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Sanatoria revisited: sunlight and health

I Greenhalgh[1], AR Butler[2]

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Abstract

Since the 18th century tuberculosis has been a major cause of death throughout the world. It is a highly infectious disease that spreads by droplet infection and finding effective treatment to combat tuberculosis took a great deal of time. One of the first treatments to have some real success was a stay in a sanatorium. Sanatoria were homes that provided patients with good food and fresh air (and therefore sunlight). The first sanatorium to use sunlight therapy (heliotherapy) seriously was founded in Leysin, Switzerland, by Auguste Rollier. Patients built up their sun exposure gradually to prevent sunburn or skin damage. We suggest that heliotherapy was more successful in treating tuberculosis than was appreciated once chemotherapy became available. The birth of heliotherapy coincided with an increased appreciation of the association of sunlight and health among the general public. The secret of its success is the combined effects of sunlight on the skin inducing the production of nitric oxide and vitamin D. Nitric oxide is not only a messenger in the cardiovascular system and responsible for relaxation of vascular muscle but is also involved in the innate immune system. Vitamin D is responsible for immune system functions and multiple studies have found an association between tuberculosis immunity and high vitamin D levels. Therefore, it is understandable that providing tuberculosis patients with sunlight may have boosted their immune system and aided them in the fight against tuberculosis. In view of the high level of resistance to all drug regimens in some patients, perhaps it is time to revive the use of sanatoria in the fight against tuberculosis.

Correspondence to:
AR Butler
Medical School
University of St Andrews
St Andrews
Fife KY16 9AJ
UK

Email:
arb3@st-andrews.ac.uk

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Introduction

Tuberculosis (TB) has existed for a considerable time and much has been written of its history.[1–3] Genuine treatment, let alone a cure, has been possible only during the last 80 or so years. The condition, be it pulmonary TB (consumption), TB of the joints (surgical TB) or TB of the skin (lupus vulgaris), appears not to have been a major public health issue before 1750; during the previous era, Hansen's disease (leprosy) was the most prevalent infectious disease. Curiously the pathogens causing the two, *Mycobacterium tuberculosis* and *Mycobacterium leprae*, are closely related and it has been suggested[4] that the cross-immunity generated by the upsurge in TB is the cause of the disappearance of leprosy from northern Europe. What contributed so much to the rising tide of TB sufferers was migration, during the Industrial Revolution, of thousands of people from the sparsely populated countryside to the crowded slums of the burgeoning industrial cities. TB is a highly infectious disease, transmitted by aerosol droplets resulting from coughing, sneezing, speaking, singing and spitting. The infectious dose of TB is very small and so close contact with a sufferer is almost certain to result in transmission. However, people differ very greatly in their susceptibility to TB and, in spite of infection, development of symptoms may not occur. Other features of slum life, such as lack of sunlight, damp dwellings and inadequate food, greatly enhanced the incidence of full-blown TB. Factory children (orphans taken from the workhouses of the big cities) employed on ten hour shifts, working in overcrowded and insanitary conditions with too little food for a growing child, were particularly prone to TB in all its forms and many did not live into maturity. TB was also rife in other groups living in close proximity, such as those in prisons and convents. However, TB was not only a disease of poverty; many members of the upper classes succumbed and this meant the condition received more attention from doctors than it might have done had it been solely a disease of the poor.

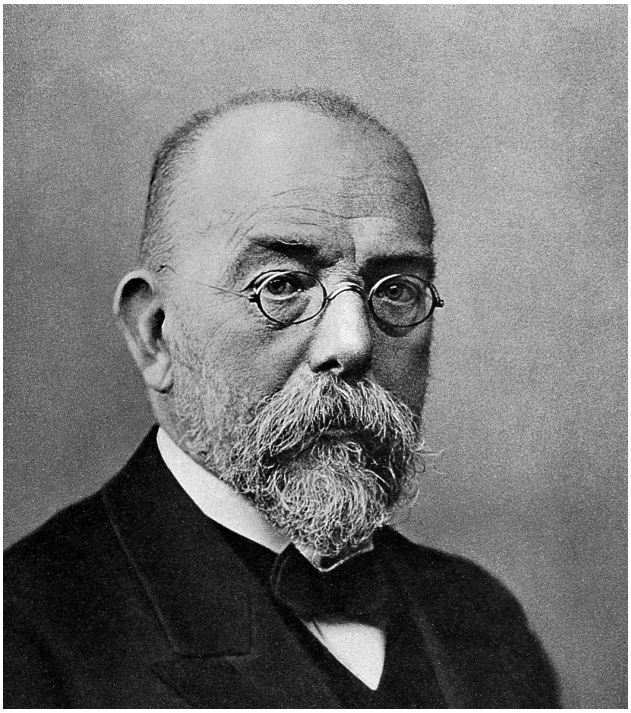
Treatment

In medieval times the only treatment was bloodletting; it is difficult to imagine anything more injurious to the life of a consumptive than loss of blood. It might be expected that the

[1]Student, MSc Neuroscience, University College London, London, UK; [2]Retired, Department of Chemistry and the Medical School, University of St Andrews, St Andrews, UK

identification of the cause of TB, *Mycobacterium tuberculosis*, by Robert Koch (Figure 1) in 1882 could have brought about a revolution and led to a cure but that was not the case. His work was controversial and many thought that TB was hereditary rather than the result of an infection, but Koch's work was soon generally accepted, particularly after it was commended by Pasteur. In 1900 Koch announced he had made a vaccine, tuberculin, which protected humans from the disease. In spite of Koch's cautious announcement, he quickly became the centre of attention and doctors all over Europe begged him for access to tuberculin to treat their favoured clients. However, it proved to be a damp squib and the success rate was far too low to make it clinically viable. Koch's reputation suffered but the German authorities managed to supress much of the adverse assessment of his scientific reputation and he remained a national hero. He was awarded a Nobel Prize in 1905.

Figure 1 Robert Koch. Wellcome Library, London



The rise of sanatoria

A more successful therapy which, although not a cure, allowed the sufferer to live more comfortably with the condition, was a move to a location with a congenial climate. This was common practice for wealthy northern Europeans even without a lung condition. Ibsen wrote some of his Norwegian dramas while living in Italy and Alfred Nobel owned villas in France and Italy, although his main residence was in Stockholm. In former times, consumptives must have felt that the milder climate of southern Europe would ease their living and there was always the hope that they would be rid of the disease as sufferers can recover spontaneously. The sanatorium movement turned this idea of an easeful and congenial climate into a successful medical therapy.

However, this simple narrative does not describe fully the origins of the sanatorium movement. When the infectious nature of TB was established it was suggested that consumptives should be separated from the rest of the community, as lepers had been, and housed in isolation hospitals. The sanatorium movement proper provided more than just isolation; residents were given rest (from complete bed rest to only mild physical activity), good food, and clean, fresh air with time in the sun. In view of the pollution common in most cities of the Victorian era, fresh air was probably as beneficial to consumptives as anything else. Sanatoria are often associated in the public mind with the curative properties of sunlight (heliotherapy) but the systematic use of sunlight as a distinct therapy was a later development. Initially sunlight was seen just as part of the fresh air treatment but the idea that sunshine is especially good for you is as old as civilisation itself. The sun was promoted as a source of material and spiritual wellbeing in most ancient civilisations, particularly the Greek and Egyptian. Peasants toiling in the fields got plenty of sunlight and it was only when they moved to the overcrowded and polluted slums that they were deprived. Deprivation led rapidly to the decline in the health of slum children and, dramatically, to the prevalence of rickets. Folklore suggested that rickets was due to poor diet and lack of sunlight but this was not confirmed until the 1920s.[5] Although it was known that it could be treated by giving cod liver oil, some schemes for rehousing slum children, such as Sunnyside Way in Mitcham, also had provision for exposure to the sun.[6]

Health spas, catering for invalids with a range of conditions, were common throughout Europe but the first for the specific treatment of TB was opened in 1863 by Hermann Brehmen in Görbesdorf in Silesia as Brehmersche Hielanstalt für Lungenkranke. Soon many more sprang up all over North America, and Europe (including Scotland), in particular in Switzerland where, it was felt, the clean, mountain air would be particularly beneficial.

In 1903, Auguste Rollier (1874–1954), a Swiss physician, opened a sanatorium in Leysin where he made sunlight the dominant therapy. It was one of the first systematic therapies of modern medicine.[7] Leysin may have been a good choice as Malthus, in his study of population growth, had noted the longevity of its inhabitants.[8] A location in the Alps was considered favourable because, despite the bitter cold in winter, there was still plenty of sunlight. In Rollier's sanatorium every patient had a private room with a balcony facing south, a design that was widely copied.[9] Details of his use of sunlight as a therapeutic agent are given in Rollier's book.[10] The sunlight therapy began, in the summer, between 5.00 and 6.00 am and ceased long before the heat of the midday sun, when blinds were drawn. To avoid sun damage to the skin (erythema) the patient was introduced to the sun over a period of 15 days; Figure 2 shows how it was controlled. On the first day the feet were exposed to the sun for 5 min, on the second day 10 min and the lower leg 5 min. Thus it continued for 15 days of gradually increasing exposure before the body was ready for a sun bath of 3 or 4 h. Rollier thus avoided the now much publicised dangers of rapid exposure of the skin to strong sunlight.[11]

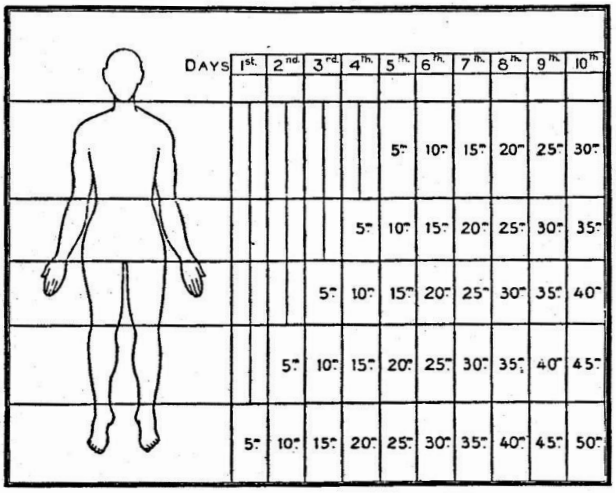
It is difficult to believe that Rollier's regimen was not influenced by the work of the Scandinavian doctor Niels Finsen (1860–1904). In his laboratory in Copenhagen he noted that UV light had bactericidal properties. To enhance this effect, he invented a special lamp using a carbon arc and fused quartz lenses to provide a reliable source of UV radiation of the relevant frequency. One of the engineers helping him in the lamp's development suffered from TB of the skin (lupus vulgaris) and Finsen shone UV light on the affected area. After 4 days treatment there was a dramatic improvement and actinotherapy was born; therapy using light but not natural sunlight. Finsen was awarded a Nobel Prize in 1903 but died a year later from Niemann-Pick disease.[12]

Rollier used his sunlight regimen to treat not consumption but surgical TB, particularly of the joints. For the period 1903–1913, he claimed over 75% success in restoring joints to normality and, even allowing for some exaggeration, this is impressive. Some of his patients were also suffering from consumption but he was very cautious in claiming success in treating this condition. Sanatoria elsewhere were occupied largely by consumptives and there are few extant records giving success rates. Because of the frequency of recrudescence, success should be claimed only after a follow-up of some years and this makes any retrospective assessment of success difficult. However, the fact that families and charities often spent much money sending relatives to sanatoria suggests that a stay there was perceived as beneficial.

As well as its use in sanatoria, during the late 19th and early 20th century there was a growing association of cleanliness and sunlight with health among the general public. In 1884 Lever Brothers (now the major international corporation Unilever) launched a highly successful soap called 'Sunlight', a brand name that has remained in some parts of the world to this day. They also built a model village for their workers named Port Sunlight. In the interwar years, nudism had a small but devoted following, particularly in Germany. Formation of outdoor youth movements like the Boy Scouts (1908) and Boys Brigade (1872) are further examples of the same phenomenon. At a more modest level, in Britain a health campaigner Dr Caleb Saleeby founded the Sunshine League in 1924. This remarkable man, an Edinburgh medical graduate, did not practise medicine but became a freelance journalist and writer with many causes. His name is of Arabic origin and means 'crusader'. He was in favour of motherhood, divorce reform, eugenics, clean air, sunlight and woman's suffrage, but against pollution, tobacco, alcohol and poor public morals. His book *Sunlight and Health* gives a plain account of the value of exposing the body to the sun's rays to a much greater extent than was normal at that time.[13]

A society with more general aims, the New Health Society, was founded in 1925 by Sir William Arbuthnot Lane. He was mainly concerned with dietary improvement for the avoidance of constipation but his Society also advocated ample sunshine and dress reform. A subcommittee concerned with the last of these eventually spawned another society:

Figure 2 Rollier's programme of gradual exposure to sunlight avoiding skin damage



the Men's Dress Reform Party. The name is a curious one as it appears not to have had political ambitions. The Party thought that the style and coverage of a man's clothing was, among other things, a barrier to the benefits of sunlight. They disliked trousers and favoured tailored shorts or the kilt. Ties and buttoned up shirts were thought restrictive. Although considered revolutionary or possibly subversive at that time, such a dress code is now commonplace. The Party thought that women of that period had much greater freedom of dress and envied them. However, the female body was often encased in restrictive foundation garments which could cause orthopaedic damage. With long skirts and high necklines, exposure to the sun was minimised and no respectable girl would have gone out in summer without a parasol.

The end of an era

Until the 1950s, a stay in a good sanatorium was the most hopeful treatment for a consumptive. Assessing the success of this retrospectively is very difficult. Certainty of a successful cure requires completion of the course, which will vary from person to person, and a follow -up of several years. The latter was rarely undertaken and people often left the sanatorium because of family or financial reasons. Dying patients were sometimes sent home to die there rather than in the sanatorium. When chemotherapy became available in the 1940s the situation changed dramatically. A course of streptomycin (and later rifampicin, para-aminosalicylic acid or isoniazid) generally secured a cure with far less expense and disruption than a stay in a sanatorium.[14]

Over the next few years, sanatoria closed, often re-opening as sports hotels or health spas. Others changed to more mainstream medical use; the Tambaran Sanatorium in South India is now a hospital for AIDS patients. A glorious sunlit episode in medical history drew to a close after 50 years of apparent success, although it had then no sound basis in medical science and little documented evidence of successful outcomes. Thomas Dormandy writes: '…the rise, dominance and fall of the TB sanatoria [is] one of the strangest episodes in the history of medicine.'[15]

After its initial stunning success, TB chemotherapy ran into difficulties. Resistance arose and recrudescence was a frequent occurrence. Even the development of multidrug regimens (MDR) by Sir John Crofton and his team in Edinburgh[16] did not prevent resistance remaining a major problem. As TB is currently rampant in many developing countries, there is continued use of a cheaper monotherapy rather than the more expensive MDR and non-compliance further exacerbates the problem. To make matters worse, resistance to many MDRs is now observed and even, in a few cases, to every drug combination (XDR). The widespread incidence of AIDS is another complicating factor. For the worldwide eradication of TB, innovations are required. The most important is the development of new drugs for which resistance has not yet occurred. There is also a need for improved surveillance of patients undergoing therapy, something developing countries find difficult to finance.

There is one further strategy that might help ease the enormous burden of TB in the developing world and it comes from the sanatorium movement. We suggest that the heliotherapy used in sanatoria was, in fact, more successful than was generally supposed once the antibiotic era had arrived. The advent of sulphonamides, penicillin and streptomycin, over a relatively short time, made all previous treatments for infectious diseases look cumbersome and archaic. However, there is now good scientific evidence that heliotherapy could have a beneficial effect on a number of diseased conditions, including consumption, for reasons that are now becoming clear.

Nitric oxide

Exposure of the skin to sunlight is known to cause release of nitric oxide from enzymatic[17] as well as non-enzymatic sources.[18,19] As nitric oxide is one of the agents responsible for arterial muscle relaxation and enhanced blood flow, it is not surprising that frequent exposure to sunlight may improve cardiovascular health.[20] There is good epidemiological evidence to support this assertion. Death from cardiovascular disease is more common among those living in the north of Scotland than among a comparable social group living in Cornwall.[21] As nitric oxide is also part of the innate immune system, it is not unreasonable to think that sunlight enhances the immune system in dealing with infectious diseases. This might explain, in part at least, why patients in a sanatorium undergoing heliotherapy made a recovery. *Mycobacterium tuberculosis* is unusual in a number of ways including its resistance to phagocytosis; indeed it can multiply within the macrophage and this could lessen the effectiveness of the innate immune system. However, nitric oxide is itself antibiotic, by binding to the iron of the iron-sulphur clusters of bacterial mitochondria[22] and it can also combine with reactive oxygen species, produced by the action sunlight as in photodynamic therapy, to give peroxynitrite, a particularly effective but short-lived antibacterial agent.[23]

Vitamin D

Sunlight on skin produces vitamin D. This is known to be responsible for the prevention of rickets but it is now clear this is not the only function of the vitamin. It has been credited with having a beneficial effect in a number of areas: immunity, autoimmunity, cardiovascular disease, cancer, fertility, pregnancy and dementia.[24] Cod liver oil, a source of vitamin D, was used in the treatment of consumption before the antibiotic era and vitamin D supplementation has been shown to enhance the immunity of those in contact with TB.[25] There is now convincing evidence of a significant association between low vitamin D levels and susceptibility to TB infection.[26] Vitamin D downregulates the production of pro-inflammatory cytokines and could protect the host from excessive tissue damage at the site of infection.[27] In a placebo-controlled study it has been shown that vitamin D accelerates resolution of inflammatory responses during TB treatment.[28] An overall estimate of the role vitamin D with respect to TB is given in an Expert Review:' Vitamin D plays a large role in the innate response against *T. tuberculosis* infection, activation and progression.'[29]

If supplementation can play a role in controlling infection then so should sunlight and it is generally thought that in vivo production of vitamin D is more effective than supplementation.[30] How much effect sunlight has depends on a number of factors including skin type, as vitamin D production is greater in paler skin on exposure to sun. In TB treatment it would appear that vitamin D is not a cure but a valuable adjunct to elimination of the pathogen by the immune system and antibiotics.[31]

Conclusion

There is still much work to be done on the effect of sunlight on skin, particularly at a cellular and molecular level, but there is now strong evidence that, given in the correct quantity, sunlight could be beneficial in the treatment of TB. This possibility goes a long way in explaining the sustained era of sanatoria. With the emergence of MDR and XDR and widespread TB infection due to the burden of HIV, it may be time to resurrect sunlight as a therapy. By a happy coincidence MDR and XDR occur most frequently in countries with an abundance of sunlight, such as South Africa. It might be profitable to put the sufferers undergoing chemotherapy in sanatoria[32] to see whether the addition of sunlight can succeed where drugs alone have failed. The success of chemotherapy at home and in a sanatorium was compared[33] in a trial in South India in the 1950s and found to be no different.

With modern understanding of the effect of sunlight on the skin, heliotherapy is worth another try. Caleb Seeleby would surely be pleased to see that nearly a century after the founding of the Sunshine League, his claims for sunlight are being taken more seriously than in his time.

References

1 Daniel TM. The history of tuberculosis. *Respir Med* 2006; 100: 1862–70.
2 Bynum H. *Spitting Blood: The History of Tuberculosis*. Oxford: OUP; 2012.
3 McMillen CW. *Discovering Tuberculosis, a Global History, 1900 to the Present*. New Haven: Yale University Press; 2015.
4 Chaussinaud R. Tuberculose et lèpre, maladies antagoniques. Eviction de la lèpre par la tuberculose. *International Journal of Leprosy* 1948; 46: 486–7.
5 Rajakumar K. Vitamin D, cod-liver oil, sunlight and rickets: a historical perspective. *Pediatrics* 2003; 112: e132–5.
6 Mitcham News and Mercury 20 November 1936.
7 Carter S. The medicalisation of sunlight in the early twentieth century. *J Hist Sociol* 2012; 25: 83–105.
8 *Dictionnaire historique de la Suisse*. Vol 7. Basel: Schwabe AG; 2001. p.424.
9 Hobday RA. Sunlight therapy and solar architecture. *Med Hist* 1997; 41: 455–72.
10 Rollier A. *Heliotherapy*. London: Hodder and Stoughton; 1923.
11 Bataille V, Winnett A, Sasieni P et al. Exposure to the sun and sunbeds and the risk of cutaneous melanoma in the UK: a case control study. *Eur J Cancer* 2004; 40: 429–35.
12 Grzybowski A, Pietrzek K. From patient to discoverer – Niels Ryberg Finsen (1860-1904) – the founder of phototherapy in dermatology. *Clinics in Dermatology* 2012; 30: 451–5.
13 Saleeby CW. Sunlight and Health. London: Nisbet & Co. Ltd.; 1923.
14 Schatz S, Bugle E, Waksman S. Streptomycin, a substance exhibiting antibiotic activity against gram-positive and gram-negative bacteria. *Exp Biol Med* 1944; 55: 66–9.
15 Dormandy T. *The White Death*. London: The Hambledon Press; 1999. p.302.
16 Crofton JW (ed. DC Kilpatrick). *Saving Lives and Preventing Misery*. Peterborough: Fastprint; 2013.
17 Weller R. Nitric oxide - a newly discovered chemical transmitter in human skin. *Br J Dermatol* 1997; 137: 655–72.
18 Paunel, AN, Dejam A, Thelen S et al. Enzyme-independent nitric oxide formation during UVA challenge of human skin: characterization, molecular sources and mechanisms. *Free Radic Biol Med* 2005; 38: 606–15.
19 Mowbray M, McLintock S, Weerakoon R et al. Enzyme-independent NO stores in human skin: quantification and influence of UV radiation. *J Invest Dermatol* 2009; 129: 834–42.
20 Weller RB. Sunlight has cardiovascular benefits independently of vitamin D. *Blood Purif* 2016: 41: 130–4.
21 Feelisch M, Kolb-Bachofen V, Liu D et al. Is sunlight good for our heart? *Eur Heart J* 2010; 31: 1041–5.
22 Liew FY, Cox FEG. Nonspecific defence mechanism: the role of nitric oxide. *Immunol Today* 1991: 12: A17–21.
23 Crow JP, Beckman JS. Pathological implications of nitric oxide, superoxide and peroxynitrite formation. *Biochem Soc Trans* 1993; 21: 330–4.
24 Pludowski P, Holick MF, Pitz, S et al. Vitamin D effects on musculosketetal health, immunity, autoimmunity, cardiovascular disease, cancer, fertility pregnancy, dementia and mortality- A review of recent evidence. *Autoimmun Rev* 2013; 12: 976–89.
25 Martineau AR, Wilkinson RJ, Wilkinson KA et al. A single dose of vitamin D significantly enhances immunity to mycobacteria. *Am J Respir Crit Care Med* 2007; 176: 208–13.
26 Facchini L, Venturini E, Galli L et al. Vitamin D and tuberculosis: a review of a hot topic. *J Chemother* 2015; 27: 128–38.
27 Harishankar M, Afsal K, Banurekha V et al. 1,25-Dihydroxy vitamin D-3 downregulates pro- inflammatory cytokine responses in pulmonary tuberculosis. *Int Immunopharmacol* 2014; 23: 148–52.
28 Coussens AK, Wilkinson RJ, Hanifa Y et al. Vitamin D accelerates resolution of inflammatory responses during tuberculosis treatment. *Proc Natl Acad Sci USA* 2012; 109: 15449–54.
29 Turnbull ER, Drobniewski FD. Vitamin D supplementation: a comprehensive review on supplementation for tuberculosis prophylaxis. *Expert Rev Respir Med* 2015: 9: 269–75.
30 Rice SA, Carpenter M, Fityan A et al. Limited exposure to ambient ultraviolet radiation and 25-hydroxyvitamin D levels: a systematic review. *Br J Dermatol* 2015; 172: 652–61.
31 Chesney RW. Vitamin D and the magic mountain: the anti-infectious role of the vitamin. *J Pediatr* 2010; 156: 698–703.
32 Dheda K, Migliori G. The global rise of extensively drug-resistant tuberculosis: is the time to bring back sanatoria overdue? *Lancet* 2012; 379: 773–5.
33 Dawson JJY, Davadatta S, Fox W et al. A 5-year study of patients with pulmonary tuberculosis in a concurrent comparison of home and sanatorium treatment for one year with isoniazid plus PAS. *Bull World Health Org* 1966; 34: 533–51.