Melatonin may decrease risk for and aid treatment of COVID-19 and other RNA viral infections

James J DiNicolantonio, Mark McCarty, Jorge Barroso-Aranda

ABSTRACT
A recent retrospective study has provided evidence that COVID-19 infection may be notably less common in those using supplemental melatonin. It is suggested that this phenomenon may reflect the fact that, via induction of silent information regulator 1 (Sirt1), melatonin can upregulate K63 polyubiquitination of the mitochondrial antiviral-signalling protein, thereby boosting virally mediated induction of type 1 interferons. Moreover, Sirt1 may enhance the antiviral efficacy of type 1 interferons by preventing hyperacetylation of high mobility group box 1 (HMGB1), enabling its retention in the nucleus, where it promotes transcription of interferon-inducible genes. This nuclear retention of HMGB1 may also be a mediator of the anti-inflammatory effect of melatonin therapy in COVID-19—complementing melatonin’s suppression of nuclear factor kappa B activity and upregulation of nuclear factor erythroid 2-related factor 2. If these speculations are correct, a nutraceutical regimen including vitamin D, zinc and melatonin supplementation may have general utility for the prevention and treatment of RNA virus infections, such as COVID-19 and influenza.

MELATONIN SUPPLEMENTATION MAY REDUCE RISK FOR COVID-19
A retrospective analysis of 791 intubated patients with COVID-19 has found that, after adjustment for pertinent demographics and comorbidities, those treated with melatonin had a markedly lower risk for mortality (HR: 0.131, 95% CI: 0.076 to 0.223)—suggestive of a profound anti-inflammatory benefit. Such an effect might be anticipated, in light of melatonin’s ability to upregulate expression of silent information regulator 1 (Sirt1)—a deacetylase that is known to suppress the activity of the proinflammatory nuclear factor kappa B (NF-kappaB) transcription factor—and also upregulate nuclear factor erythroid 2-related factor 2 (Nrf2), which promotes the transcription of a range of antioxidant proteins. Moreover, recent epidemiology suggests that melatonin usage may reduce the risk for contracting COVID-19. A recent retrospective study, examining data from 26799 subjects in a COVID-19 registry and using propensity score matching to account for a range of covariates, found that current supplementation with melatonin was associated with a significant 28% reduction in risk for serologically detectible COVID-19 infection. Among Black Americans, this reduction in risk was a remarkable 52% (OR=0.48, 95% CI 0.31 to 0.75). The basis of this decrease in risk for COVID-19 is unclear, especially since Sirt1 activity, which melatonin promotes, is known to transcriptionally upregulate expression of ACE2—the cellular membrane receptor for COVID-19.

MELATONIN-INDUCED SIRT1 MAY BOOST VIRALLY MEDIATED MITOCHONDRIAL ANTIVIRAL-SIGNALLING (MAVS) ACTIVATION
Here is a possible explanation. Melatonin, via its membrane receptors, induces nuclear translocation of the transcription factor retinoid-related orphan receptor alpha (RORα); RORα, in turn, promotes transcription of the gene encoding the clock transcription factor brain and muscle ARNT-like 1 (Bmal1). Bmal1 upregulates transcriptionally the expression of a number of proteins, including Sirt1 and Nrf2. The MAVS protein is a key mediator in the pathway of double-strand RNA sensing that leads to activation of interferon regulatory factor 3 (IRF3) and induction of type 1 interferons; its K63 polyubiquitination via TRIM31 triggered by upstream detectors of cytosolic double-stranded RNA, such as melanoma differentiation-associated protein 5 and RIG1, enable it to form multimers that promote activating phosphorylation of IRF3, which in turn induces the type 1 interferons. But the ubiquitinase ovarian tumour ubiquitinase 3 (OTUD3) opposes this activation by deubiquitinating MAVS. The activity of OTUD3 in this regard hinges on acetylation of its Lys129; Sirt1 can remove this acetyl group, turn off OTUD3 activity and thereby upregulate viral activation of MAVS and type...
1 interferon induction. For reasons still unclear, RNA viral infection causes Sirt1 to associate with OTUD3, such that the latter is deacetylated and thereby inactivated, enabling the K63 polyubiquitination of MAVS and subsequent multimer formation, figure 1 attempts to clarify these relationships.

The net effect of Sirt1 on interferon-mediated antiviral immunity is however complicated by the fact that Sirt1 inhibits NF-kappaB’s transcriptional activity; NF-kappaB also functions downstream from MAVS to promote the induction of type 1 interferons. The cellular response to RNA viruses typically activates IRF3, NF-kappaB, ATF2 and c-Jun, all of which can bind to the promoter of the interferon-β gene and promote its transcription. However, there is evidence that activation of IRF3, in the absence of NF-kappaB, ATF2 or c-Jun activation, can drive transcription of the interferon-β gene.

Notably, in HEK293T cells infected with Sendai virus, transfection with Sirt1 more than doubles the mRNA expression of interferon-β, despite the potential inhibitory impact of Sirt1 on NF-kappaB activity. Analogously, resveratrol, a Sirt1 activator, doubles interferon-β mRNA induction in Huh7 cells infected with dengue virus.

In light of the fact that melatonin enhances Sirt1 expression via activation of Bmal1, it is pertinent that knockout of Bmal1 in mice impairs their ability to control pulmonary infections with the Sendai and influenza RNA viruses.
in the elderly, who are more prone to poor zinc status, zinc supplementation has been found to boost acquired, antigen-specific immunity, while also exerting an anti-inflammatory action; such supplementation of the elderly was associated with a marked decrease in total infections in a 12-month randomised controlled trial.44 45 More speculatively, supplementation with glucosamine or with high-absorption sources of quercetin may have potential for boosting the type-1 interferon response and reducing viral infection risk.46–49 Hence, it is not unreasonable to suggest that a supplementation programme incorporating vitamin D, zinc, melatonin and possibly additional nutraceuticals could reduce risk for and aid control of COVID-19 and a range of other viral infections.

In regard to melatonin dosing, it should be acknowledged that, when used in the context of virally induced cytokine storm, multiple daily doses may be appropriate to optimise its anti-inflammatory efficacy. Indeed, a recent case series of 10 patients with COVID-19 pneumonia noted that melatonin supplementation (36–72 mg per day given in four divided doses) was associated with a reduction in hospital stay, mortality and mechanical ventilation.50 The large retrospective study of melatonin use in intubated patients with COVID-19 cited above does not clarify the dosing schedules employed.1 Whereas, when used in a preventive mode, bedtime dosing is appropriate so as not to disrupt circadian rhythm.

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ORCID iD
James J DiNicolantonio http://orcid.org/0000-0002-7888-1528

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