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Photobiomodulation: a potential adjunctive obesity intervention

Abstract

Obesity, a largely intractable health condition with incalculable health and financial and social costs and ramifications remains an immense challenge to mitigate effectively. Multiple interventions to offset obesity, while studied and implemented for many years, have generally failed to eliminate this growing global epidemic. Alternately, interventions that can offer hope, especially to those who are physically as well as emotionally challenged, with negative outcome expectations, would appear of high significance. Studied for over 40 years, various forms of light therapy are proving to be of possible adjunctive benefit in efforts to reduce excess weight. This mini review discusses some findings regarding photobiomodulation or light therapy and whether more intense study and evaluation will improve the overall obesity burden and outlook. Extracted from current literature, it is concluded that this is a field of significant promise.

Keywords: epidemic, intervention, light therapy, obesity, photobiomodulation, therapy

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Overview

The term obesity refers to the presence of excess body fat, rather than being overweight due to the presence of high volumes of muscle mass, bone mass, or water. A rapidly growing epidemic in the United States, and in developing countries, obesity literally affects millions of citizens, including children worldwide.[1–3] In addition to obesity representing a continuously growing global epidemic, it is one associated with another global epidemic, namely the development of type 2 diabetes mellitus.[4] As well, many premature COVID-19 deaths were found to be associated with the presence of obesity.[5]

Associated with these multiple unquestionable negative health outcomes, health risks and others, such as painful chronically disabling osteoarthritis, as well as sleep disorders, which all appear to increase incrementally in magnitude and severity as an individual's obesity level increases, obesity remains a highly complex condition to intervene upon impactfully without much effort and concerted long-term behavior changes and weight control recommendation adherence strategies. In the absence of any cure for this condition with its predictable serious social and psychological ramifications, affecting virtually all ages and socioeconomic groups, and with only limited success in response to a variety of evidence based mainstream approaches, more emphasis on novel alternatives or adjunctive strategies that can be employed readily to control or mitigate one or more obesity correlates or consequences are potentially warranted.

While commonly attributed in part to excess eating and poorly devised diets, and an energy imbalance due to sedentary behavior, unlike traditional epidemics, current evidence strongly implies the obesity epidemic cannot be defeated readily solely by altering these behaviors, nor via any pill or vaccine. In addition, many who could benefit may have limited access to affordable, nutritious foods, exercise opportunities, social support, or quality health care. Very often, too, progress is slow, thus possibly demoralizing to some degree. Stigma and bias against obese persons, challenges in moving without pain, and cardiovascular, diabetic, and depression complications are additional barriers to achieving desirable tangible favorable weight reduction results.

That is, even when many barriers to food access, plus the nature of the foods available are made available, for example using low cost food carts and food stamps, there may yet be physiological as well as psychological barriers to successful weight control. For example, psychological challenges such as depression,[6] or limited ability to cope with stress, as well as the presence of chronic pain and inflammation, heart failure, plus poor sleep health may all ensure rather than mitigate weight gain, even in the midst of campaigns to reduce consumption of soda and sugar sweetened beverages, and eat more healthily, while exercising often. Indeed, one area of obesity intervention that is not well documented is the link between the physiology of obesity, and its psychological influences, including psychosocial health and quality of life, especially among older adults, who may have multiple co existing health conditions, plus the presence of chronic pain, and a reduced ability to function physically. As well, a negative cycle of health issues that may ensue due to persistent challenges in weight control, such as depression and pain that necessitates the use of psychotropic drugs and opioids and others-may be expected to do more overall harm than good if obesity is unabated. Chirricozzi et al.,[7] note that obesity, one of the most common comorbid conditions, can also interfere with antipsoriatic therapies, used to combat psoriasis, often associated with obesity, and this condition could be worsened by these drugs if efforts to regulate body weight are neglected.

In short, and without doubt. having too high a body mass index, that is not impacted by traditional mitigation approaches alone, poses immense health risks to children, adolescents, and adults of all ages, as well as untold fiscal, social and emotional costs. These include, but are not limited to various degrees of:

a. Premature disability
b. Depression
c. Anxiety
d. Social isolation
e. Comorbid health conditions
f. Chronic pain

g. COVID-19 disease

h. Various addictions

Objective

Bearing in mind the challenges as well as the imperatives to act 'now' rather than later, while attempting to offer recommendations that lead to some notable important and desired tangible short term, as well as long term results, this brief was designed to examine if more could be done in the clinical realm to offset obesity and its multiple negative outcomes via the application of various forms of phototherapy.

Methods

To achieve the aims of this review, **PUBMED**, **PubMed Central**, and **GOOGLE SCHOLAR** believed to house salient topical peer reviewed articles were specifically sought using the key terms *obesity, overweight* and *photobiomodulation [PBM], phototherapy*, or *low level laser therapy*. No limitations were placed on document type or year of publication and while some articles may not have been *examined, it was believed* that most of the salient published articles in these data bases were reviewed. The ultimate goal was to broaden awareness of the possible utility of light therapy in some form in helping extremely obese individuals to manage their weight. Eliminated though are those studies describing the use of PBM for purposes of body contouring and cellulite reduction. All pertinent data that were downloaded and carefully scanned and found relevant are presented in this overview solely in a narrative form, given the low number of well controlled studies on this topic. Phototherapy, lower level laser therapy, also now termed photobiomodulation therapy [PBMT] topics selected were not differentiated into subcategories as it has been found that the terms are basically used interchangeably, although PMB is the current term largely employed. Light therapy was selected for review because it has been observed to provide a safe non thermal non invasive means of possibly reducing several associated health correlates thought to foster obesity and its highly predictable negative impact on physical psychosocial, and behavioral health.

Results

In addition to the aforementioned points concerning obesity reiterated in numerous articles for more than 20 years [with more than 34,000 in 2021 already published in the first 8 months on **PUBMED**], a small number of current articles have emerged that highlight the potential benefits of applying various forms of sunlight, PBM, low level laser light, or bright light phototherapy to reduce the degree of prevailing obesity in various models via different mechanisms, including having a consistently favorable impact on exercise approaches, plus various body systems that appear relevant in impacting attributes of obesity, including inflammation, joint problems and pain, sleep, depression, diabetic retinopathy, heart failure, and glucose levels.[5,8–13] As well, as well as having the capacity to promote tissue healing, and reduce inflammation, as well as sleep deficits, and pain,[14] evidence further shows benefits as far as fostering a direct loss of fat cells that appears to occur favorably and significantly.[15]

Consequently, Elnaggar[16] argued that while efforts to control obesity have frequently focused on physical activities and dietary control, the more specific and direct effect of PBMT on abdominal adiposity should not be overlooked. This group, who examined 54 obese adolescents randomly assigned to one of three groups found the waist to hip ratio and degree of subcutaneous abdominal fat thickness was reduced significantly in the PBMT group compared with the control groups post-intervention. Indeed, as noted by Danilenko et al.,[17] applications of morning bright light treatment were observed to effectively reduce body fat and appetite in overweight women and may be useful therefore, to include in weight control programs.

In other related work, Liebert et al.,[18] who chose to review the dual effects of microbiome and PBM on human health, a study based on the observation that PBM can impact tissue structure and function as well as relieve pain and inflammation, showed that that PBM [red and NIR light] delivered to the abdomen in mice, can alter the gut microbiome in a potentially beneficial way. This has also now been demonstrated in human subjects. This was also supported by Bicknell et al.[19]

Guo et al.,[20] also imply that as a result of its ability to improve systemic blood glucose and insulin resistance in diet-induced diabetes, PBM applications could potentially be harnessed to reduce obesity. This group specifically found that eight-weeks of daily PBM, ameliorated diet-induced weight gain, hyperlipidemia, and hyperglycemia. It also protected against diet-induced hepatic steatosis and insulin resistance. Furthermore, PBM increased AMP-activated protein kinase activation, lowered nuclear translocation of sterol regulatory element binding protein 1, decreased aberrant lipogenesis, and enhanced insulin sensitive in the livers of the mice. The findings also extended to the observations of an associated Ca^{2}+/calmodulin-dependent protein kinase β activation outcome, and all these results implied that PBM applications can yield far reaching favorable effects on tissues and systems associated with obesity onset/protection.

As per Silva et al.,[4] such findings are of immense current value, because obesity continues to represent a growing global health issue and is a health condition strongly associated with the development of type 2 diabetes. As such PBM therapy might prove to be a highly valuable non-pharmacological, non-invasive strategy that can be safely applied to improve insulin resistance and by analogy, obesity risk or presence. Moreover, PBM therapy in combination with physical exercise does appear to significantly reduce insulin resistance, as well as improving glucose tolerance, while reversing the increased area of epididymal and mesenteric adipocytes associated with obesity.

In another report, Silva et al.,[21] do show that insulin resistance is improved in high-fat fed mice who undergo photobiomodulation therapy at 630 nm. They concluded this after studying male Swiss albino mice divided into low-fat control and high-fat diet for 12 weeks and who were treated with red (630 nm) PBMT or no treatment (Sham) during weeks 9 to 12. PBMT was delivered at 31.19 J/cm2 , 60 J total dose per day for 20 days. In HFD-fed mice, PBMT improved glucose tolerance, insulin resistance and fasting hyperinsulinemia. PBMT also reduced adiposity and inflammatory infiltrate in adipose tissue. Phosphorylation of Akt in epididymal adipose tissue and rectus femoralis muscle was improved by PBMT. In epididymal fat PBMT reversed the reduced phosphorylation of AS160 and the reduced Glut4 content. In addition, PBMT reversed the alterations caused by HFD in rectus femoralis muscle on proteins involved in mitochondrial dynamics and β-oxidation. Thus, the PBMT used in the study clearly improved the insulin resistance and glucose metabolism of the high fat diet fed mice.

Hu et al.,[22] who set out to describe some clinical observations on laser acupuncture in the context of simple obesity therapy for reducing visceral postmenopausal obesity when used in combination with a low-calorie diet, found that among the 73 women and 22 men studied showed the laser acupuncture appeared to exert a therapeutic effect on simple obesity as shown by its association with a reduced body weight and body mass index.

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Other research has shown low-level laser therapy for reducing the hip, waist, and upper abdomen circumference of individuals with obesity and when applied to individuals with a BMI between 30 and 40 kg/m2 is successful[23] and may reflect the power of low level laser applications to reduce inflammatory processes associated with obesity[5,24,25] and pain.[25] It may also enhance exercise associated benefits to reduce obesity,[26–29] as well as the extent of comorbid disease associations.[26] Fleury et al.,[30] further suggest a number of obesity associated benefits could be achieved by regular exposure to safe (non-burning) levels of sunlight or UV-containing phototherapy, with effects potentially dependent on the predominance of the wavelengths of UVR administered.

Croghan et al.,[3] have proposed that the results achieved by applying laser to moderate the extent of obesity in those with high body weights may similarly depend on the frequency of the laser applications used Other factors affecting light therapy responses may be related to age, the presence of pain, the degree of inflammation, the presence and extent of any insulin resistance, overall health status, and extent and duration of the obesity state and laser light therapy schedule.

According to Gong et al.,[31] PBM therapy decreases free fatty acid generation and its release in insulin-resistant adipose cells and tissues through its effect on free radicals and photoactivation of transcriptional pathways that destroy fat cells. The application of PBMT also appears to ameliorate the presence of excess glucose in diabetic mice. Moreover, when coupled with exercise training, it also appears to promote an improvement in body composition and inflammatory processes, and possible browning adiposity processes.[27]

Avci et al.,[32] further propose that low level laser light has the potential to be used in fat and cellulite reduction efforts, as well as in efforts to improve blood lipid profiles without any significant side effects. This idea is based upon the ability of light waves to produce transient pores in adipocytes, thus allowing lipids to escape. Another possibility is that through the activation of the complement cascade, light applications may be able to induce adipose cell death with the subsequent release of lipids.

While more study is needed, this suggests that this mode of intervention is likely to be applicable in clinical practice to control obesity and related comorbidities, and has the potential to be used in fat and cellulite reduction, as well as in improvement of blood lipid profile without any significant side effects as a possible outcome of the impact of the light stimuli on the fat cell membrane and lipid contents. Alternately, a failure to offset or initiate such weight loss processes, when this is in fact possible, can predictably be expected to increase the high risk of acquiring: COVID-19 respiratory disease and others, including, a) gastrointestinal/hepatic or liver complications, b) renal or kidney failure, c) obstructive sleep apnea (periodic cessation of breathing while asleep), d) cardiac arrhythmias, e) various forms of cancer, and f) neurocognitive defects, including lapses in concentration and memory. Moreover, the risk of acquiring type 2 diabetes, dyslipidemia or abnormal lipid or lipoprotein levels, left ventricular hypertrophy, nonalcoholic steatohepatitis or inflammatory liver disease, orthopedic problems, iron deficiencies], low bone mineral density and psychosocial problems] as a result of being overweight actually begins at quite a low BMI.[33]

In short, since their early study[34] that showed preliminary evidence that the addition of bright light treatment to a 6-week moderate exercise program can alter body composition by significantly reducing body fat, many subsequent authors have indicated similar positive results in the quest to find practical safe approaches to maximize the effects of exercise, as well as to reduce obesity through other pathways. These include body weight excess and pathways associated with sleep, depression, pain, food intake, muscle soreness, fatigue, and metabolic processes.

The possible multidimensional psychological, and physical benefits are conceptualized below (Figure 1).

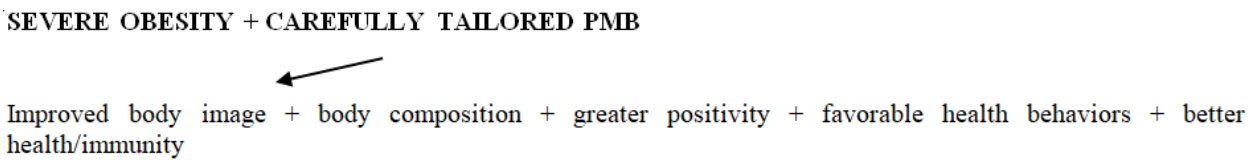

Figure 1 Schematic representation of possible benefits of carefully applied photobiomodulation approaches [PMB} to cases with intractable obesity.

Summary and discussion

Although very few articles on photobiomodulation, which encompasses a broad range of different terminologies including low level laser/light therapy, cold laser therapy and phototherapy[14] focus on its possible application for reducing obesity, when compared to the focus given to diets and exercise, as well as possible surgery, this topic as a whole is emerging as one that has not only raised some degree of optimism concerning efforts to reduce levels of obesity vicariously and safely, but one that appears to have considerable promise.

Indeed, alone or in combination with exercise and other strategies, it does appear PBM interventions can help to either initiate or help offset excess weight, as well as ameliorating inflammation and diabetes extent, especially in cases where losing weight may have previously been a 'losing' battle.[35]

As well, even though more research is needed in multiple spheres wherein its application in the wider context of weight loss should be differentiated in different age groups and health conditions, the modality is increasingly supported by a fairly wide array of in vitro and in vivo studies that all point to its apparent efficacy to safely impact one or more obesity correlates, or fat cells of adipose tissue directly and effectively. Coupled with a recommended dietary and exercise schedule, and other needed behavior change strategies, its application among those obese cases who have mobility challenges, or are too intimated to attend the gym, or both, may be especially helpful and may yet obviate the need for narcotics due to associated inflammatory mediators and persistent joint pain, plus psychotropic drug usage due to major depression and sleep challenges, plus bariatric surgery in those who are already quite ill, while increasing immunity and wound healing in the case of surgery. Its immediate use may be especially indicated in efforts to reduce COVID-19 risk and excess morbidity that continues to affect obese person incrementally and more severely than not.[36]

To this end, we would strongly encourage medical care providers and public health officials to examine the literature on PBM therapy,

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since it can be applied in the home at low cost, and if found suitable, support its careful usage where indicated.

At the same time, educating the obese child or adult and their families about PBM approaches and its possible immense value in fostering overall obesity management, and more desirable outcomes, including its aesthetic value, its possible impact on COVID-19 risk abatement,[36] and the risk of secondary heart disease, chronic pain, diabetes, and cancers, without any undue risks is strongly encouraged as well. Helping to provide what is needed, including dignity, empathy, and respect in this regard in the long-term, as opposed to pessimism and despair, also appears most promising to consider in the context of the immense stigma, stress, low self-image, reduced social mobility, and overall burden experienced by youth and adults of all ages who may feel too challenged or overwhelmed to pursue self-care and efforts to reduce weight without some degree of tangible therapeutic support and perceived benefit.

With so many obesity sufferers worldwide, and an unexpected increase in their incidence due to one or more ensuing and recent lockdown associated factors, food security, and economic challenges, and with no ready solutions to lessen this immense degree of burgeoning distress, research directed towards extending the current promising study findings sooner rather than later appears highly indicated. Examining its short-term effects as well as long-term stand-alone and complementary effects, especially as regards exercising is especially recommended. The impact of PBM parameters and treatment duration and method, of application and its impact on various degrees and manifestations of obesity and its correlates using advanced physiological outcome tools may yield further insights and salient direction to this promising body of growing research.[14] Where the therapy fails to advance weight control as a whole, both the methodology of application, as well as salient mechanisms underpinning this failure should be carefully sought as well.

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Conflicts of interest

No conflict of interest was reported by the authors.

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References

1. Seidell JC, Halberstadt J. The global burden of obesity and the challenges of prevention. *Ann Nutr Metab*. 2015;66(S2):7–12.
2. Junior AEDA, Carbinatto FM, Castro CAD, et al. Photobiomodulation decrease antioxidant enzymes activity in obese trained rats. *Bioenergetics*. 2017;6(153);2.
3. Croghan IT, Hurt RT, Schroeder DR, et al. Low–level laser therapy for weight reduction: a randomized pilot study. *Lasers Med Sci*. 2020;35(3):663–675.
4. Silva G, Ferraresi C, de Almeida RT, et al. Infrared photobiomodulation (PBM) therapy improves glucose metabolism and intracellular insulin pathway in adipose tissue of high–fat fed mice. *Lasers Med Sci*. 2018;33(3):559–571.
5. Sigman SA, Mokmeli S, Vetrici MA. Adjunct low level laser therapy (LLLT) in a morbidly obese patient with severe COVID–19 pneumonia:a case report. *Can J Respir Ther*. 2020;56:52–56.
6. Milaneschi Y, Simmons WK, van Rossum EFC, et al. Depression and obesity: evidence of shared biological mechanisms. *Mol Psychiatry*. 2019;24(1):18–33.
7. Chiricozzi A, Gisondi P, Girolomoni G. The pharmacological management of patients with comorbid psoriasis and obesity. *Expert Opin Pharmacother.* 2019;20(7):863–872.
8. Eveleens Maarse BC, Loh NY, Karpe F, et al. Associations between outdoor temperature and bright sunlight with metabolites in two population–based European cohorts. *Nutr Metab Cardiovasc Dis*. 2020;30(12):2252–2261.
9. Hamblin MR. Photobiomodulation or low–level laser therapy. *J Biophotonics*. 2016;*9*(11–12):1122.
10. Mayer JS, Hees K, Medda J, et al. Bright light therapy versus physical exercise to prevent co–morbid depression and obesity in adolescents and young adults with attention–deficit / hyperactivity disorder:study protocol for a randomized controlled trial. *Trials*. 2018;19(1):140.
11. Cheng Y, Du Y, Liu H, et al. Photobiomodulation inhibits long–term structural and functional lesions of diabetic retinopathy. *Diabetes*. 2018;67(2):291–298.
12. Ferguson AL, Kok LF, Luong JK, et al. Exposure to solar ultraviolet radiation limits diet–induced weight gain, increases liver triglycerides and prevents the early signs of cardiovascular disease in mice. *Nutr Metab Cardiovasc Dis*. 2019;29(6):633–638.
13. Capalonga L, Karsten M, Hentschke VS, et al. Light–emitting diode therapy (LEDT) improves functional capacity in rats with heart failure. *Lasers Med Sci*. 2016;31(5):937–944.
14. Serrage H, Heiskanen V, Palin WM, et al. Under the spotlight: mechanisms of photobiomodulation concentrating on blue and green light. *Photochem Photobiol Sci*. 2019;18(8):1877–1909.
15. Caruso–Davis MK, Guillot TS, Podichetty VK, et al. Efficacy of low–level laser therapy for body contouring and spot fat reduction. *Obes Surg*. 2011;21(6):722–729.
16. Elnaggar RK. A randomized, controlled trial on the effectiveness of photobiomodulation therapy and non–contact selective–field radiofrequency on abdominal adiposity in adolescents with obesity. *Lasers Surg Med*. 2020;52(9):873–881.
17. Dilenko KV, Mustafina SV, Pechenkina EA. Bright light for weight loss: results of a controlled crossover trial. *Obes Facts*. 2013;6(1):28–38.
18. Liebert A, Bicknell B, Johnstone DM, et al. "Photobiomics":can light, including photobiomodulation, alter the microbiome?. *Photobiomodulation, Photomed Laser Surg.* 2019;37(11),681–693.
19. Bicknell B, Liebert A, Johnstone D, et al. Photobiomodulation of the microbiome:implications for metabolic and inflammatory diseases. *Lasers Med Sci*. 2019;34(2):317–327.
20. Guo S, Gong L, Shen Q, et al. Photobiomodulation reduces hepatic lipogenesis and enhances insulin sensitivity through activation of CaMKKβ/AMPK signaling pathway. *J Photochem Photobiol B*. 2020;213:112075.
21. Silva G, Ferraresi C, de Almeida RT, et al. Insulin resistance is improved in high–fat fed mice by photobiomodulation therapy at 630 nm. *J Biophotonics*. 2020;13(3):e201960140.
22. Hu WL, Chang CH, Hung YC. Clinical observations on laser acupuncture in simple obesity therapy. *Am J Chin Med*. 2010;38(5):861–867.
23. Roche GC, Shanks S, Jackson RF, et al. Low–level laser therapy for reducing the hip, waist, and upper abdomen circumference of individuals with obesity. *Photomed Laser Surg*. 2017;35(3):142–149.
24. Yoshimura TM, Sabino CP, Ribeiro MS. Photobiomodulation reduces abdominal adipose tissue inflammatory infiltrate of diet–induced obese and hyperglycemic mice. *J Biophotonics*. 2016;9(11–12):1255–1262.

25. Ojea AR, Madi O, Neto RM, et al. Beneficial effects of applying low–level laser therapy to surgical wounds after bariatric surgery. *Photomed Laser Surg.*2016;34(11):580–584.

26. Sene–Fiorese M, Duarte FO, de Aquino Junior AE, et al. The potential of phototherapy to reduce body fat, insulin resistance and "metabolic inflexibility" related to obesity in women undergoing weight loss treatment. *Lasers Surg Med.* 2015;47(8):634–42.

27. da Silveira Campos RM, Dâmaso AR, Masquio DCL, et al. The effects of exercise training associated with low–level laser therapy on biomarkers of adipose tissue transdifferentiation in obese women. *Lasers Med Sci*. 2018;33(6):1245–1254.

28. Aquino AE Jr, Sene–Fiorese M, Paolillo FR, et al. Low–level laser therapy (LLLT) combined with swimming training improved the lipid profile in rats fed with high–fat diet. *Lasers Med Sci.* 2013;28(5):1271–1280.

29. Duarte FO, Sene–Fiorese M, de Aquino Junior AE, et al. Can low–level laser therapy (LLLT) associated with an aerobic plus resistance training change the cardiometabolic risk in obese women? A placebo–controlled clinical trial. *J Photochem Photobiol B.* 2015;153:103–110.

30. Fleury N, Feelisch M, Hart PH, et al. Sub–erythemal ultraviolet radiation reduces metabolic dysfunction in already overweight mice. *J Endocrinol.* 2017;233(1):81–92.

31. Gong L, Zou Z, Huang L, et al. Photobiomodulation therapy decreases free fatty acid generation and release in adipocytes to ameliorate insulin resistance in type 2 diabetes. *Cellular Signalling.* 2020;67;109491.

32. Avci P, Gupta A, Sadasivam M, et al. Low–level laser (light) therapy (LLLT) in skin: stimulating, healing, restoring. Semin Cutan *Med Surg.* 2013;32(1):41–52.

33. Gill T. Importance of preventing weight gain in adulthood. *Asia Pac J Clin Nutr.* 2002;11:S632–636.

34. Dunai A, Novak M, Chung SA, et al. Moderate exercise and bright light treatment in overweight and obese individuals. *Obesity* (Silver Spring). 2007;15(7):1749–1757.

35. Aquino AE Jr, Sene–Fiorese M, Castro CA, et al. Can low–level laser therapy when associated to exercise decrease adipocyte area? *J Photochem Photobiol B*. 2015;149:21–26.

36. Fernandes AB, de Lima CJ, Villaverde AGJB, et al. Photobiomodulation: shining light on COVID–19. *Photobiomodul Photomed Laser Surg*. 2020;38(7):395–397.

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