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Sun Exposure and Anorexia Nervosa: A Potential Environmental–Biological Interaction?

Andrea Phillipou[1,2,3,4,5,6]

[1]Orygen, Melbourne, Australia | [2]Centre for Youth Mental Health, The University of Melbourne, Melbourne, Australia | [3]Orygen Specialist Program, Royal Melbourne Hospital, Melbourne, Australia | [4]Department of Psychological Sciences, Swinburne University of Technology, Melbourne, Australia | [5]Department of Mental Health, St Vincent's Hospital, Melbourne, Australia | [6]Department of Mental Health, Austin Health, Melbourne, Australia

Correspondence: Andrea Phillipou (andrea.phillipou@orygen.org.au)

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ABSTRACT

Objective: Despite first being described in 1888, anorexia nervosa continues to be the deadliest of all psychiatric illnesses. Although efforts have been made to elucidate the aetiological factors involved in the illness, little progress has been made in uncovering what contributes to the development and maintenance of anorexia nervosa. A particular shortcoming of the current literature has been the investigation of interactions between environmental and biological factors. One such interaction which has yet to receive attention in anorexia nervosa is that of sun exposure. Exposure to the sun—including levels of ultraviolet radiation (UVR) and vitamin D—in the pathogenesis of other mental illnesses has long been investigated (with lower levels of vitamin D reportedly involved in the pathogenesis of conditions such as schizophrenia, for example) but is yet to be explored in anorexia nervosa.

Conclusions: The current paper proposes a novel hypothesis for the potential contribution of reduced sun exposure in the aetiology of anorexia nervosa for future investigation, and possible mechanisms for how this relationship may operate.

Anorexia nervosa is a serious psychiatric illness characterised by significant body image disturbances which lead to dietary restriction and exceptionally low body weight (American Psychiatric Association 2022). The illness is associated with poor treatment response, the highest premature death rate of any mental illness, and long-term recovery rates of merely ~50%–60% among surviving patients (Eddy et al. 2017; Harris and Barraclough 1998; Murray et al. 2019; Steinhausen 2002). Despite first being described in the scientific literature over a century ago (Gull 1888), the disorder remains poorly understood, which has limited the development of effective treatments targeting underlying aetiological factors (Phillipou et al. 2019). Although it is well accepted that both biological and environmental factors likely contribute to anorexia nervosa—and that different combinations of factors between individuals may contribute to the illness—the specific factors involved in the disorder are yet to be elucidated (Phillipou et al. 2019, 2023). In particular, biological factors—as well as environmental factors that have biological consequences—remain unclear and have received far less research interest than pure environmental contributions, such as sociocultural influences (Phillipou et al. 2019).

Historically, sociocultural theories had attributed the stereotypical presentation of anorexia nervosa (young white females in Western societies) to sociocultural influences in Western cultures regarding the idealisation of thin bodies by young women (Garner and Garfinkel 1980). More recently, it has been recognised that anorexia nervosa affects people of any age, sex,

race and culture (Hay et al. 2023). Despite issues with anorexia nervosa being stigmatised as a 'female disorder' which may hinder identification in males (Griffiths et al. 2014), the reported incidence appears to remain the highest among teenage girls (Van Eeden et al. 2021). In relation to race and culture, limited epidemiological data outside of Western countries is thought to have contributed to the misconceptions of anorexia nervosa being a culture-bound illness specific to the West (Hay et al. 2023). However, more recent evidence suggests that the adoption of Western ideals in relation to body image may contribute to increased rates of anorexia nervosa in non-Western cultures (Eddy et al. 2007). Although the adoption of Western ideals regarding body image may contribute to anorexia nervosa, other critical environmental factors may have been overlooked. Could recent changes to the environment itself—or recent changes to lifestyle factors in response to the environment—be contributing?

The first descriptions of anorexia nervosa refer to an increased occurrence of the illness during colder months of the year (Anonymous 1888). Colder environments and climates have long been linked to a range of neurological and mental illnesses, including anorexia nervosa (Gutierrez et al. 2017). Although it has been theorised that lower ambient temperature may play a role in anorexia nervosa, little evidence exists to support this hypothesis outside of rat models of activity-based anorexia (Cerrato et al. 2012). However, ambient temperature is only one aspect of the environment and climate, and the direct effects of ultraviolet radiation (UVR) emitted from the sun have not been explored in anorexia nervosa. Although the pathophysiological mechanisms are not entirely clear, UVR emitted from the sun (or a lack thereof) may play a role in different mental illnesses.

Although both UVA and UVB radiation (the two types of UVR that reach the earth's surface) directly cause skin cancer—particularly UVB—UVR exposure also plays important roles in the body. In particular, UVB is involved in the synthesis of vitamin D in the skin (specifically, vitamin D_3) (Nair and Maseeh 2012), and is considered our best source of the vitamin as few foods are naturally rich in vitamin D (Macdonald 2013). Vitamin D aids in the absorption of calcium and phosphate, and deficiencies can result in a number of physical issues including osteoporosis (Lips and Van Schoor 2011)—a common complication in anorexia nervosa (Misra and Klibanski 2006). Low vitamin D during sensitive developmental periods (e.g., neonatally) has also been linked with a number of mental health and neurodevelopmental conditions including schizophrenia (Cui et al. 2021) and autism spectrum disorder (Lee et al. 2021); and there is substantial evidence that vitamin D supplementation and UV exposure can improve symptoms of mental health conditions such as depressive disorders (Parker et al. 2017; Veleva et al. 2018). Although vitamin D levels prior to illness onset have not been explored in anorexia nervosa, low rates have been reported in individuals with the illness (Veronese et al. 2015). Contradictorily, there is a strong inverse relationship between serum vitamin D and body fat, which is thought to be a consequence of volumetric dilution with increased body weight (Drincic et al. 2012). As such, it would be expected that individuals with anorexia nervosa (who have very low body weight) would have increased levels of vitamin D. Further, as vitamin D is primarily acquired through sun exposure, dietary disturbances present in individuals with anorexia nervosa are less likely to impact vitamin D status; though, very low body fat, poor nutritional status, and the physical consequences associated with anorexia nervosa may affect absorption of vitamin D from the sun.

Other than its important role in the generation of vitamin D in the skin, sun exposure has also been linked to improved neurocognitive function, including enhancing learning, memory, and flexible thinking styles (Zhu et al. 2018; Keller et al. 2005). Furthermore, increased UVR, independent of vitamin D, has been found to be important for the functioning of various neurotransmitter systems, including promoting the synthesis of glutamate (Zhu et al. 2018) and the turnover of serotonin (Lambert et al. 2002), as well as being involved in a large number of neuroendocrine functions (Slominski et al. 2018). As disruptions in each of these neurocognitive and neurobiological processes have been implicated in anorexia nervosa (Miles et al. 2020; Nikendei et al. 2011; Foerde and Steinglass 2017; Godlewska et al. 2017; Kaye et al. 2005; Lawson and Klibanski 2008), it lends support to the hypothesis that reduced UVR exposure may play a role in the neurobiological underpinnings of the illness.

Although anorexia nervosa may appear to be more prevalent in Western societies that often have lower levels of sun and UVR exposure than other parts of the world, Australia has one of the highest levels of UVR globally as well as the highest prevalence rate of anorexia nervosa (Vos et al. 2020). Although limitations regarding data availability in different countries contribute to these prevalence statistics, the rate of anorexia nervosa in Australia continues to stand out compared to other countries that have similar levels of data availability (Vos et al. 2020). It could be postulated that sociocultural influences specific to the Australian context—including Australia's Western culture—increases the risk of anorexia nervosa, but it would remain difficult to explain why the statistics differ so vastly to other areas with a very similar culture (and similar data availability), such as New Zealand (anorexia nervosa prevalence: Australia = 207.78/100 000 people; New Zealand = 131.54/100 000 people) (Vos et al. 2020). Although any noteworthy cultural differences between Australia and New Zealand are difficult to identify, one notable difference is the public health policy response to sun exposure between the two countries. Although extensive public health campaigns to reduce sun exposure led to a substantial cultural shift in Australia in the 1990's, such campaigns and resultant changes in sun exposure behaviours were not prominent in New Zealand. Launched in the 1980s, and extensively promoted and enforced—particularly in primary school aged children—from the 1990s, Australia's 'SunSmart' campaign (i.e., behaviours to reduce sun exposure) is widely praised as the country's most successful health campaign and is embedded in the Australian culture. As a result, the incidence of skin cancer among the 'post-SunSmart population' (i.e., younger people who grew up with SunSmart behaviours instilled in them) has decreased substantially (Staples et al. 2006). Since then, Australia has also seen a sharp increase in the incidence of anorexia nervosa compared to the rest of the world—particularly in youth (Vos et al. 2020). Could reduced sun exposure in this population be a contributing factor to the concurrent surge in anorexia nervosa cases? Although the reasons for this surge in anorexia nervosa cases likely result from a range of psychosocial factors, it is interesting to note whether reduced UVR exposure during adolescence may be a contributing factor.

The majority of mental illnesses, including anorexia nervosa, are associated with a peak onset in adoelscence (Uhlhaas et al. 2023); a time of substantial biological and social development. Across childhood and young adulthood, there are a number of 'sensitive' periods—time-limited developmental windows where environmental exposures have a pronounced effect on brain function and neural circuitry organisation. The degree of sun exposure during sensitive developmental periods is yet to be explored in anorexia nervosa but could provide a promising avenue for better understanding the neurobiological underpinnings of the illness and how interactions with neuroendocrinological changes around the time of puberty may put young females most at risk.

Although no direct evidence exists and it is of course premature to suggest that sun exposure, or a lack thereof, may contribute to the development of anorexia nervosa, it is an area worth exploring. Importantly, this paper provides an example of how broader societal and lifestyle factors may contribute to neurobiological changes—not only psychosocial changes—and highlights the need to consider how broader societal changes may be contributing to the neurobiology of mental illnesses.

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Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

References

American Psychiatric Association. 2022. *Diagnostic and Statistical Manual of Mental Disorders: DSM-5-TR*. American Psychiatric Association.

Anonymous. 1888. "The Lancet: London: Saturday, March 24, 1888." *Lancet* 131: 581–584. https://doi.org/10.1016/S0140-6736(00)48619-8.

Cerrato, M., O. Carrera, R. Vazquez, E. Echevarría, and E. Gutierrez. 2012. "Heat Makes a Difference in Activity-Based Anorexia: A Translational Approach to Treatment Development in Anorexia Nervosa." *International Journal of Eating Disorders* 45, no. 1: 26–35. https://doi.org/10.1002/eat.20884.

Cui, X., J. J. McGrath, T. H. Burne, et al. 2021. "Vitamin D and Schizophrenia: 20 Years on." *Molecular Psychiatry* 26: 2708–2720.

Drincic, A. T., L. A. Armas, E. E. Van Diest, and R. P. Heaney. 2012. "Volumetric Dilution, Rather Than Sequestration Best Explains the Low Vitamin D Status of Obesity." *Obesity* 20, no. 7: 1444–1448. https://doi.org/10.1038/oby.2011.404.

Eddy, K. T., M. Hennessey, and H. Thompson-Brenner. 2007. "Eating Pathology in East African Women: The Role of Media Exposure and Globalization." *Journal of Nervous and Mental Disease* 195: 196–202. https://doi.org/10.1097/01.nmd.0000243922.49394.7d.

Eddy, K. T., N. Tabri, J. J. Thomas, et al. 2017. "Recovery From Anorexia Nervosa and Bulimia Nervosa at 22-Year Follow-Up." *Journal of Clinical Psychiatry* 78: 17085.

Foerde, K., and J. E. Steinglass. 2017. "D Ecreased Feedback Learning in Anorexia Nervosa Persists After Weight Restoration." *International Journal of Eating Disorders* 50: 415–423.

Garner, D. M., and P. E. Garfinkel. 1980. "Socio-Cultural Factors in the Development of Anorexia Nervosa." *Psychological Medicine* 10: 647–656.

Godlewska, B. R., A. Pike, A. L. Sharpley, et al. 2017. "Brain Glutamate in Anorexia Nervosa: A Magnetic Resonance Spectroscopy Case Control Study at 7 Tesla." *Psychopharmacology* 234: 421–426.

Griffiths, S., J. M. Mond, S. B. Murray, and S. Touyz. 2014. "Young Peoples' Stigmatizing Attitudes and Beliefs About Anorexia Nervosa and Muscle Dysmorphia." *International Journal of Eating Disorders* 47: 189–195.

Gull, W. 1888. "Anorexia Nervosa." *Lancet* 131: 516–517.

Gutierrez, E., O. Carrera, R. Vazquez, et al. 2017. "The Association of Anorexia Nervosa and Climate Revisited: A Bibliometric Perspective." *International Journal of Emergency Mental Health and Human Resilience* 19: 1–7.

Harris, C., and B. Barraclough. 1998. "Excess Mortality of Mental Disorder." *British Journal of Psychiatry* 173: 11–53.

Hay, P., P. Aouad, A. Le, et al. 2023. "Epidemiology of Eating Disorders: Population, Prevalence, Disease Burden and Quality of Life Informing Public Policy in Australia–A Rapid Review." *Journal of Eating Disorders* 11: 1–46. https://doi.org/10.1186/s40337-023-00738-7.

Kaye, W. H., G. K. Frank, U. F. Bailer, et al. 2005. "Serotonin Alterations in Anorexia and Bulimia Nervosa: New Insights From Imaging Studies." *Physiology and Behavior* 85, no. 1: 73–81. https://doi.org/10.1016/j.physbeh.2005.04.013.

Keller, M. C., B. L. Fredrickson, O. Ybarra, et al. 2005. "A Warm Heart and a Clear Head: The Contingent Effects of Weather on Mood and Cognition." *Psychological Science* 16: 724–731.

Lambert, G. W., C. Reid, D. M. Kaye, G. L. Jennings, and M. D. Esler. 2002. "Effect of Sunlight and Season on Serotonin Turnover in the Brain." *Lancet* 360: 1840–1842.

Lawson, E. A., and A. Klibanski. 2008. "Endocrine Abnormalities in Anorexia Nervosa." *Nature Clinical Practice Endocrinology and Metabolism* 4: 407–414.

Lee, B. K., D. W. Eyles, C. Magnusson, et al. 2021. "Developmental Vitamin D and Autism Spectrum Disorders: Findings From the Stockholm Youth Cohort." *Molecular Psychiatry* 26: 1578–1588.

Lips, P., and N. M. Van Schoor. 2011. "The Effect of Vitamin D on Bone and Osteoporosis." *Best Practice and Research Clinical Endocrinology and Metabolism* 25: 585–591.

Macdonald, H. M. 2013. "Contributions of Sunlight and Diet to Vitamin D Status." *Calcified Tissue International* 92: 163–176.

Miles, S., I. Gnatt, A. Phillipou, and M. Nedeljkovic. 2020. "Cognitive Flexibility in Acute Anorexia Nervosa and After Recovery: A Systematic Review." *Clinical Psychology Review* 81: 101905. https://doi.org/10.1016/j.cpr.2020.101905.

Misra, M., and A. Klibanski. 2006. "Anorexia Nervosa and Osteoporosis." *Reviews in Endocrine and Metabolic Disorders* 7: 91–99.

Murray, S. B., D. S. Quintana, K. L. Loeb, S. Griffiths, and D. le Grange. 2019. "Treatment Outcomes for Anorexia Nervosa: A Systematic Review and Meta-Analysis of Randomized Controlled Trials." *Psychological Medicine* 49: 535–544.

Nair, R., and A. Maseeh. 2012. "Vitamin D: The "Sunshine" Vitamin." *Journal of Pharmacology and Pharmacotherapeutics* 3: 118–126.

Nikendei, C., C. Funiok, U. Pfüller, et al. 2011. "Memory Performance in Acute and Weight-Restored Anorexia Nervosa Patients." *Psychological Medicine* 41: 829–838.

Parker, G. B., H. Brotchie, and R. K. Graham. 2017. "Vitamin D and Depression." *Journal of Affective Disorders* 208: 56–61.

Phillipou, A., S. Croce, L. A. Abel, et al. 2023. "Investigating the Cause and Maintenance of Anorexia Nervosa–The I-CAN Study: Protocol and Open Call for Study Sites and Collaboration." *Psychiatry Research* 328: 1–2. https://doi.org/10.1016/j.psychres.2023.115468.

Phillipou, A., S. Musić, and S. L. Rossell. 2019. "A Biopsychosocial Proposal to Progress the Field of Anorexia Nervosa." *Australian and New Zealand Journal of Psychiatry* 53: 1145–1147. https://doi.org/10.1177/0004867419849487.

Slominski, A. T., M. A. Zmijewski, P. M. Plonka, J. P. Szaflarski, and R. Paus. 2018. "How UV Light Touches the Brain and Endocrine System Through Skin, and Why." *Endocrinology* 159: 1992–2007.

Staples, M. P., M. Elwood, R. C. Burton, J. L. Williams, R. Marks, and G. G. Giles. 2006. "Non-Melanoma Skin Cancer in Australia: The 2002 National Survey and Trends Since 1985." *Medical Journal of Australia* 184: 6–10.

Steinhausen, H.-C. 2002. "The Outcome of Anorexia Nervosa in the 20th Century." *American Journal of Psychiatry* 159: 1284–1293.

Uhlhaas, P. J., C. G. Davey, U. M. Mehta, et al. 2023. "Towards a Youth Mental Health Paradigm: A Perspective and Roadmap." *Molecular Psychiatry* 28: 3171–3181.

Van Eeden, A. E., D. van Hoeken, and H. W. Hoek. 2021. "Incidence, Prevalence and Mortality of Anorexia Nervosa and Bulimia Nervosa." *Current Opinion in Psychiatry* 34: 515–524.

Veleva, B. I., R. L. van Bezooijen, V. G. Chel, et al. 2018. "Effect of Ultraviolet Light on Mood, Depressive Disorders and Well-Being." *Photodermatology, Photoimmunology and Photomedicine* 34: 288–297.

Veronese, N., M. Solmi, W. Rizza, et al. 2015. "Vitamin D Status in Anorexia Nervosa: A Meta-Analysis." *International Journal of Eating Disorders* 48, no. 7: 803–813. https://doi.org/10.1002/eat.22370.

Vos, T., S. S. Lim, C. Abbafati, et al. 2020. "Global Burden of 369 Diseases and Injuries in 204 Countries and Territories, 1990–2019: A Systematic Analysis for the Global Burden of Disease Study 2019." *Lancet* 396: 1204–1222.

Zhu, H., N. Wang, L. Yao, et al. 2018. "Moderate UV Exposure Enhances Learning and Memory by Promoting a Novel Glutamate Biosynthetic Pathway in the Brain." *Cell* 173: e1717.