedentary Behaviour. ISBN 978-92-4-001512-8 (electronic version).

Wu, C. F., Shen, F. H., Li, Y. R., Tsao, T. M., Tsai, M. J., Chen, C. C., Hwang, J., Hsu, S. H., Chao, H., Chuang, K. J., Chou, C. C. K., Nwang, Y., Ho, C., & Su, T. C. (2016). Association of short-term exposure to fine particulate matter and nitrogen dioxide with acute cardiovascular effects. *Science of the Total Environment, 569*, 300-305. https://doi.org/10.1016/j.scitotenv.2016.06.084

Xia, B., Zhou, Y., Zhu, Q., Zhao, Y., Wang, Y., Ge, W., Yang, Q., Zhao, Y., Wang, P., Si, J., Luo, R., Li, J., Shi, H., & Zhang, Y. (2019). Personal exposure to PM2. 5 constituents associated with gestational blood pressure and endothelial dysfunction. *Environmental Pollution, 250*, 346-356. https://doi.org/10.1016/j.envpol.2019.04.024

Xing, Y.-F., Xu, Y.-H., Shi, M.-H., & Lian, Y.-X. (2015). The impact of PM2.5 on the human respiratory system. *Journal of Thoracic Disease, 8*(1), 69-74. https://doi.org/10.3978/j.issn.2072-1439.2016.01.19

Xu, Y.-B., Chen, G.-L., & Guo, M.-Q. (2019). Antioxidant and anti-inflammatory activities of the crude extracts of *Moringa oleifera* from enya and their correlations with flavonoids. *Antioxidants, 8*(296), 1-12. https://doi.org/10.3390/antiox8080296

Yang, L., Li, C., & Tang, X. (2020). The impact of PM2.5 on the host defense of the respiratory system. *Frontiers in Cell and Developmental Biology, 8*(91), 1-9. https://doi.org/10.3389/fcell.2020.00091

Yi, S. J., & Kim, J. S. (2015). The effects of respiratory muscle strengthening exercise using a sling on the amount of respiration. Journal of Physical Therapy Science, 27(7), 2121-2124. https://doi.org/10.1589/jpts.27.2121

Yu, M., Zheng, X., Witschi, H., & Pinkerton, K. (2002). The role of interleukin-6 in pulmonary inflammation and injury induced by exposure to environmental air pollutants. *Toxicological Sciences, 68*(2), 488-497. https://doi.org/10.1093/toxsci/68.2.488.

Zhang, H., & Sun, S.-C. (2015). NF-KB in inflammation and renal diseases. *Cell & Bioscience, 5*(63), 1-12. https://doi.org/10.1186/s13578-015-0056-4

Zhang, H., Sun, Q., & Lin, M. (2021). Mitochondrial dysfunction in air pollution-related diseases. *ournal of Toxicology and Environmental Health, 84*(11), 784-796.

Zhang, L., Ravipati, A. S., Koyyalamudi, S. R., Jeong, S. C., Reddy, N., Smith, P. T., Bartlett, J., Shanmugam, K., & Wu, M. J. (2011). Antioxidant and anti-

inflammatory activities of selected medicinal plants containing phenolic and flavonoid compounds. *Journal of agricultural and food chemistry, 59*(23), 12361-12367. https://doi.org/10.1021/jf203146e

Zhang, T., Ma, C., Zhang, Z., Zhang, H., & Hu, H. (2021). NF-KB signaling in inflammation and cancer. *MedComm, 2*(4), 618-653. https://doi.org/10.1002/mco2.104

Zhang, Y., & Xu, H. (2016). Translational regulation of mitochondrial biogenesis. *Biochemical Society Transactions*, *44*(6), 1717-1724. https://doi.org/10.1042/BST20160071C

Zhao, X., Yee Kwan, J. Y., Yip, K., Liu, P. P., & Liu, F.-f. (2020). Targeting metabolic dysregulation for fibrosis therapy. *Nature Reviews Drug Discovery, 19*, 57–75. https://doi.org/10.1038/s41573-019-0040-5

Zhou, Zhanyi., Chen, Chaoyi., Teo,Ee-Chon., Zhang, Yan., Huang, Jialu., Xu, Yining., Gu, Yaodong. (2022). Intracellular Oxidative Stress Induced by Physical Exercise in Adults: Systematic Review and Meta-Analysis. Antioxidants 2022, 11(9), 1751; https://doi.org/10.3390/antiox11091751

Zourikian, N., Jarock, C., & Mulder, K. (2010). *Physical activity, exercise and sports. A Guide for Families.* Canadian Hemophilia Society