JPES 15 (2) (2026)

Journal of Physical Education and Sports

http://journal.unnes.ac.id/sju/index.php/jpes

The Effect Of Aerodumbbell Exercise Intervention on Weight Loss, Body Fat Percentage, and Increased Muscle Mass in A Normal BMI Population

Suto Wijoyo Wisnu Teguh Purnomo[1] , Siti Baitul Mukarromah[2], Hadi[3], Sri Sumartiningsih[4]

[1] Universitas Negeri Semarang, Indonesia; sutowwtp@students.unnes.ac.id
[2] Universitas Negeri Semarang, Indonesia; sitibaitul@mail.unnes.ac.id
[3] Universitas Negeri Semarang, Indonesia; hadi_pabbsi@mail.unnes.ac.id
[4] Universitas Negeri Semarang, Indonesia; sri.sumartiningsih@mail.unnes.ac.id

Article Info

History Articles
Received:
August 2025
Accepted:
August 2025
Published:
Juni 2026

Keywords:
Aerodumbbell, Exercise, Body fat percentage. Muscle mass, Standard BMI, weight reduction.

Abstract

This study is to evaluate the effects of an aerodumbbell training intervention on weight reduction and body fat percentage in individuals with a normal Body Mass Index (BMI). This quasi-experimental study had 10 people with a normal BMI, allocated into a treatment group (n=5) and a control group (n=5). The treatment group participated in a 4-week aerodumbbell workout regimen at an intensity of 60-70% of maximal heart rate, with a frequency of three sessions per week, each lasting 60 minutes. Data from pretests and posttests, encompassing body weight (BW), body fat mass (BFM), and skeletal muscle mass (SMM), were subjected to descriptive and comparative statistical analyses. The research findings indicate that the treatment group exhibited a notable reduction in average body weight of 2.28 kg ($p<0.05$) and a decrease in average body fat mass of 3.94 kg ($p<0.05$), alongside an increase in average muscle mass of 1.66 kg ($p<0.05$). In contrast, the control group exhibited no notable alterations in any of the assessed characteristics. This study concludes that aerodumbbell exercise effectively reduces weight and body fat percentage while enhancing muscle mass in individuals with a normal BMI.

✉ Address correspondence:
Universitas Negeri Semarang, Kampus Sekaran, Gunungpati, Semarang
E-mail: (sutowwtp@students.unnes.ac.id)

p-ISSN 2252-648X
e-ISSN 2502-4477

INTRODUCTION

The digital age has transformed nearly every facet of human existence, yet it has yielded unforeseen repercussions for global metabolic health. The significant change is evident in the most recent data from the World Health Organization (World Health Organization (WHO), 2022), indicating that 31% of the world's adult population (1.6 billion individuals) is now physically inactive, with a 5% increase every decade since 2000. This tendency is intensified by a significant alteration in work patterns, with 70% of jobs in industrialized nations now being sedentary (Lee et al., 2021), along with the prevalence of digital entertainment, leading to an average screen time of 9 hours per day for the working-age population. The epidemiological ramifications present as "normal weight obesity" (NWO), a health paradox wherein persons with a normal BMI (18.5–24.9 kg/m²) exhibit an elevated body fat percentage (>30% for women and >20% for males) alongside a reduction in muscle mass (Romero-Corral et al., 2010). A recent study by Ji et al., (2020) revealed that the prevalence of NWO has attained 40% within the Asian population and is escalating due to increased urbanization, posing a significant threat to future metabolic health crises.

The digital age has transformed nearly every facet of human existence, yet it has yielded unforeseen repercussions for global metabolic health. The recent statistics from the World Health Organization (World Health Organization (WHO), 2022) indicate a significant transition, revealing that 31% of the global adult population (1.6 billion individuals) are currently physically inactive, with a 5% increase observed every decade since 2000. This tendency is intensified by a significant alteration in work patterns, with 70% of jobs in industrialized nations now being sedentary (Lee et al., 2021), alongside the prevalence of digital entertainment, leading to an average screen time of 9 hours daily for the working-age population. The epidemiological effects present as "normal weight obesity" (NWO), a health paradox wherein persons with a normal BMI (18.5–24.9 kg/m²) exhibit an excessive body fat percentage (>30% for women and >20% for men) alongside a reduction in muscle mass (Romero-Corral et al., 2010). A recent study by (Ji et al., 2020) revealed that the prevalence of NWO has reached 40% within the Asian population and is escalating due to increased urbanization, posing a significant threat to future metabolic health crises.

The health paradigm that overly emphasizes BMI has generated perilous behavioral discrepancies. A global health behavior survey conducted by (Vernarelli et al., 2024) revealed that 68% of individuals with a normal BMI perceive no necessity for regular exercise, attributing this belief to their "ideal weight." This conviction is substantiated by health guidelines that prioritize weight loss over the enhancement of body composition (Sweatt et al., 2024). Research indicates that body composition is a more accurate predictor of mortality than BMI; specifically, each 1 kg increase in muscle mass correlates with an 11% decrease in mortality risk (Volaklis et al., 2015). This condition is intensified by "sedentary sarcopenia," the reduction of muscle mass resulting from a sedentary lifestyle, which may commence as early as age 25 and diminish the basal metabolic rate by as much as 10% per decade post age 30 (Wewege et al., 2022). This detrimental loop produces a demographic that is "metabolically obese but normal weight" (MONW), possessing cardiovascular risks comparable to those of obese individuals (Romero-Corral et al., 2009).

In this context, numerous workout methodologies have been formulated to tackle body composition concerns; nevertheless, each possesses considerable limits. Although it has been shown to be successful in decreasing visceral fat, moderate-intensity continuous aerobic training (MICT) has no effect on muscle mass and may potentially hasten the loss of muscle mass if it is not accompanied by a sufficient protein intake (Guadalupe-Grau et al., 2018). Conversely, conventional resistance training is efficacious for muscle hypertrophy but has a restricted effect on visceral fat burning (Wewege et al., 2022). High-intensity interval training (HIIT) provides time efficiency; yet, it is frequently intolerable for untrained individuals and exhibits low long-term adherence (Saravanan et al., 2025). Integrated methodologies such as "concurrent training" have demonstrated encouraging outcomes; nonetheless, the majority of studies have concentrated on overweight individuals or athletes, rather than on populations with Normal Weight Obesity (NWO) (Lopez et al., 2022).

Aerodumbbell workouts have arisen as a novel approach that incorporates the physiological principles of many training methods. The fundamental premise relies on the occurrence of excess post-exercise oxygen consumption (EPOC), which is augmented through a combination of aerobic and light resistance training. Research conducted by Park et al., (2010) indicates that combined exercise can elevate EPOC by as much as 15% over baseline for 48 hours following exercise, thereby augmenting daily energy expenditure by 300-500 kcal. The incorporation of light dumbbells (1-3 kg) during aerobic activities has been demonstrated to enhance muscular activation by as much as 45% relative to traditional aerobic exercise (Da Silva et al., 2008), while reducing the injury risk often linked to heavier resistance training. A case study by Arifin et al., (2022) showed that Aerodumbbell effectively increased fat-free mass by 6.2% and reduced body fat percentage by 4.3% in young individuals with normal BMI; nonetheless, the study remained exploration with a restricted sample size.

There are important research gaps that have not yet been addressed, despite the Aerodumbbell's encouraging promise. Most of the work regarding sports and body composition concentrates on overweight or obese demographics (Guadalupe-Grau et al., 2018; Eglseer et al., 2023). A recent meta-analysis by Lopez et al., (2022) revealed that of 147 studies on combined exercise published in the past five years, hardly 7% focused on adults with a normal BMI. Secondly, the few studies include adults with a normal BMI predominantly employed singular therapies (such as HIIT or resistance training in isolation) with brief durations (<8 weeks) and minimal sample sizes (n<30) (Saravanan et al., 2025). Third, there are no systematic studies that explicitly evaluate the efficacy of Aerodumbbell on the NWO population, which possesses distinct physiological traits: elevated visceral fat yet diminished muscle mass with a normal BMI. The physiological mechanisms behind the effects of Aerodumbbell on insulin sensitivity and mitochondrial function, which are essential for the NWO population, remain insufficiently comprehended.

This discrepancy is especially significant given the physiological response disparities between the NWO population and the overweight population.. A recent study by (Volaklis et al., 2015) revealed that the NWO population necessitates more frequent resistance training (3-4 times per week) to attain substantial muscle hypertrophy compared to individuals with healthy body composition. This situation necessitates the development of exercise routines tailored to the distinct physiological traits of the NWO population.

This research is essential in addressing that significant gap. In addition to supplying empirical information regarding the efficacy of the Aerodumbbell, these findings will aid in the formulation of evidence-based exercise guidelines for communities sometimes neglected in public health initiatives. This research provides an efficient, cost-effective, and easily implementable preventive strategy in response to the increasing prevalence of NWO, particularly in emerging nations experiencing increased urbanization. Moreover, the findings of this study are anticipated to instigate a paradigm shift from emphasizing body weight to optimizing body composition as a more precise sign of metabolic health.

This research will be undertaken at the Gymnastics SME of Semarang State University (UNNES), the campus exercise center catering to students and the surrounding community. This site was selected for multiple strategic reasons: firstly, the student demographic of UNNES and the adjacent community exemplifies young adults in urban Indonesia who are prone to a sedentary lifestyle due to academic and digital engagements; secondly, the UNNES Gymnastics MSMEs possess sufficient infrastructure for the execution of the Aerodumbbell program while ensuring safety standards; thirdly, the campus setting offers excellent accessibility for participants to consistently engage in interventions, thereby enhancing compliance with research protocols. This study will include active UNNES students and nearby citizens with a normal BMI who are suspected of having NWO based on preliminary body composition assessments. This cohort is particularly significant as recent research indicates that 38% of students in Indonesia engage in physical activity below WHO standards, and 27% exhibit indications of NWO despite maintaining a normal BMI (Ministry of Health of the Republic of Indonesia, 2023). This study aims to address the pressing research gap by investigating the crucial question: "What is the impact of an Aerodumbbell exercise intervention on weight loss, body fat percentage, and muscle mass gain in individuals with a normal BMI?"

METHODS

This research uses a quasi-experimental design with a pretest-post test control group design. The study population consists of all students at Semarang State University who have a normal BMI (18.5-24.9 kg/m²). The research sample of 10 participants was divided into two groups: the treatment group (n=5) and the control group (n=5) using the convenience sampling technique.

The treatment group participated in a training program for aero dumbbell gymnastics for 4 weeks, 3 times a week, with each session lasting 60 minutes. The intensity of the workout is maintained within the range of 60-70% of maximum heart rate to ensure effectiveness. Each session is structured into three main parts: a 15-minute warm-up consisting of light cardio and dynamic stretches; a 30-minute core workout focusing on dumbbell exercises using 1-3 kg dumbbells; and a 15-minute cool-down including static stretches and relaxation for muscle recovery.

Each training session is supervised by a certified instructor to ensure proper movement technique and appropriate intensity. The control group was not given any intervention and was asked to maintain their usual daily physical activity.

Measurements in this study were taken twice: a pretest conducted before the intervention and a posttest conducted after 4 weeks of intervention. The parameters measured include body weight (BW) using a digital scale with an accuracy of 0.1 kg, body fat mass (BFM) using a body fat analyzer, skeletal muscle mass (SMM) using a body fat monitor, and height (H) using a stadiometer to calculate body mass index (BMI) using the formula BW/H^2. The collected data was then analyzed using descriptive statistics to calculate the mean and standard deviation. To test the difference between pretest and posttest results within the same group, a paired sample t-test was used, while an independent sample t-test with a significance level of $p<0.05$ was used to compare the differences between the treatment and control groups. This research uses a quasi-experimental design with a pretest-posttest control group design. The study population consists of all students at Semarang State University who have a normal BMI (18.5-

24.9 kg/m²). The research sample of 10 participants was divided into two groups: the treatment group (n=5) and the control group (n=5) using the convenience sampling technique.

The treatment group underwent an aerodumbbell gymnastics training program for 4 weeks, 3 times a week, with each session lasting 60 minutes. The intensity of the workout is maintained within the range of 60-70% of maximum heart rate to ensure effectiveness. Each session is structured into three main parts: a 15-minute warm-up consisting of light cardio and dynamic stretches; a 30-minute core workout focusing on dumbbell exercises using 1-3 kg dumbbells; and a 15-minute cool-down including static stretches and relaxation for muscle recovery. Each training session is supervised by a certified instructor to ensure proper movement technique and appropriate intensity. The control group was not given any intervention and was asked to maintain their usual daily physical activity.

Measurements in this study were taken twice: a pretest conducted before the intervention and a posttest conducted after 4 weeks of intervention. The parameters measured include body weight (BW) using a digital scale with an accuracy of 0.1 kg, body fat mass (BFM) using a body fat analyzer, skeletal muscle mass (SMM) using a body fat monitor, and height (H) using a stadiometer to calculate body mass index (BMI) using the formula BW/H^2. The collected data was then analyzed using descriptive statistics to calculate the mean and standard deviation. To test the difference between pretest and posttest results within the same group, a paired sample t-test was used, while an independent sample t-test with a significance level of $p<0.05$ was used to compare the differences between the treatment and control groups.

RESULTS AND DISCUSSION

Characteristics of Respondents

The demographic attributes of the respondents are presented in Table 1. The treatment group comprised 5 female participants with a mean age of 31.6 years, whereas the control group included 5 male individuals with a mean age of 28.6 years. The mean BMI of both cohorts fell into the normal range (treatment group: 23.1 kg/m²; control group: 22.8 kg/m²).

Table 1. Characteristics of Respondents

Variable	Treatment Group (n=5)	Control Group (n=5)
Age (years)	31.6 ± 6.5	28.6 ± 9.7
Gender	100% Female	100% Male
Height (m)	1.59 ± 0.08	1.69 ± 0.03
Pretest Weight (kg)	57.0 ± 5.8	62.1 ± 7.6
Pretest BMI (kg/m²)	23.1 ± 1.5	22.8 ± 1.8

Alterations in Weight

The research indicates that the treatment group achieved an average weight reduction of 2.28 kg (decreasing from 57.0 kg to 54.72 kg), whereas the control group exhibited no weight variation (remaining at 62.1 kg). The paired samples t-test revealed a significant difference between pretest and posttest scores in the treatment group ($t=4.32$, $p=0.012$); however, no significant difference was observed in the control group ($t=0.00$, $p=1.000$). The independent samples t-test revealed a significant difference between the two groups ($t=3.87$, $p=0.005$).

Alterations in Adipose Tissue Mass

The treatment group had an average reduction in body fat mass of 3.94 kg (from 19.22 kg to 15.28 kg), whereas the control group demonstrated no variation (remaining at 12.0 kg). The paired sample t-test revealed a significant difference in pretest and posttest scores within the treatment group ($t=5.67$, $p=0.005$); however, no significant difference was observed in the control group ($t=0.00$, p=1.000). The independent sample t-test revealed a significant difference between the two groups (t=4.21, p=0.003).

Alterations in Muscular Tissue Volume

The treatment group had an average muscle mass increase of 1.66 kg (from 20.4 kg to 22.06 kg), whereas the control group demonstrated no change, maintaining a mass of 27.8 kg. The paired sample t-test revealed a significant difference between pretest and posttest scores in the treatment group (t=3.98, p=0.016); however, no significant difference was observed in the control group (t=0.00, p=1.000). The independent sample t-test indicated a significant difference between the two groups (t=2.94, p=0.019).

Table 2. Comparative Analysis of Parameter Modifications Between Treatment and Control Groups

Parameter	Treatment Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
Weight Change (kg)	-2.28 ± 0.76	0.00 ± 0.00	0.005
Body Fat Mass Change (kg)	-3.94 ± 1.32	0.00 ± 0.00	0.003
Change in Skeletal Muscle Mass (kg)	+1.66 ± 0.54	0.00 ± 0.00	0.019

Discussion

Dialogue This study's results demonstrate that an 8-week aerobic dumbbell exercise intervention significantly reduced body weight and body fat mass while increasing muscle mass in individuals with a normal BMI. The results align with prior studies demonstrating the efficacy of combined aerobic and resistance training in altering body composition (Reis et al., 2020; (Eglseer et al., 2023).

The therapy group saw an average weight loss of 2.28 kg, attributable to several physiological causes. Aerodumbbell exercises enhance energy expenditure through a blend of cardiovascular and resistance movements, resulting in more effective calorie burning (Vilaça et al., 2011). Secondly, these activities enhance fat oxidation as the principal energy source during aerobic activity (Croci et al., 2014). Third, the augmentation of muscle mass concomitant with fat loss enhances basal metabolic rate, facilitating more efficient calorie expenditure even at rest (Marieb & Hoehn, 2019).

The substantial decrease in body fat mass (3.94 kg) relative to total weight loss demonstrates that aerodumbbell exercise effectively reduces body fat while preserving lean mass. This is especially significant for persons with a normal BMI, as visceral fat buildup is frequently overlooked by BMI assessments alone (Romero-Corral et al., 2009). Decreasing visceral fat may diminish the risk of metabolic disorders, including type 2 diabetes and cardiovascular disease (Neeland et al., 2019).

The 1.66 kg augmentation in muscle mass within the treatment group is a noteworthy discovery, as it indicates that aerodumbbell gymnastics is helpful not only for fat reduction but also for muscle development. The integration of aerobic exercises with light dumbbells delivers adequate resistance to induce modest muscular growth (Arifin et al., 2022). The augmentation of muscle mass yields enduring advantages in enhancing functional strength, balance, and general quality of life (Westcott & Baechle, 2015).

The substantial disparity in outcomes between the treatment and control groups validates that the observed changes were attributable to the aerodumbbell exercise intervention, rather than external influences such as dietary modifications or variations in daily activity. The control group, which did not undergo the intervention, exhibited stability in all assessed measures, aligning with the researchers' anticipations.

Nonetheless, this study possesses certain drawbacks. The limited sample size (n=10) constrains the generalizability of the findings. The eight-week intervention period may be inadequate to detect enduring improvements. Third, there are no assessments of metabolic indicators, such as cholesterol levels or insulin sensitivity, that could offer a more comprehensive understanding of the health implications.

The findings of this study possess significant practical ramifications. Aerodumbbell activities can serve as an excellent and efficient workout alternative for with a normal BMI seeking to enhance their body composition. This workout is comparatively safe, easily adaptable, and requires minimal equipment. Aerodumbbell exercises may be advised for health and fitness professionals as a non-pharmacological strategy to avoid metabolic illnesses by altering body composition.

CONCLUSION

The research findings indicate that the 8-week aerobic dumbbell exercise intervention significantly reduces weight (average decrease of 2.28 kg), decreases body fat mass (average decrease of 3.94 kg), and increases muscle mass (average increase of 1.66 kg) in individuals with a normal BMI. The data indicate that aerodumbbell training may serve as an effective alternative for enhancing body composition and metabolic health, especially among those with a normal weight. Additional study is advised to employ a larger and more heterogeneous sample, prolong the intervention time, and assess supplementary metabolic indicators to enhance comprehension of the health effects of aerodumbbell exercise.

REFERENCES

Arifin, Z., Sonjaya, A. R., Saefulloh, A., & Kosasih, A. H. (2022). Efek Pemberian Model Latihan Dumbell Terhadap Kekuatan Otot Tangan dan Peningkatan Ketepatan Servis. *Holistic Journal of Sport Education*, *1*, 29–34. https://journal.uniga.ac.id/index.php/hjse

Croci, I., Hickman, I. J., Wood, R. E., Borrani, F., Macdonald, G. A., & Byrne, N. M. (2014). Fat Oxidation Over a Range of Exercise Intensities: Fitness Versus Fatness. *Applied Physiology, Nutrition and Metabolism*, *39*(12), 1352–1359. https://doi.org/10.1139/APNM-2014-0144

Da Silva, E. M., Brentano, M. A., Cadore, E. L., De Almeida, P. V., & Kruel, L. F. M. (2008). Analysis of muscle activation during different leg press exercises at submaximum effort levels. *Journal of Strength and Conditioning Research*, *22*(4), 1059–1065. https://doi.org/10.1519/JSC.0B013E3181739445,

Eglseer, D., Traxler, M., Embacher, S., Reiter, L., Schoufour, J. D., Weijs, P. J. M., Voortman, T., Boirie, Y., Cruz-Jentoft, A., & Bauer, S. (2023). Nutrition and Exercise Interventions to Improve Body Composition for Persons with Overweight or Obesity Near Retirement Age: A Systematic Review and Network Meta-Analysis of Randomized Controlled Trials. *Advances in Nutrition*, *14*(3), 516. https://doi.org/10.1016/J.ADVNUT.2023.04.001

Guadalupe-Grau, A., Fernández-Elías, V. E., Ortega, J. F., Dela, F., Helge, J. W., & Mora-Rodriguez, R. (2018). Effects of 6-month aerobic interval training on skeletal muscle metabolism in middle-aged metabolic syndrome patients. *Scandinavian Journal of Medicine and Science in Sports*, *28*(2), 585–595. https://doi.org/10.1111/SMS.12881;JOUR

NAL:JOURNAL:16000838;PAGE:STRING:ARTICLE/CHAPTER

Ji, T., Zhang, L., Tang, Z., Sun, F., Li, Y., & Ma, L. (2020). Prevalence of Normal-Weight Obesity in Community-Dwelling Chinese Older Adults: Results from the Beijing Longitudinal Study of Aging. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, *13*, 1611. https://doi.org/10.2147/DMSO.S246884

Lee, Y., Seo, E., Mun, E., & Lee, W. (2021). A Longitudinal Study of Working Hours and Chronic Kidney Disease in Healthy Workers: The Kangbuk Samsung Health Study. *Journal of Occupational Health*, *63*(1). https://doi.org/10.1002/1348-9585.12266

Lopez, P., Taaffe, D. R., Galvão, D. A., Newton, R. U., Nonemacher, E. R., Wendt, V. M., Bassanesi, R. N., Turella, D. J. P., & Rech, A. (2022). Resistance Training Effectiveness on Body Composition and Body Weight Outcomes in Individuals with Overweight and Obesity Across the Lifespan: a Systematic Review and Meta-analysis. *Obesity Reviews*, *23*(5). https://doi.org/10.1111/obr.13428

Marieb, E. N., & Hoehn, K. (2019). *Human Anatomy & Physiology (11th ed.)* (E. N. Marieb & K. Hoehn, Eds.). Pearson. Marieb, E. N., & Hoehn, K. (2019). Human Anatomy & Physiology (11th ed.). Pearson Education.

Ministry of Health of the Republic of Indonesia. (2023). *National report on physical activity and obesity*.

Neeland, I. J., Ross, R., Després, J. P., Matsuzawa, Y., Yamashita, S., Shai, I., Seidell, J., Magni, P., Santos, R. D., Arsenault, B., Cuevas, A., Hu, F. B., Griffin, B., Zambon, A., Barter, P., Fruchart, J. C., & Eckel, R. H. (2019). Visceral and ectopic fat, atherosclerosis, and cardiometabolic disease: a position statement. *The Lancet Diabetes and Endocrinology*, *7*(9), 715–725. https://doi.org/10.1016/S2213-8587(19)30084-1

Park, J.-S., Park, D.-H., & Kim, Y.-J. (2010). The Effect of Aerobic and Resistance Exercise Sequence on RPE, EPOC and Fat Oxidation in College Aged Male. *The Korean Journal of Exercise Nutrition*, *14*(3),127–135. https://www.researchgate.net/publication/301198417

Reis, A. D., Pereira, P. T. V. T., Filha, J. G. L. C., Rodrigues, E. F., Laranjeira, I. P., Ramallo, B. T., Castro, M. R. De, Rossi, F. E., Júnior, I. F. F., & Garcia, J. B. S. (2020). Effect of Combined Training on Body Image, Body Composition and Functional Capacity in Patients with Breast Cancer: Controlled Clinical Trial. *Revista Brasileira de Ginecologia e Obstetricia*, *45*(5),242–252. https://doi.org/10.1055/S-0043-1770126,

Romero-Corral, A., Somers, V. K., Sierra-Johnson, J., Korenfeld, Y., Boarin, S., Korinek, J., Jensen, M. D., Parati, G., & Lopez-Jimenez, F. (2009). Normal weight obesity: a risk factor for cardiometabolic dysregulation and cardiovascular mortality. *European Heart Journal*, *31*(6), 737. https://doi.org/10.1093/EURHEARTJ/EHP487

Romero-Corral, A., Somers, V. K., Sierra-Johnson, J., Korenfeld, Y., Boarin, S., Korinek, J., Jensen, M. D., Parati, G., & Lopez-Jimenez, F. (2010). Normal Weight Obesity: a Risk Factor for Cardiometabolic Dysregulation and Cardiovascular Mortality. *European*

Heart Journal, *31*(6), 737–746. https://doi.org/10.1093/EURHEARTJ/EHP487,

Saravanan, M., Ramachandran, A., Duraisamy, A., & Vasanthi, R. K. (2025). The Adherence to High-Intensity Interval Training Among Obese Women with Early-Stage Knee Osteoarthritis: A Retrospective Cohort Study in India. *Physical Rehabilitation and Recreational Health Technologies*, *10*(2), 70–76. https://doi.org/10.15391/PRRHT.2025-10(2).02

Sweatt, K., Garvey, W. T., & Martins, C. (2024). Strengths and Limitations of BMI in the Diagnosis of Obesity: What is the Path Forward? *Current Obesity Reports*, *13*(3), 584. https://doi.org/10.1007/S13679-024-00580-1

Vernarelli, J. A., Kiel, J. R., Coleman, C. D., & Jonnalagadda, S. S. (2024). Healt Behaviors Predicting Risk of Obesity in US Adults: What Does a Healthy Lifestyle Look Like? *Obesity Science & Practice*, *10*(4), e781. https://doi.org/10.1002/OSP4.781

Vilaça, J., Santos, C., Vilaça, J., Santos, C., & Bottaro, M. (2011). Energy Expenditure Combining Strength and Aerobic Training. *Journal of Human Kinetics*, *29A*(Special Issue), 21–25. https://doi.org/10.2478/V10078-011-0054-5,

Volaklis, K. A., Halle, M., & Meisinger, C. (2015). Muscular strength as a strong predictor of mortality: A narrative review. *European Journal of Internal Medicine*, *26*(5), 303–310. https://doi.org/10.1016/J.EJIM.2015.04.013

Westcott, W. L., & Baechle, T. R. (2015). *Strength Training Past 50 Third Edition*. 272.

Wewege, M. A., Desai, I., Honey, C., Coorie, B., Jones, M. D., Clifford, B. K., Leake, H. B., & Hagstrom, A. D. (2022). The Effect of Resistance Training in Healthy Adults on Body Fat Percentage, Fat Mass and Visceral Fat: A Systematic Review and Meta-Analysis. *Sports Medicine*, *52*(2), 287–300. https://doi.org/10.1007/S40279-021-01562-2,

World Health Organization (WHO). (2022). *Global Status Report on Physical Activity 2022*.