# Mathematicians predict delaying school start times won't help sleep deprived teenagers

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Delaying school start times in the UK is unlikely to reduce sleep deprivation in teenagers, research from the University of Surrey and Harvard Medical School has found. The research, conducted in collaboration between mathematicians and sleep scientists, predicts that turning down the lights in the evening would be much more effective at tackling sleep deprivation.

Teenagers like to sleep late and struggle to get up in time to go to school. The commonly accepted explanation for this is that adolescents' biological brain clocks are delayed. It has been suggested that to remedy this, school start times should be delayed for older teenagers so that they are again in tune with their biological clock.

The study, which is published today in *Scientific Reports*, used a mathematical model that takes into account whether people are naturally more of a morning or evening person, the impact of natural and artificial light on the body clock and the typical time of an alarm clock, to predict the effects of delaying school start times.

The mathematical model showed that delaying school start times in the UK would not help reduce sleep deprivation. Just as when clocks go back in the autumn, most teenagers' body clocks would drift even later in response to the later start time, and in a matter of weeks they would find it just as hard to get out of bed. The results did, however, lend some support to delaying school start in the US, where many schools start as early as 7am.

The mathematical explanation has its roots in the work of the 17th century Dutch mathematician Huygens. He saw that clocks can synchronise, but it depends on both the clocks and how they influence each other. From research over the last few decades we know that body clocks typically run a little slow, so they need to be regularly 'corrected' if they are to remain in sync with the 24-hour day. Historically, this correcting signal came from our interaction with the environmental light/dark 'clock'.

The mathematical model shows that the problem for adolescents is that their light consumption behaviour interferes with the natural interaction with the environmental clock - getting up late in the morning results in adolescents keeping the lights on until later at night. Having the lights on

late delays the biological clock, making it even harder to get up in the morning. The mathematics also suggests that the biological clocks of adolescents are particularly sensitive to the effects of light consumption.

The model suggests that an alternative remedy to moving school start times in the UK is exposure to bright light during the day, turning the lights down in the evening and off at night. For very early start times, as in some US regions, any benefit gained from delaying school start times could be lost unless it is coupled with strict limits on the amount of evening artificial light consumption.

Lead author Dr Anne Skeldon said: "The power of the mathematics is that we are able to use existing knowledge about how light interacts with the biological clock to make predictions about different interventions to help reduce 'social jetlag'.

"It highlights that adolescents are not 'programmed' to wake up late and that by increasing exposure to bright light during the day, turning lights down in the evening and off at night should enable most to get up in time for work or school without too much effort and without changing school timetables."

Co-author Dr Andrew Phillips said: "The most interesting part of this analysis for me was the counter-intuitive finding that the most extreme evening types are predicted to derive the least benefit from a delay in school start times, because they tend to use evening artificial light for a longer interval of time.

"For evening types, it is critical to keep evening light levels low to derive any of the potential benefits of a delay in morning alarm times, otherwise their bed time is very prone to shifting later. Understanding these individual differences, and how they are influenced by light consumption, is necessary to maximize the effects of any policy

change."

Co-author Prof Derk-Jan Dijk said: "Just as mathematical models are used to predict climate change, they can now be used to predict how changing our light environment will influence our biological rhythms.

"It shows that modern lifestyles make it hard for body clocks to stay on 24 hours, which shifts our rhythm of sleepiness and alertness to later times - meaning we are sleepy until late in the morning and remain alert until later in the evening.

"As a result, during the working week our alarm clocks go off before the body clock naturally wakes us up. We then get insufficient sleep during the week and compensate for it during the weekend. Such patterns of insufficient and irregular sleep have been associated with various health problems and have been termed 'social jet lag'."

The mathematical understanding of biological clocks suggests that adolescents are particularly sensitive to the effects of light consumption. However, the model can be applied to other age-groups as well. It can be used to design new interventions not only for sleepy teenagers but also for adults who suffer from delayed sleep phase disorders or people who are not synchronised to the 24-hour day at all.

The research draws attention to light, light consumption and darkness as important environmental and behavioural factors influencing health. This has implications for how we design the light environment at work and at home in our modern light-polluted societies.

**More information:** Anne C. Skeldon et al, The effects of self-selected light-dark cycles and social constraints on human sleep and circadian timing: a modeling approach, *Scientific Reports* (2017). DOI: 10.1038/srep45158

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