

Light intensity exercise: An investigation into potential effects on oxygen perfusion and metabolism as measured by momentary post-activity drops in blood oxygen saturation

Pete Anthony Gryffin

gryffin_pa@mercuer.edu

Mercer University

Qihai Gu

Mercer University

Research Article

Keywords: Walking, Tai Chi, Qigong, Cellular Regeneration

Posted Date: April 9th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9043764/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Sport Sciences for Health on October 1st, 2026. See the published version at <https://doi.org/10.1007/s11332-026-01956-7>.

Abstract

Background

Previous research suggests slower paces of walking, tai chi, qigong and other light intensity physical activities may develop states of relaxation which may trigger increased oxygen perfusion and metabolism.

Methods

A Nonin WristOx 3150 was used to record and graph blood oxygen saturation (SpO₂) changes in 10 members of an older adult tai chi group during slow-paced walking, tai chi, and qigong. All participants noted a chronic condition. Measurements were compared to 10 participants from a fitness center group reporting good health.

Results

The tai chi group experienced a brief momentary post-activity drop in SpO₂ before returning to normal levels ($P < .001$), with mean of $90.20 \pm 1.55\%$ following slow-paced walking; $89.30 \pm 1.70\%$ following tai chi; and $88.40 \pm 1.43\%$ following qigong. No significant change was recorded in the fitness center group.

Conclusion

The brief large drop in SpO₂ averaging 22.2 seconds following activities in the tai chi group may signal an adjustment and shift in oxygen use and metabolism. A metaerobic hypothesis is proposed as a potential explanation, suggesting that a relaxed state coupled with enhanced respiration may enhance oxygen perfusion and metabolism, potentially supporting healing and cellular regeneration. Avenues for further research are suggested, including comparison to aerobic exercise and stages of sleep.

1. Introduction

Light intensity physical activities, including slower paces of walking, as well as forms of tai chi and qigong (breathing exercises) do not raise the heart rate sufficiently to be considered aerobic forms of exercise for cardiovascular health.¹⁻⁵ A systematic review of 72 studies noted that light intensity physical activities are associated with a beneficial acute and long-term lower risk of mortality. However, the authors stressed that there is an absence of an established biological mechanism underlying benefits, which inhibits clinical recommendations.¹

Current modalities of exercise are divided into two primary categories, aerobic and anaerobic exercise. Unless the intensity of walking, tai chi, and qigong are increase sufficiently, these exercises do not

generate aerobic benefits. Possibly due to a need to fit tai chi into an existing category of exercise, tai chi is often categorized as a moderate intensity aerobic exercise.^{6,7} However, existing evidence does not support tai chi as an effective way for increasing aerobic capacity.⁶ Aside from general benefits for stress reduction, the question remains as to what is happening in the body during these exercises.^{3,8-12}

Previous research indicated that tai chi and qigong exercises may affect oxygen use in the body in unique ways.¹²⁻¹⁴ Preliminary investigations in one study documented a slight increase in blood oxygen saturation (SpO₂) during tai chi (mean percent change + 2.12%±1.25%; $P<.001$).¹⁴ But what was particularly notable in this study was the large brief momentary drop in SpO₂ following tai chi before returning to normal levels ($M = 90.78\%\pm2\%$; $P<.001$). No significant change in measurements was noted during or following running.¹⁴

This prompted the question if any slow-paced or light intensity exercise might also result in a large momentary post-activity drop in blood oxygen saturation, such as slower paces of walking, as well as following qigong. The following pilot study investigated potential changes in SpO₂ during and following walking at 1.5 mph (2.41 km/h), Yang style tai chi, and baduanjin qigong. Potential implications and recommendations for further research are presented in the discussion section.

2. Methods

2.1 Participants and study design

As an exploratory study examine potential differences in SpO₂ following light intensity physical activities other than tai chi, measurements were taken of 10 members of a tai chi group during 20 minutes of exercise, and for 5 minutes post exercise, for walking (1.5 mph/2.41 km/h); Yang style tai chi; and baduanjin qigong. Participants were selected from a tai chi group for comparison of the three activities due to being regular practitioners of tai chi and qigong. Data was continuously recorded for download and evaluation. Age and health status were also recorded. All members of this group were older adults ranging in age from 50 to 71, with a mean age of 62.3 years. All noted a chronic condition, including two respiratory conditions; one with asthma, and one with sleep apnea. However both of these participants reported the conditions as well controlled and not impacting respiration during the activities. No other respiratory conditions were reported. See Table 1 for participant characteristics.

Participant	Age	Sex	Medical Condition(s)
1	66	M	Type 2 Diabetes, Sleep Apnea
2	55	M	Recovering from Hernia Surgery
3	68	M	High Blood Pressure, Asthma
4	71	F	Chronic Kidney Disease, High Blood Pressure, High Cholesterol
5	65	M	High Blood Pressure
6	69	F	Chronic Pain/Neuralgia
7	54	F	Chronic Cytomegalovirus (CMV) Disease
8	63	F	Abdominal Cysts
9	50	F	High Blood Pressure, Lupus
10	62	M	Peripheral Neuropathy

Table 1. Participants in the older adult tai chi group.

Participants in the older adult tai chi group were measured while walking on a measured track for 20 minutes at 1.5 mph (2.41 km/h), as well as during 25 minutes of Yang style tai chi, and 15 minutes of the baduanjin qigong exercise. Participants were also measured for 5 minutes following each exercise while at rest. Measurements were conducted over a series of Saturday mornings during the group's regular meeting time between 9 am to 10 am.

Measurements were then compared to an unpublished study conducted at fitness center during a summer scholars program with the Mercer University School of Medicine. In this study 7 men and 3 women were included in the final fitness center group, ranging in age from 23 to 68 ($M = 52.7$ years). The participants included in the fitness center group were all in good health. One participant had recently completed an iron man competition (participant 2, Male, age 23). Participants in this study walked on a treadmill at 1.5 mph (2.41 km/h) for 20 minutes, followed by 5 minutes of rest. Data was continuously recorded for download and evaluation. Another male, age 77, had also been measured but was excluded from the fitness center group due to being overweight and being treated for prostate cancer, to obtain a more homogenous sample in the original study. The results of this individual were similar to those in the current study, so are included below for comparison.

2.2 Instruments

To graph and obtain more accurate measurements of changes in blood oxygen saturation, the Nonin WristOx 3150 (Nonin Medical Inc, Plymouth, MN, USA) was used to record SpO₂ levels. Unlike commercial oximeters which can miss brief changes in SpO₂ level, the WristOx 3150 can record and print results in graph format for more accurate analyses. This device can record changes in SpO₂ at 1

second intervals, with an accuracy of +/- 2%, including during challenging conditions which can include movement and low perfusion. This instrument is regularly used in military testing due to its durability and reduced rate of error during movement. The motion tolerant software minimizes motion artifacts.^{15,16} Sample measurements of respiration rate were taken during activities with a Go Direct Respiration Belt (Vernier, Beaverton, OR, USA).

2.3 Statistical analysis

A paired t-test was used to make pre and post-test comparisons with a threshold of $p<.05$ for statistical significance, using SPSS for analysis (IBM, Armonk, NY, USA). A post hoc test using SpO2 level as the outcome determined that a sample size of 4 participants per group would provide more than 80% power using a two-tailed alpha of 5% and an effect size of 2.25. Effect size was determined using data from a study conducted by Gryffin and Diaz.¹⁴ The research protocol was reviewed and approved by Mercer University's Institutional Review Board and the Office of Research Compliance, with all participants completing an informed consent form.

3. Results

All participants in the older adult tai chi group experienced a momentary significant post activity drop in SpO2 before returning to normal levels ($P< .001$). SpO2 dropped to $89.30 \pm 1.70\%$ following tai chi; $88.40 \pm 1.43\%$ following qigong; and $90.20 \pm 1.55\%$ following walking. The mean post activity drop in SpO2 at or below 92% was for 22.2 seconds, with a range from 6 to 90 seconds before returning to normal levels, within 5 minutes of stopping the activity. See Table 2 for statistical results for the older adult tai chi group, and also the fitness center group from the summer scholar study. See Fig. 2 for sample graphs from the older adult tai chi group.

Activity	SpO2 During	Post SpO2	P-Value
Older Adult Group			
Tai Chi	96.25 ± 0.98	89.30 ± 1.70	$<.001$
Qigong	96.60 ± 0.74	88.40 ± 1.43	$<.001$
Slow Walking	97.00 ± 0.97	90.20 ± 1.55	$<.001$
Fitness Center Group			
Slow Walking	96.60 ± 1.37	96.80 ± 1.21	.269

*Data are presented as mean $\pm$ SD.

Table 2. Change in SpO₂. Results from the older adult tai chi group (tai chi, qigong, slow waking) and the healthy participants in the fitness center group (slow walking). Participants in both groups walked

at a pace of 1.5 mph (2.41 km/h).

Figure 3 shows sample charts from the fitness center study of a healthy participant who exhibited a potential although insignificant post activity drop, and also the chart from the fitness center participant with prostate cancer, who had been excluded from the healthy participant comparison in the original study. The fitness center group did not show a statistical difference between measurements during and following walking (during $96.60 \pm 1.37\%$; post $96.80 \pm 1.21\%$; $P=.269$). Participant 2 may have exhibited a potential momentary post exercise drop to 94%, however this is still within normal levels (Fig. 3). The older participant with prostate cancer experienced a large momentary drop to 86% before returning to normal levels.

4. Discussion

In the older adult tai chi group results demonstrated a significant momentary drop in SpO₂ to levels as low as $88.40 \pm 1.43\%$ following qigong; $89.30 \pm 1.70\%$ following tai chi; and $90.20 \pm 1.55\%$ following walking, for a period ranging from approximately 6 to 90 seconds with a mean of 22.2 seconds, before returning to normal levels. The older adult with prostate cancer who was not included in the fitness center group also experienced a large momentary post-activity drop, to 86%.

From a hypothetical perspective it is suggested that the large momentary drop in SpO₂ following these exercises in the participants with chronic conditions may relate to a larger demand on oxygen in the body, possibly due to a greater need for healing and cellular regeneration, and a greater prevalence of hypoxic areas in the body which are associated with health conditions.¹²⁻¹⁴ Hypoxia consists of lower levels of oxygen content compared to normal states in organs, specific tissues, and cell types.¹⁷ Hypoxemia, low levels of oxygen in the blood, can be affected by blood flow to the lungs, ventilation or airflow to the alveoli, and gas exchange through diffusion.^{18,19} The latter is particularly relevant, since extreme rates of oxygen perfusion and diffusion may affect SpO₂ levels.²⁰ Oximeters generally do not reflect cellular oxygen use since they measure arterial as opposed to venous oxygen levels, which usually reflects a return of oxygen levels to normal levels above 94%.²¹ However, low levels of oxygen in arterial blood can result from various factors which can reduce SpO₂ measurements to below 94%, including chronic obstructive pulmonary disease (COPD),²² and during extreme athletic performance.²⁰

There were also physical indications in participants, which may signal changes in oxygen perfusion and diffusion. During the practice of tai chi and qigong the participants reported feeling a tingling in the hands, and sometimes the arms, which is common during these practices. The tingling sensation may be a result of consciously focusing on relaxation and the breath.^{12,13} The sensation is similar to when a limb falls asleep due to a lack of circulation, but pleasant instead of painful. One hypothesis is that the tingling felt during tai chi and qigong may indicate an increase in oxygen perfusion in the body.^{12,13} That this sensation was not reported during slow-paced walking may indicate subtle differences between walking and tai chi/qigong, potentially related to level of focus on relaxation. The results in Table 2

showed the greatest drop in SpO₂ following baduanjin qigong, which has a slightly greater level of relaxation and is more stationary than tai chi. While the momentary large drop following tai chi was slightly lower than walking.

Returning to considerations related to hypoxia and hypoxemia, SpO₂ levels below a certain threshold (typically 92%) can indicate that the body is not adequately oxygenated, signifying hypoxia/hypoxemia.²³ However, in the case of the slower-paced exercises measured in this study, and in previous research,¹⁴ the timing and short duration of these drops, within 5 minutes of stopping the activity, suggests a state other than hypoxia or hypoxemia.

Zhang and colleagues suggest that a mechanism of action underlying the benefits of qigong may be the generation of an oxygen supply and acid-base balance during these exercises, which may counter the hypoxic effects which underly many physiological conditions.¹² It should be noted that tai chi can also be considered a form of qigong when focused on relaxation and the breath. It is suggested by the authors that these exercises may (1) improve microcirculation to affect metabolic accumulations such as lactate; (2) reduce oxygen demand through relaxation in the large muscle groups, as well as the brain; and (3) increase oxygen exchange in the lungs, as well as blood oxygen concentration, thereby alleviating local hypoxic conditions in the tissues. The authors note that as a breathing exercise, qigong exercises may supercharge respiration by improving air-exchange capacity and elevate oxygen loading in red blood cells, thereby enhancing microcirculation and oxygen supply in metabolism and physiological function. They note that the end effect may be to enhance metabolism, resistance to disease, and the self-repair ability of the body.

In relation to reduced oxygen demand, which the authors state reduced oxygen demand by the large muscle groups during qigong may play a role,¹² it may be worth noting that during resting conditions, oxygen extraction in the skeletal muscle tissues ranges between 20% and 40%, while during heavy exercise this demand can increase to 70–80% of the oxygen carried by the blood.²⁴ The relaxed state of slow-paced exercises may reduce the muscular need for oxygen and enhance oxygen use by the rest of the cells of the body. Particularly in the organs, which are more prone to disease. Cancer development is very rare in skeletal muscle tissue.²⁵ One reason given relates to the larger demand for oxygen and the increased blood flow and perfusion in skeletal muscle tissue. Relaxation focused exercises may lead to an increase in oxygen delivery to the organs, compared to the musculature during more active exercises and during general waking hours.

A metaerobic hypothesis is proposed as an alternative to aerobic or anaerobic effects of exercise, as a potential distinct category of exercise. The primary premise being considered is that a momentary large post-activity drop in SpO₂ in individuals with health conditions may be the result of a shift and return to normal metabolism, following a period of increased use and metabolism of oxygen during these exercises related to enhanced cellular regeneration and healing (Fig. 3).

The large momentary post-activity drop in SpO₂ may reflect a shift from enhanced metabolism and cellular respiration back to normal function. Any increase in oxygen saturation and perfusion during these activities may underly the many reported benefits of these exercises, by enhancing healing at the cellular level. As noted above, Zhang and colleagues suggest a similar mechanism in response to hypoxic areas of the body and a need for enhanced healing and cellular regeneration.¹²

In the older adult tai chi group in the current study, respiration slowed down from 12 to 20 breaths per minute, typical in healthy adults during rest,²⁶ to as low as 6 to 10 breaths per minute during tai chi and qigong, which is supported in the literature.^{27,28} Measurements of respiration rate during walking at 1.5 mph/2.41 km/h ranged between 10 to 12 breaths per minute.

A metaerobic hypothesis may explain the momentary drop in SpO₂ below normal levels, shortly after stopping the activity, possibly due to a shift from enhanced perfusion, oxygen use, and metabolism, back to normal perfusion, oxygen use, and metabolism. A metaerobic effect may also occur during other activities which involve a level of relaxation as well, such as during sleep and sitting meditation. Stages 2 and 3 of sleep, also associated with healing, result in a similar reduction of breathing rate, as well as a relaxed state.²⁹ Sitting meditation, which also focuses on relaxation and the breath, has been associated with a range of physical health benefits, including benefits for oxidative stress, telomere length, and associated reduction of cellular aging.³⁰ However, the authors note that how meditation results in these benefits is unclear. A metaerobic hypothesis may offer one explanation. A reduced demand for oxygen by the large muscle groups, coupled with a relaxed state and enhanced respiration, may result in a similar physiological response.

Various limitations and cautions are worth noting. The first being the small number of participants in the pilot study, and that the participants in the tai chi group were all older adults with chronic conditions. Also to be considered is the potential of undocumented COPD or other respiratory conditions in the participants in the tai chi group.

There is also the role the level of relaxation may play. One participant in the summer bridge fitness center study noted how difficult it was to force themselves to keep to a slow pace. The environment of the walking location may also have played a role. Although both groups were paced at 1.5 mph (2.41 km/h), the fitness center group walked on a treadmill while the older adult tai chi group used a walking path. However, the participant not included in the fitness center group who had prostate cancer also walked on a treadmill, yet also experienced a drop in SpO₂ similar to the older adult tai chi group.

That the individuals included in the fitness center group, with no reported health conditions, did not experience a significant drop in SpO₂ following walking raises interesting questions. The results and graphs of the fitness center group were all within the normal range, so any drops in SpO₂ may not have been noticeable, with the possible exception of participant 2. Participant 2 showed a potentially distinct momentary post-activity drop in SpO₂, but only to 94% (Fig. 3). Momentary drops within the normal

range for SpO₂ in healthy individuals may not be as clear as were the larger drops in SpO₂ in the older adult tai chi group (Table 2 and Fig. 2), and in the participant with prostate cancer (Fig. 3).

If the degree of the momentary post-activity drop in SpO₂ is tied to the health of the person, healthier individuals may experience a drop in SpO₂, but less of a drop compared to individuals with health conditions. The participants who experienced the large post-activity momentary drop in SpO₂, aside from having a range of health conditions (Table 1), were also all older adults, as was the individual with prostate cancer, which may also indicate a greater need for cellular regeneration due to aging.

The observations presented in this research presents potential relationships, but these relationships may be independent of actual cause and effect. Future research will confirm, deny, or provide alternate associations and hypotheses. It will be important to conduct a range of measurements beyond SpO₂ which may detect unique effects of tai chi and other light-intensity exercises, potentially through cerebral oximetry, transcutaneous oxygen measurement (TCOM), near-infrared spectroscopy (NIRS), capnography, and other measures.

It is recommended to replicate these measurements with a larger number of participants targeting those in good health as well as those with various health conditions, and in various age cohorts. Another recommendation is to investigate a wider range of activities, including various levels of aerobic activity, strength training, sleep, and sitting meditation. Elkhenany and colleagues have noted that although the healing process is faster during sleep, the mechanism underlying the healing benefits of sleep has not been studied to any satisfactory extent.³¹

5. Conclusion

In this preliminary study SpO₂ was observed to drop significantly for a brief moment following light-intensity physical activities consisting of walking at 1.5 mph (2.41 km/h); Yang style tai chi; and baduanjin qigong, in a group of older adults with various health conditions. No significant change was observed following walking at 1.5 mph (2.41 km/h) in a younger group of fit individuals. A metaerobic hypothesis is proposed, stating that the large momentary post activity drop in light-intensity physical activities, to as low as 85% in the current study, may indicate a shift from an increase in oxygen perfusion, metabolism, and cellular regeneration during exercise, to a normal state of oxygen perfusion and use following these exercises. Follow up studies are recommended with a larger number and range of participants for a variety of activities, including aerobic and non-aerobic exercises, sitting meditation, and sleep.

One last and potentially particularly important point. Since SpO₂ dropped significantly in the participants with health conditions, measurements might be able to be used to detect potentially unknown health conditions or illness. It might be worth conducting a range of medical evaluations in those without a documented condition, yet who exhibit a large post activity drop in SpO₂ following these activities, to see if these drops correspond to an unknown illness or condition. Carlson and others note that declines

during sleep in regional cerebral oxygen saturation in older adults from resting baseline may help identify individuals who are at risk for cognitive decline.³²

It is also important to note that aerobic and resistance exercises are still key for overall health.^{4,33} However, for those who have an inability to engage in vigorous exercise, or for those with chronic conditions, slower-paced and light intensity activities may offer a valuable supplement for health. Understanding the physiological mechanisms underlying the benefits of tai chi, qigong, as well as other slow-paced, stationary, and light intensity activities, may enhance more effective research and promotion. Similar to what occurred with the understanding of cardiovascular health following the Framingham Heart Study, and with aerobic exercise following the publication of *Aerobics* by Kenneth Cooper.^{34,35}

Declarations

Acknowledgements

The authors wish to thank Jesurebor I. Ivbaze for collecting the data from the fitness center participants as part of the Mercer University School of Medicine Summer Scholars Program.

Conflict of interest

The authors have no conflict of interest to declare.

Human and Animal Rights/Ethics approval

The research protocol was reviewed and approved by Mercer University's Institutional Review Board and the Office of Research Compliance.

Informed consent

All participants completed an informed consent form approved by the Mercer University's Institutional Review Board and the Office of Research Compliance.

Funding

No funds, grants, or other support were received.

References

1. Chastin SFM, De Craemer M, De Cocker K, et al. How does light-intensity physical activity associate with adult cardiometabolic health and mortality? Systematic review with meta-analysis of experimental and observational studies. *Br J Sports Med*. 2019;53(6):370–376. doi:10.1136/bjsports-2017-097563

2. American College of Sports Medicine (ACSM). *Starting a Walking Program*. 2011. Accessed August 26, 2024. <https://www.acsm.org/docs/default-source/files-for-resource-library/starting-a-walking-program.pdf>
3. Zuhl M. *Tips for Monitoring Aerobic Exercise Intensity*. 2020. Accessed August 26, 2024. <https://www.acsm.org/docs/default-source/files-for-resource-library/exercise-intensity-infographic.pdf>
4. Liguori G. *American College of Sports Medicine. (2000). ACSM's Guidelines for Exercise Testing and Prescription*. 11th ed. Lippincott Williams & Wilkins;; 2021.
5. Myers J. Exercise and Cardiovascular Health. *Circulation*. 2003;107(1). doi:10.1161/01.CIR.0000048890.59383.8D
6. Lee MS, Lee EN, Ernst E. Is tai chi beneficial for improving aerobic capacity? A systematic review. *Br J Sports Med*. 2009;43(8):569–573. doi:10.1136/bjsm.2008.053272
7. Sannes TS, Mansky PJ, Chesney MA. The Need for Attention to Dose in Mind–Body Interventions: Lessons from *T'ai Chi* Clinical Trials. *The Journal of Alternative and Complementary Medicine*. 2008;14(6):645–653. doi:10.1089/acm.2007.0680
8. Kelly P, Williamson C, Niven AG, Hunter R, Mutrie N, Richards J. Walking on sunshine: scoping review of the evidence for walking and mental health. *Br J Sports Med*. 2018;52(12):800–806. doi:10.1136/bjsports-2017-098827
9. Yeh GY, Wang C, Wayne PM, Phillips R. Tai Chi Exercise for Patients With Cardiovascular Conditions and Risk Factors. *J Cardiopulm Rehabil Prev*. 2009;29(3):152–160. doi:10.1097/HCR.0b013e3181a33379
10. Yeh GY, Wang C, Wayne PM, Phillips RS. The Effect of Tai Chi Exercise on Blood Pressure: A Systematic Review. *Prev Cardiol*. 2008;11(2):82–89. doi:10.1111/j.1751-7141.2008.07565.x
11. Li X, Chang P, Wu M, et al. Effect of Tai Chi vs Aerobic Exercise on Blood Pressure in Patients With Prehypertension. *JAMA Netw Open*. 2024;7(2):e2354937. doi:10.1001/jamanetworkopen.2023.54937
12. Zhang J, Su Q, Li SC. Qigong Exercise Balances Oxygen Supply and Acid-Base to Modulate Hypoxia: A Perspective Platform toward Preemptive Health & Medicine. *Medical Sciences*. 2023;11(1):21. doi:10.3390/medsci11010021
13. Gryffin P. Qi: Implications for a New Paradigm of Exercise. *Integrative Medicine*. 2013;12(1):36–40.
14. Gryffin PA, Diaz RE. Effects of Tai Chi and running on blood oxygen saturation: a pilot study. *J Complement Integr Med*. 2021;18(4):821–825. doi:10.1515/jcim-2020-0306
15. Nonin. WristOx2 Model 3150 with USB. <https://www.nonin.com/support/3150-usb/>.
16. Nonin. Nonin Medical's WristOx2® Model 3150 Beats VirtuOx VPOD in Hypoxia Testing. <https://www.nonin.com/resource/wristox2-model-3150-beats-virtuox-vopd-in-hypoxia-testing/>.
17. Chen PS, Chiu WT, Hsu PL, et al. Pathophysiological implications of hypoxia in human diseases. *J Biomed Sci*. 2020;27(1):63. doi:10.1186/s12929-020-00658-7

18. Leach RM, Treacher DF. ABC of oxygen: Oxygen transport—2. Tissue hypoxia. *BMJ*. 1998;317(7169):1370–1373. doi:10.1136/bmj.317.7169.1370
19. Bhutta BS AFBI. Hypoxia. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK482316/>. March 4, 2024.
20. Galy O, Hue O, Chamari K, Boussana A, Chaouachi A, Préfaut C. Influence of Performance Level on Exercise-Induced Arterial Hypoxemia During Prolonged and Successive Exercise in Triathletes. *Int J Sports Physiol Perform*. 2008;3(4):482–500. doi:10.1123/ijsspp.3.4.482
21. Torp KD MPPE et al. Pulse Oximetry. <https://www.ncbi.nlm.nih.gov/books/NBK470348/>. July 30, 2023.
22. Owens RL, Derom E, Ambrosino N. Supplemental oxygen and noninvasive ventilation. *European Respiratory Review*. 2023;32(167):220159. doi:10.1183/16000617.0159-2022
23. Majumdar SR, Eurich DT, Gamble JM, Senthilselvan A, Marrie TJ. Oxygen Saturations Less than 92% Are Associated with Major Adverse Events in Outpatients with Pneumonia: A Population-Based Cohort Study. *Clinical Infectious Diseases*. 2011;52(3):325–331. doi:10.1093/cid/ciq076
24. Korthuis R. Exercise Hyperemia and Regulation of Tissue Oxygenation During Muscular Activity. In: *Skeletal Muscle Circulation*. Morgan & Claypool Life Sciences; 2011:4. doi:10.4199/C00035ED1V01Y201106ISP023
25. Kump DS. Mechanisms Underlying the Rarity of Skeletal Muscle Cancers. *Int J Mol Sci*. 2024;25(12):6480. doi:10.3390/ijms25126480
26. Chourpiliadis C, Bhardwaj A. *Physiology, Respiratory Rate*. 2025.
27. Mendo B, Gonçalves M, Lopes L, Matos LC, Machado J. Can Yoga, Qigong, and Tai Chi Breathing Work Support the Psycho-Immune Homeostasis during and after the COVID-19 Pandemic? A Narrative Review. *Healthcare*. 2022;10(10):1934. doi:10.3390/healthcare10101934
28. Russo MA, Santarelli DM, O'Rourke D. The physiological effects of slow breathing in the healthy human. *Breathe*. 2017;13(4):298–309. doi:10.1183/20734735.009817
29. NIH. *Your Guide to Healthy Sleep*. 2011.
30. Dasanayaka NN, Sirisena ND, Samaranayake N. The effects of meditation on length of telomeres in healthy individuals: a systematic review. *Syst Rev*. 2021;10(1):151. doi:10.1186/s13643-021-01699-1
31. Elkhenany H, AlOkda A, El-Badawy A, El-Badri N. Tissue regeneration: Impact of sleep on stem cell regenerative capacity. *Life Sci*. 2018;214:51–61. doi:10.1016/j.lfs.2018.10.057
32. Carlson BW, Neelon VJ, Carlson JR, Hartman M, Dogra S. Exploratory Analysis of Cerebral Oxygen Reserves During Sleep Onset in Older and Younger Adults. *J Am Geriatr Soc*. 2008;56(5):914–919. doi:10.1111/j.1532-5415.2008.01672.x
33. Schroeder EC, Franke WD, Sharp RL, Lee D chul. Comparative effectiveness of aerobic, resistance, and combined training on cardiovascular disease risk factors: A randomized controlled trial. *PLoS One*. 2019;14(1):e0210292. doi:10.1371/journal.pone.0210292
34. Cooper K. *Aerobics*. 1st ed. Bantam Books; 1968.

Figures

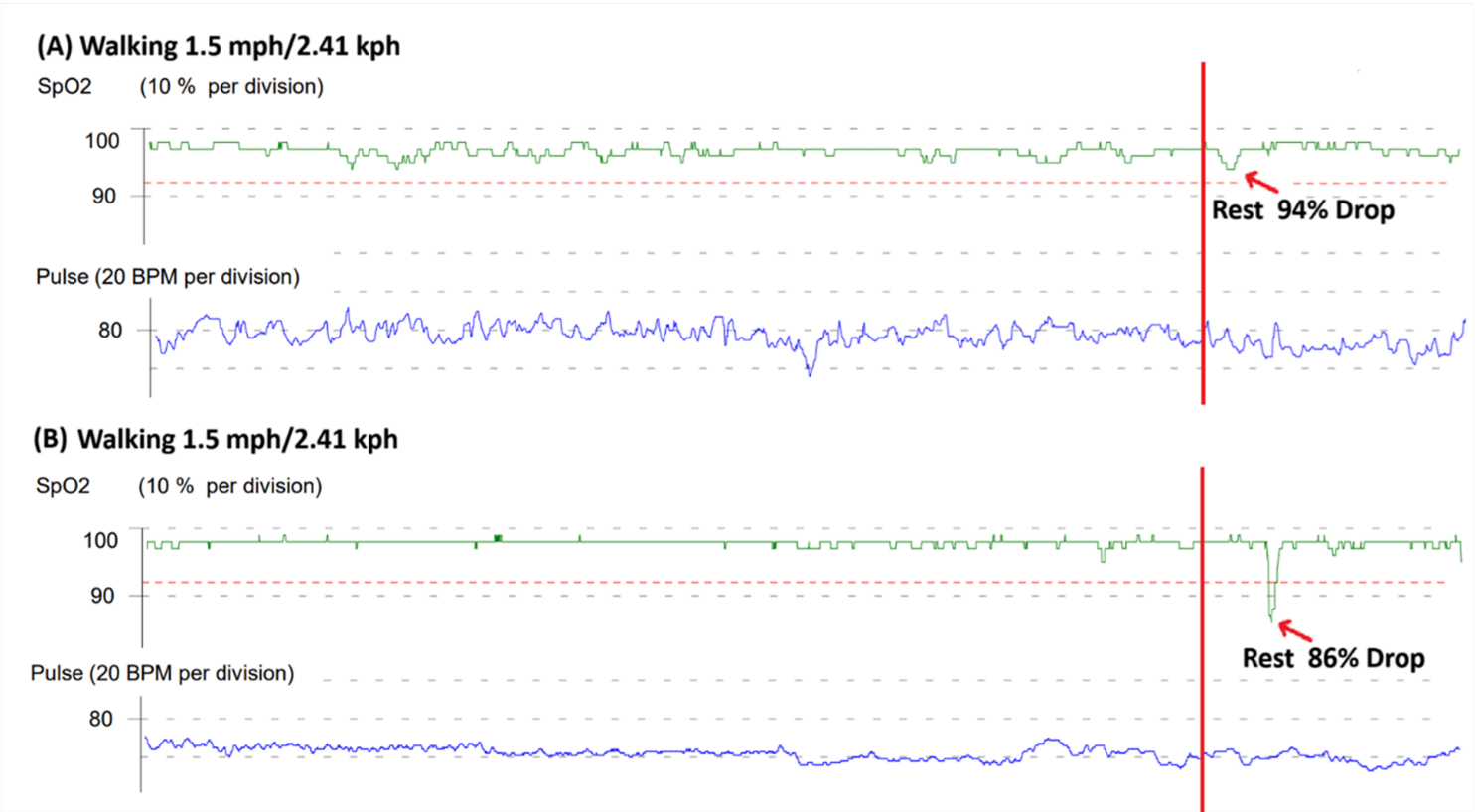


Figure 1

(A) Participant 2 in the fitness center group showed a potential distinct but insignificant drop in SpO2. (B) The older participant with prostate cancer showed a large momentary drop to 86% before returning to normal levels. See the discussion section for implications.

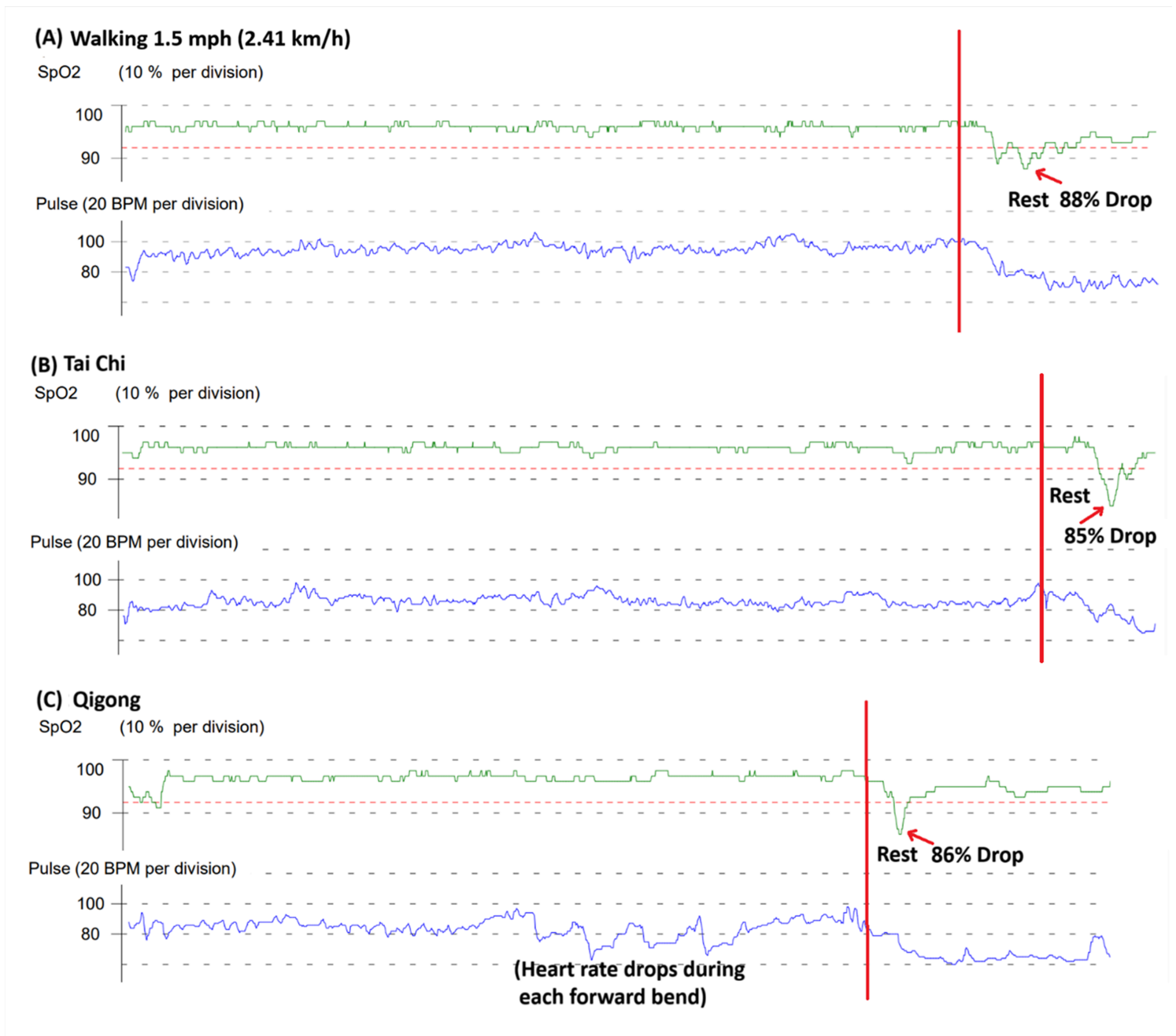


Figure 2

Sample measurements from the older adult tai chi group during and following (A) 20 minutes of walking at 1.5 mph (2.41 km/h); (B) 25 minutes of Yang style tai chi; and (C) 15 minutes of baduanjin qigong.

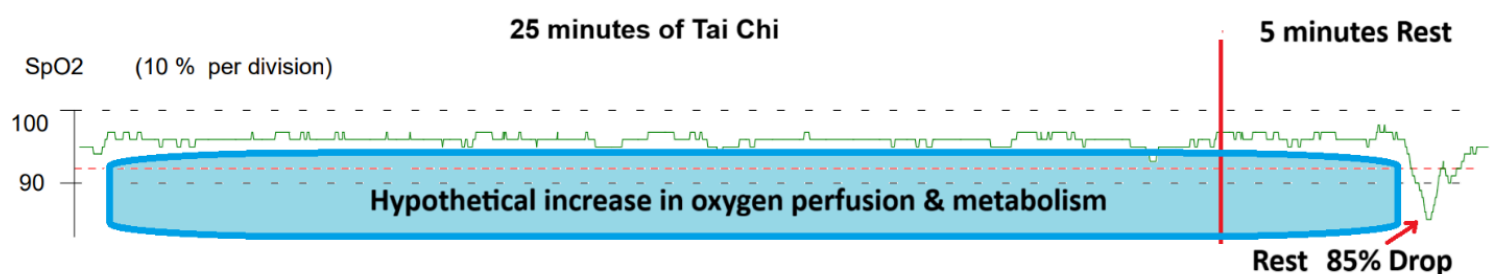


Figure 3

The metaerobic hypothesis posits that the momentary post-drop in SpO₂ may be the result of a shift from enhanced oxygen perfusion and metabolism, back to normal perfusion, cellular activity and metabolism. The above shows the momentary drop in SpO₂ to 85% following 25 minutes of tai chi. Similar drops occurred during slow walking and qigong.