

The practice of Daylight Saving Time in Canada: Review of the scientific literature and its suitability with regards to sleep and circadian rhythms

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Introduction

Daylight Saving Time (DST) is the practice of setting the clocks one hour forward from Standard Time (ST) in the spring and back again to ST in the fall. ST is typically close to solar time meaning that daylight is equally distributed before and after noon time, i.e., when the sun is at its highest point in the sky. DST was introduced in Canada a century ago (during the First World War) mainly to save energy. In recent years, many countries have questioned the practice and, in several cases, have contemplated or implemented its abolishment and/or replacement with other time practices. In Canada, some provinces are proposing to opt out of DST to either return to constant ST throughout the year or to implement permanent DST. Several National and International associations of researcher on Sleep and Biological Rhythms have produced position statements on the issue (see Appendix B). We present here our own review of available research literature including that used by other associations of researchers to formulate recommendations. Particular attention is given to the northern geographical location of Canada and its consequences on the relationship between time zones and natural light exposure.

Literature Review

A literature search was conducted using [“Daylight Saving Time” AND (“Sleep” OR “Circadian”)] as key words on all articles published in English before February 2021 across PsycINFO, PubMed, and Scopus. A total of 146 publications were retrieved with a total of 133 publications being retained after further screening for relevance. They were then categorized across topics representing the various issues studied from health to economy. Appendix A presents a complete list of references by category that were used for this review along with additional articles outside the search strategy. The next section presents an overview of the key findings by categories: sleep and biological rhythms, health, accidents and injuries, academic performance, criminal activities, daytime activities and sports, social jetlag and finally a review of reviews.

Main findings on the effects of seasonal transitions to DST by topics and implications for Canada

Sleep and biological rhythms

We found several studies on sleep and biological rhythms, with an overwhelming consensus for disruptions of sleep quantity and quality associated with the spring switch to DST, together with a negative influence on daytime functioning. Significant sleep disruptions are found in all age groups, lasting several weeks. Adolescents appear to be particularly impacted

with sleep loss and daytime sleepiness since their sleep schedule is already delayed. As a matter of fact, two large studies suggest that persons with an evening chronotype are the most affected by DST and recommend permanent ST for this reason (Allebrandt et al., 2014; Sládek et al. 2020).

Most studies do not find significant negative impacts with the return to ST in the fall. The best explanation is a return to a normal state of harmony within the circadian system. In a thorough review of the impact of DST, Meira e Cruz et al. (2019) conclude that the “impact of DST over the superchiasmatic master clock and then, over peripheral oscillators seem likely to be sufficient to cause an internal chrono-disruption leading, at least theoretically, to significant impairments of homeostasis, at the cellular level, tissue and organ levels and body/systemic level favoring disease. Accepting that science is dynamic and further clarifications are needed should not allow to neglect the potential harm that actual knowledge suggests”.

Social Jetlag

Social jetlag (SJL) is defined as a misalignment of biological time, governed by circadian clocks, and social time, governed themselves by work, school or other social schedules (Caliandro et al., 2021; Wittmann et al., 2006). It is quantified as the absolute value of the difference in the midpoint of sleep times between “weekdays” and “weekends”. Eight papers studying SJL confirm that DST induces SJL, and this phenomenon is maintained through the fall season. While later sunsets in the summer do favor SJL, there is evidence that DST exacerbates this phenomenon. As a matter of fact, it seems then that SJL does not totally disappear with ST and the Spring transition to DST disrupts its easing (Borisenkov et al., 2017).

Very few studies report on the effects of permanent DST since few countries have made such a choice. It is noteworthy to mention that the USA tried permanent DST in the winter of 1974 and rejected it in the Fall of the same year following major complaints from the population because of the late morning darkness. Borisenkov et al. (2017) also report that in Russia, which transitioned to permanent DST from March 2011 to October 2014, the phenomenon of social jetlag can persist in the winter with a greater lag than usual. They observed as well that DST exerts a negative influence on adolescents’ sleep habits, mood, and behavior, a phenomenon that can be associated to the evening chronotype of adolescents.

Health

Cardiac Health

All the papers on acute myocardial infarction (AMI) mention higher risks of incidents at both the Spring and Fall time changes but most incidences occur during the Spring transition to DST. In a recent review, Manfredini et al. (2018) report that the available evidence suggests the existence of an association between DST and a modest increase of occurrence of AMI, especially in the first week after the Spring shift. Some studies observe gender differences in occurrences and/or other risk factors; it is generally agreed that more studies are needed to clarify their respective contribution.

Mental Health

These studies look at DST transitions in relation to mental and behavioral health in general or more particularly to unipolar depression, manic episodes, trauma activations, parasuicide presentations, registered suicides, psychiatric outpatient contacts and inpatient admissions. DST is not found to influence the incidence of the above, except for a study by Hansen et al. (2017). These authors report a 11% increase of unipolar depressive episodes during the Fall transition from DST to ST in a Scandinavian population who experiences an important reduction of daylight in the winter while no effects are found in the Spring transition from ST to DST. On the contrary, Lindenberger (2019) found a relation between the introduction to DST in Spring and an increase in suicide rate most likely due to the loss of sleep. Finally, Kuehnle and Wunder (2016) show that individuals in both the UK and Germany experience deteriorations in life satisfaction in the first week after the spring transition, but not following the fall one. This agrees with the fact that people with an evening chronotype are more prone to affective disorders (Gao et al., 2019).

Other Health issues

Several other health issues have been examined such as seizures and spontaneous delivery with no significant impact associated with time changes. One study (Liu, 2017) found that pregnancy loss rates were comparable in Spring and Fall (15.5%, 17.1%) but that rates of loss were significantly higher in spring when DST occurred after embryo transfer (24.3%). Loss was marked in patients with a history of prior spontaneous pregnancy loss (60.5%), pointing to risk factors.

Accidents and injuries

Traffic Accidents

Most of the reviewed article do not show increases in traffic accidents with time changes. One study found that fatal alcohol-related traffic crashes increased after changes to and from DST. Huang & Levinson (2010) observe a reduction in crashes on roads during DST associated with better visibility for drivers in the evening. Smith (2016) report that the sleep deprivation attributed to the transition into DST from 2002-2011 is associated with traffic accidents resulting in over 30 deaths and at a social cost of \$275 million annually. Carey & Sarma (2017) conclude that the evidence from their review could not support or refute the assertion that a permanent shift in light from morning to evening would have a road safety benefit.

Other Accidents

Seven studies were reviewed. While three studies do not find any impact of time changes on work accidents, (for example Ferrazzi et al., 2018) four do report increases in workplace injury mostly during the spring change to DST and attribute it to sleep deprivation (for examples, Lindenberger et al., 2019; Coren, 1996; Barnes & Wagner, 2009).

Academic performance

Upon reviewing the literature on the implementation of DST, Gaski & Sagarin (2011) reported that the main finding was a surprisingly strong negative relationship between imposition

of DST and Scholastic Aptitude Test scores of local high school students. Skeldon and Dijk, (2019) suggest that permanent DST would disrupt the beneficial effects of the recent decision to delay school start times.

Criminal activities

If darkness facilitates crime (Fotios et al., 2021), then prolonged lightning upon DST should reduce it. That is what Munyo (2018) indeed observes immediately after the time change, while Doleac and Sanders (2015) reports reduced evening crime rates in the weeks following the Spring DST transition. This could be due to the fatigue experienced by potential offenders as discussed by Umbach et al. (2017). Moreover, Cho et al. (2017) observe that judges give longer sentences following the Spring transition to DST possibly because they are sleep deprived. The content of the transgressions is however not controlled for.

Daytime activities and sports

Sexton & Beatty (2014) report that individuals shift intensive activities earlier in the day upon the DST transition, in accordance with previous findings of increased energy usage. Other studies suggest that DST does not significantly increase overall sports activity, but that daylight is associated with more cycling and walking. Indeed, Zick (2014) concludes that while DST may affect the choices people make about the timing and location of their sports/recreational activities, the potential for DST to serve as a broad-based intervention that encourages greater sports/recreation participation is not supported by this analysis.

Review of Reviews

Twelve reviews pertaining to the effects of DST confirm that time changes disrupt the circadian clocks. The consensus is that it is the Spring switch to DST that disrupts the most because it implies sleep deprivation. Indeed, the disruptions that are observed with daytime functioning, injuries, and health activities are the same as those associated with sleep deprivation. Skeldon and Dijk, (2019) point out that permanent DST would weaken the beneficial effects of the recent trend to delay school start times because DST induces social jetlag.

The most recent review by Roenneberg et al. 2019 compares large populations living in DST and ST zones or on western versus eastern edges of time zones and find that the advantages of permanent ST outweigh switching to DST annually or permanently. This is relevant to Canada which has a few very large time zones harmonized through North America (<https://nrc.canada.ca/en/certifications-evaluations-standards/canadas-official-time/time-zones-daylight-saving-time>). There are two important problems arising from this harmonization that are addressed below.

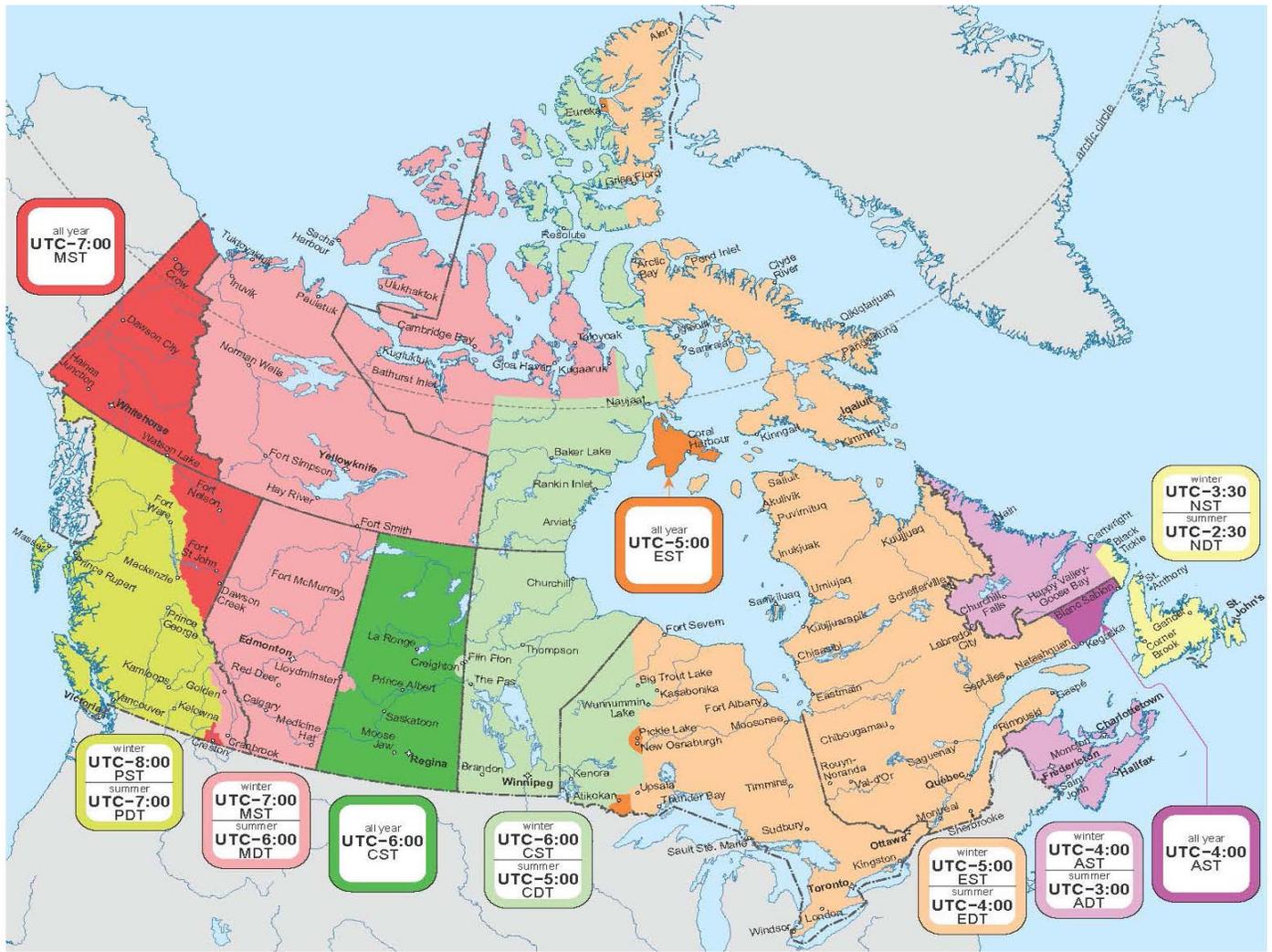
Review of Position Statements of other scientific societies

Current position statements from several research societies on sleep and biological rhythms can be found in Appendix B. These are founded on similar reviews of the literature and

include more recent reports. Also, a website keeps track of statements and results of studies that focus on DST and ST:

<https://savestandardtime.com/>

Factors pertaining to Canada’s geographical location -



(“Time in Canada”; https://en.wikipedia.org/wiki/Time_in_Canada)

A) The problem with Time Zones

Normally time zones are adjusted to solar time (noon is the time when the sun culminates) so that their center corresponds to real solar times and their borders are plus or minus 30 minutes. They were rather established on the basis of country and provinces borders and economic activity. As the figure above shows, the Canadian eastern time zone includes most of Ontario and Quebec so that Thunder Bay is at -55 minutes from solar time and Gaspé, Québec at + 44 minutes. This means that on December 21, the shortest sun exposure day of the year, sunrise in Thunder Bay, Ontario is at 8:45 under Standard Time and would be at 9:45 if Daylight Saving Time was applied all year around. In the case of Gaspé, QC the sunrise is at 7:08 and would thus

be at 8:08 under DST. Therefore, if DST would be applied year-round, Thunder Bay would be seriously affected by a late sunrise while Gaspé would do well. That is because Thunder Bay should be in the Central Time Zone and Gaspé in the Atlantic time zone. Ottawa, Ontario being at the center of the Eastern time zone is well adjusted to ST. If permanent DST would be adopted, cities and villages located in the western edge of their time zone and with solar times above -30 minutes would be more negatively affected by getting a late sunrise and would be more susceptible to some sleep loss comparable to that of jetlag since social/work activities and exposure to light would be dissociated permanently (Berument, M. H., Dogan, N., & Onar, B. 2010) It is interesting to note that Saskatchewan, which maintains a “special” Central Standard Time (CST) yearlong, is situated one hour west of the real CST. This means that citizen would be seriously affected by winter DST. In fact Saskatchewan should be under the Mountain time zone.

B) The problem with latitudes and DST

Latitude, i.e., how far one is from the equator, determines the duration of sunlight exposure. For example, close to the equator, duration of daylight and darkness are equal to 12 hours each, and in ST, transition at 6am and 6pm, leaving the application of DST with little effect. Alencar et al. (2017) reported little discomfort with DST in Brazil with no disruption for circadian rhythms. Further north, in Miami, FL on December 21st, the daylight duration is 10:30 hours, whereas in Montreal, QC it is 8:40 hours. This means almost one hour less of light in the morning and in the afternoon. This leaves little flexibility for shifting time forward as in the case of DST. Indeed, with 8.5 hours of illumination, the peak time of illumination (solar time 12:00), the morning sunrise would be 7:45 (-4:15 hours) and sunset at 16:15 (+4:15). If DST would be implemented in the winter, then sunrise would be at 8:45 and sunset at 17:15. For Canada this means that all major cities would experience sunrises well after 8am and sometimes after 9am (Calgary and Edmonton). According to Statistics Canada, “on Sunday morning, Canadians sleep in almost an hour later to 7:50 a.m., compared to the average wake up time for work nights, 6:54 a.m. Overall, men and women both tend to go to bed at about the same time, (10:56 p.m. for men and 10:55 p.m. for women). Canadian children, students and workers would have to wake up during darkness and get to school and work without proper daylight exposure. This is what the northern US population experienced in the winter of 1975 (see recent reports by Beaujon in the Washingtonian and Summers at NRP All things considered in March 2022:

<https://www.washingtonian.com/2022/03/15/the-us-tried-permanent-daylight-saving-time-in-the-70s-people-hated-it/>

<https://www.npr.org/2022/03/19/1087280464/the-u-s-tried-permanent-daylight-saving-time-in-the-1970s-then-quickly-rejected->

Since the USA seem willing to try again permanent DST and negotiations will take place between Canada, the US, and Mexico, it will be important to consider the fact that southern US states are likely to prefer permanent DST as they would not be affected by morning sunrise delays. It may thus be appropriate for Canada to dissociate itself from its southern partners due to this difference.

If it is decided to keep the current practice of DST in Canadian provinces, two improvements could be envisaged. First, time changes could be brought back to April in the spring and to October in the fall. These would then be implemented closer to the Equinoxes which would be less disruptive due to the more equal durations in daylight and darkness. The second improvement would be to implement them on a Friday night instead of Saturday night giving more time to most citizens to adjust their sleep before the return to Monday's school and work activities.

Conclusions of literature review, position statements and Canada's geographical location

Our review comes to the same conclusions as other associations of researchers and clinicians in sleep and biological rhythms:

1. While both the ST to DST and DST to ST time changes are associated with disruptions, those provoked by the spring change to DST are much more important and cover circadian rhythms, sleep deprivation, health incidences (particularly well documented cardiac events), disruptions in school performances and social jetlag. As for the fall return to ST, its one-hour disruption of circadian rhythms is likely compensated by the added opportunity to recover with one hour of sleep and return to harmony between sleep-wake rhythms and natural daytime solar light exposure.
2. The ideal practice for better sleep is harmony with the internal biological clock which is best achieved with permanent ST.
3. If permanent DST is implemented, Canadian provinces will be more affected by late sunrise in the morning and sleep deprivation associated with social jetlag than more southern states.
4. As the position of the Sleep Research Society mentions, if the practice of time change is to be abandoned, it may be a good opportunity to adjust the time zones. Ideally, this would be carried out in harmony with the US and Mexico since the North American time zones cover all three countries.

Recommendations

It is recommended that Canadian Federal and Provincial authorities consult the research community before implementing changes to the current time practices. The Canadian Sleep Society should produce a position statement that covers the particularities of the Canadian situation, notably the wide time zones and its northern latitude. It should focus on the effects of time changes on sleep and the potential permanent social jetlag and sleep deprivation that would arise with a constant DST. Here is, in order of preference, the proposed course of action:

1. The return to yearlong Standard Time (ST) would be ideal and preferable with time zones respecting one-hour borders.
2. Maintain the current practice of time changes but implement it on the night from Friday to Saturday to offer an additional day to adapt before the following Monday, and in April and October instead of March and November to reduce the light exposure impacts in the morning.

3. If permanent DST is imposed on Canadian provinces, opting out should be allowed and time zones redefined.
4. In accordance with the recent statement of the AASM, it is recommended that the federal government holds hearing on the matter in the hope of avoiding conflicting provincial decisions regarding DST practice.

Appendix A.

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Appendix B.

Sample of other Position Statements

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<https://savestandardtime.com/>