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Daylight saving time and myocardial infarction: should we be worried? A review of the evidence

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Abstract. – Transitions into and out of Daylight Saving Time (DST) may disrupt circadian rhythms and lead to sleep disturbance and deprivation. A first report observed an association between DST and acute myocardial infarction (AMI), especially after the spring shift and in women. We tried to identify and evaluate the possible association between DST and AMI, using the MEDLINE, EMBASE and Google Scholar electronic database (years 2009-2016), with regards to the searching terms 'daylight saving time', 'daylight saving time' plus 'gender', and 'daylight saving time' plus 'acute myocardial infarction'. In total, 72, 10, and 6 studies were found, respectively. Overall, 6 studies, including a total of 87,994 cases, resulted to satisfy the searching request, and were included in the present analysis. All studies confirmed a higher occurrence of AMI in the spring shift, ranging from 4 to 29%, whereas only 1 study showed a higher occurrence of AMI in the autumn shift. By the way, in 5 studies providing separate analysis, the results by sex were not univocal. In fact, as for the spring shift, 2 studies did not show differences between men and women, 2 reported a higher frequency in men, and 1 in women. Regarding the autumn shift, only 1 study reported a higher occurrence of AMI in women. These results support the presence of an association between DST and a modest increase of AMI occurrence, especially for the spring shift, and with no definite gender specific differences.

Key Words:
Daylight saving time, Acute myocardial infarction, Circadian rhythms, Gender, Chronotype, Sleep deprivation.

Introduction

The purpose of Daylight Saving Time (DST), which is applied in many countries (including the United States and some countries in Europe), is to prolong the sunlight proportion of the day. Since sunlight influences the sleep/wake physiological rhythms and most of the circadian processes, DST may induce a disruption; also, adaptation to DST requires a certain amount of time[1]. Similar to jet lag, a temporary misalignment between the endogenous circadian clock and the destination time, where eastward flights (phase advance) take longer to re-entrain the circadian clock compared with westward flights (phase delay)[1], spring DST shift (phase advance) may also disrupt circadian rhythms more than autumn DST (phase delay). Transitions into and out of DST may lead to sleep disturbance and sleep deprivation, fatigue, headache, loss of attention and alertness, as well as reduced motivation. However, despite these negative effects, a series of studies showed that DST transition does not have significant negative impact on workplace injuries, occupational accidents[2,3], and traffic road accidents[4].

Some years ago, Janszky and Ljung[5] first reported an association between acute myocardial infarction (AMI) and DST, characterized by a higher incidence of AMI (incidence ratio [IR] for the first week 1.051, 95% confidence interval [CI], 1.032-1.071) and 0.985, 95% CI, 0.969-1.002, after the spring and autumn shift, respectively). The effect of DST on the incidence of AMI also showed gender differences, being more pro-

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nounced in women in the spring shift, and more pronounced in men in the autumn shift[5]. The aim of the present review was to discuss the association between DST and AMI occurrence based on the up-to-date available literature.

Acute Myocardial Infarction and Daylight Saving Time Shifts

We aimed to evaluate the possible association between DST and AMI, using the MEDLINE, EMBASE and Google Scholar electronic database (years 2009-2016), with regards to the searching terms 'daylight saving time', 'daylight saving time' plus 'gender', and 'daylight saving time' plus 'acute myocardial infarction'. Respectively, 72, 10, and 6, were found. The 6 papers dealing with DST and AMI (Table I)[6-11] were manually checked for the presence of separate reports and/or analyses of subgroups by gender. Of these studies, 4 were conducted in Europe (Sweden[6], Croatia[7], Germany[10], and Finland[11]), and 2 in the United States [8,9].

There was a total of 87,994 AMI cases, and in 5 of 6 studies women and men were included. All the 6 studies confirmed a higher (4-29%) occurrence of AMI in the spring shift, whereas only 1 study showed a higher occurrence of AMI in the autumn shift[7] (Figure 1). As for the 5 studies with analysis by gender, in the spring shift 2 studies did not find differences between men and women[8,11], 2 reported a higher frequency in men[7,10], and 1 in women[7]. Regarding the autumn shift, only 1 study reported a higher occurrence of AMI in women[7].

Although these studies differ each other, they substantially support an association between DST and the risk of AMI, reporting a higher risk after spring DST transition. Jansky et al[5] provided substantial confirmation of their previous findings, even with a limited increase in risk (0.3% to 7.5%)[6]. A small risk (overall [IR]: 1.044, 95% CI, 1.006-1.083, expected = 2687.5, observed = 2806) was confirmed, especially for women compared with men ([IR]: 1.07 *vs.* 1.02)[6]. A modest increase in the risk of AMI ([IR]: 1.12, 95% CI, 1.00-1.36), but only in the week after the spring shift, was also confirmed by Jiddou et al[8]. Such increase in risk was characterized especially by non-ST elevation infarction, whereas no differences in risk and type of infarction were reported after the autumnal shift. This study did not provide data on sub-analysis by gender, possibly due to its small size[8]. Sandhu et al[9] reported that significantly increased rates of AMI requiring percutaneous coronary intervention were recorded on Monday after the spring shift of DST. In addition, there was a decrease in the incidence of AMI on the Tuesday after the autumn DST shift. This study did not provide data on the numerical distribution or analysis of men/women[9]. Kirchberger et al[10], after adjustment for potential confounders, reported an increased AMI risk after the spring shift, in particular for the first 3 days, especially for men, but not for women. Finally, Sipila et al[11] found an increased incidence of AMI on Wednesday (spring shift) and Thursday (autumn shift), but the overall incidence in AMI during the entire week after each DST transition was not different from control weeks. Furthermore, no gender differences were found by subgroups analysis. Only Culic[7] reported a significant increase of AMI during both spring and autumn post-transitional weeks, with more pronounced effects in subjects admitted during first workdays of those weeks and, in contrast to the other findings, with a higher risk in autumn than in spring ([IR]: 1.44 *vs.* 1.29, and 95% CI, 1.09-1.49 and 1.19-1.69, respectively). Patients with AMI during the spring shift were more likely to be men, and those with AMI during the autumn shift were more likely to be women. At multivariate analysis, male gender independently contributed to the prediction of AMI during the first 4 workdays after the spring shift, and female gender during the same period of the autumnal shift[7]. Three studies provided separate analysis of possible risk factors regarding spring and autumn shift[6,7,10], and results of significant associations found are reported in Table II.

Sleep, Personal Circadian Preference, and Gender

The spring shift of DST, due to a circadian phase-advance, is associated with modest sleep deprivation and is a plausible cause for any increased risk of AMI. Previous studies involving accelerometer-based measurements showed that transition to DST may compromise the process of sleep by both depriving sleep and reducing sleep efficiency of the deprived sleep[12]. Individual circadian physical functions identify persons with early (morning) and late (evening) chronotypes. Nearly 4 decades ago Horne and Ostberg[13] presented a self-assessment Morningness-Eveningness questionnaire (MEQ), consisting of 19 items with a definite score each, identifying 5 categories: definitely evening type (59-69), moderately evening type (31-41), neither type (42-58), moderately morning type (59-69), and definitely

Table I. Review of the available studies on the association between Daylight Saving Time and acute myocardial infarction.

Authors	Country, Years	Cases (n°) M/W (n°)	DST (overall)		DST (subgroups by gender)	
			Spring	Autumn	Spring	Autumn
Janszky et al[6]	Sweden 1995-2007	3236 2035/1201	First week: 1.04 [1.00-1.08]	First week: 0.99 [0.97-1.03]	First week: M: 1.02 [0.98-1.07] W: 1.07 [1.01-1.13]	First week: M: 1.00 [0.96-1.04] W: 0.99 [0.94-1.04]
Culic[7]	Croatia 1990-1996	2412 1666/746	1.29 [1.09-1.49] Highest: Tuesday	1.44 [1.19-1.69] Highest: Monday	Multivariate: male sex 2.84 [1.09-7.35] $p = 0.03$	Multivariate: female sex 2.08 [1.02-4.24] $p = 0.04$
Jiddou et al [8]	USA 2006-2012	328 206/122	1.12 [1.00-1.36] NSTEMI: increase $p = 0.022$	0.99 [0.85-1.16] STEMI/ NSTEMI: $p = 0.56$) Highest: Sunday 1.71 [1.09-2.02] $p < 0.05$.	No differences by gender Highest: Saturday	No differences by gender
Sandhu et al[9]	USA 2010-2013	42060 not given	Monday 1.24 [1.05-1.46] $p = 0.011$	Tuesday 0.79 [0.62-0.99] $p = 0.044$	No analysis by gender	No analysis by gender
Kirchberger et al[10]	Germany 1985-2010	25499 18524/6975	First 3 days 1.10 [0.97-1.25] Monday 1.21 [0.92-1.50] 1 week 1.08 [0.92-1.50]	First 3 days 0.98 [0.86-1.12] Friday 1.24 [1.04-1.46] 1 week 1.03 [0.93-1.13]	M: first 3 days 1.16 [1.00-1.34] 1 week 1.11 [0.99-1.23] W: first 3 days 0.96 [0.74-1.24] 1 week1.00 [0.83-1.21]	M: first 3 days 1.01 [0.85-1.18] 1 week 1.04 [0.92-1.17] W: first 3 days 0.91 [0.71-1.18] 1 week 0.99 [0.81-1.20]
Sipila et al[11]	Finland 2001-2009	14459 9301/5158	Highest: Wednesday 1.16 [1.01-1.34]	Highest: Thursday 0.85 [0.74-0.97]	No differences by gender	No differences by gender

Abbreviations: M = men; W = women; DST = Daylight Saving Time; STEMI = ST elevation myocardial infarction; NSTEMI = non-ST elevation myocardial infarction.

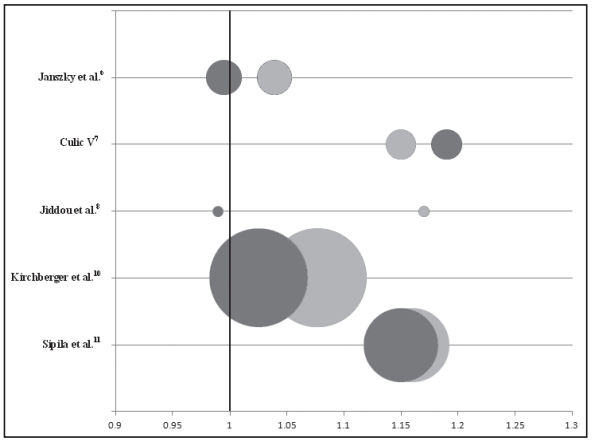

Figure 1. Graphic representation of the weighted mean ratio between number of events during spring shift (*white*) and autumn (*black*) shift. The diameter of every circle is proportional to the number of subjects analyzed in each study.

morning type (70-86) [13]. It has been reported[1] that individuals with late chronotype may have more problems in adjusting to the spring shift of DST. Even if the start of the spring shift of DST is thought to lead to the relatively inconsequential loss of 1 h of sleep on the night of the transition, there is evidence that adjustment to DST is neither immediate nor without consequence[14]. In fact, increased sleep fragmentation and sleep latency present a cumulative effect of sleep loss, at least across the following week, and perhaps longer[14]. Moreover, individuals with evening chronotype show either sleep-related issues, e.g., later bedtime and wake-up, decreased sleep quality and quantity, as well as more pronounced metabolic risk , e.g., reduced physical activity, unhealthy dietary patterns and other habits[15]. Finally, it is likely that even modest sleep deprivation and circadian misalignment may influence cardiovascular health, since even partial night sleep deprivation has been associated with increases in sympathetic tone and catecholamine levels[16]. However, none of the 6 available studies provided data on sleep (duration, quality), circadian habits, or personal chronotype. Three studies provided separate analysis of possible associations with AMI, DST and baseline characteristics, possible triggers, risk factors, and medications used[6,7,10]. It does not seem that these factors play an important role, since significant associations were found in single studies only for some of these, e.g., employment, physical activity, previous AMI, total cholesterol, and some cardiovascular medications. By the way, careful attention has to be given to female gender, since it seems to be exposed to some

Table II. Associations with baseline characteristics, possible triggers, risk factors, and medications used (significant results only) in the different studies.

Janszky et al[6]		**Spring**	
Expected vs. observed	Cholesterol: ≥ 5.2 *vs.* < 5.2 mmol/L**		
Incidence Ratios (IR)	0.960 (0.880-1.044)		
	1.099 (1.022-1.180)		
		Autumn	
	Cholesterol: ≥ 5.2 *vs.* < 5.2 mmol/L**	Calcium channel blockers: Y *vs.* N**	Statins: Y *vs.* N**
	0.919 (0.855-0.988)	0.901 (0.834-0.973)	0.917 (0.854-0.984)
	1.045 (0.981-1.112)	1.018 (0.984-1.053)	1.019 (0.984-1.055)
Culic[7]		**Spring**	
Odds Ratios (OR)	Calcium channel blockers **	Physical activity**	
	0.16 (1.09-7.35)	0.18 (0.04-0.77)	
		Autumn	
	Beta-blockers**	Physical activity**	Employment**
	0.10 (0.01-0.75) $p = 0.03$**	0.24 (0.07-0.80)	2.76 (1.34-5.68)
Kirchberger et al[10]		**Spring**	
Risk Ratios (RR)	ACE-inhibitors (3 days): Y *vs.* N*	ACE-inhibitors (1 week): Y vs. N*	
	1.489 (1.151-1.927)	1.297 (1.063-1.582)	
	1.036 (0.865-1.241)	1.059 (0.928-1.208)	
		Autumn	
	Recurrent AMI (3 days)*	Recurrent AMI (1 week)*	
	1.318 (1.029-1.691)	1.270 (1.048-1.539)	

Abbreviations: ACE = angiotensin converting enzyme; AMI = acute myocardial infarction; N = no; Y = yes. Levels of significance: *$p < 0.5$; **$p \leq 0.05$.

sex-dependent aspects of cardiovascular risk factors[17-18] and to a higher frequency of hospital multiple readmissions.[19] Finally, 3 out of the 5 studies with indication of the day of highest frequency of AMI onset, reported a higher incidence on Monday or the first days of the week[7,9,10]. It is known that Monday has been identified as a critical day for onset of acute coronary events, either AMI and Takotsubo cardiomyopathy[20-24], probably because of a series of unfavorable factors, such as stress of commencing weekly activities, higher blood pressure, and unfavorable metabolic panel[25-27]. A circadian misalignment, even if slight, could favor circadian disruption and cardiovascular consequences[28], and add another extra-risk piece to the puzzle of Monday chronorisk.

Conclusions

The available studies seem to support the presence of an association between DST and a modest increase of AMI occurrence only for the spring shift. Furthermore, in contrast to earlier findings[5], a higher risk of AMI in women is not confirmed. It is interesting that 5 out of 6 studies (83%) collected and analyzed data for both women and men, and this certain represents a point of strength when trying to draw conclusions, since it has been recently shown that only less than 44% of chronobiological studies can exhibit separate analysis by gender[29]. On one hand, since a possible disruption of biological rhythms and sleep deprivation may represent potential risk factors for AMI, an easy and inexpensive assessment of individual circadian preference (morning or evening chronotype) as well as detailed information on sleep duration and quality should be encouraged, also at a population level. If indeed a DST effect on AMI is confirmed, then certain actions can be implemented. This may include its abolition, information to the public regarding sleep pattern, and provision for increased hospital admission for AMI in the subsequent days.

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Conflict of Interest
The Authors declare that they have no conflict of interests.

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