VARIATION OF SERUM CORTISOL WITH SEASON AND DAYLIGHT SAVINGS

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ABSTRACT

Introduction
Studies on effects of season and daylight savings on cortisol are limited by small numbers and contradictory findings.

Methods
Serum cortisol tests (n=35,802) performed from 2000-2011 at Western Diagnostic Pathology were extracted. Results are reviewed by a Pathologist and history of medications or HPA-axis disease annotated to results. After exclusions, 33,362 records were performed over 12 years. The mean, median, standard deviation and 2.5th and 97.5th centiles were determined and analysed in 15 min time bands. The pattern of median cortisol over months, seasons and daylight savings and non daylight savings periods were assessed.

Results
Median cortisol increased from December nadir (319 nmol/L) to peak in July (357 nmol/L), a difference of 36 nmol/L. The warmer months (Spring / Summer) had a lower curve for cortisol than Autumn and Winter (p< 0.01) with similar cortisol by 11 am for all seasons. Median cortisol was consistently < 450 nmol/L from 7:30 am in Spring, 7:15 am Summer, 6:15 am Autumn and 8 am Winter. The overall median cortisol was 331 nmol/L in non day light saving (DST) years and 362 nmol/L in DST years, a difference of 31 nmol/L (p < 0.001). Cortisol was consistently < 450 nmol/L from 7:15 am in non-DST weeks compared to 8:15 am in DST weeks. A time shift in cortisol of ~ 45 mins with the curve for DST trial began non-DST period was observed.

Conclusion
Median cortisol varies with months, seasons and daylight savings across the day in a large population and may reflect the known dependence of the HPA rhythm on light.

BACKGROUND

Cortisol is a glucocorticoid hormone with well recognised patterns of secretion including the cortisol awakening response, a diurnal circadian rhythm of higher morning cortisol (morning acrophase) and a night time nadir. An ultradian rhythm of cortisol underpins these rhythms with discrete pulses of cortisol occurring at approximately 1 hour intervals. Most studies agree that the cortisol rhythm is relatively independent of sleep and that although restriction of sleep leads to elevated evening cortisol light is the major factor in timing of the circadian rhythm and the morning acrophase remains intact. Even in long term night shift workers the cortisol rhythm does not invert. However debate continues about the possible detrimental effects of daylight saving (Kanterm). Studies on any seasonal effects on cortisol are limited generally by small numbers and have been somewhat contradictory with some finding a high in spring (Persson), winter (Hansen) winter and fall (King) or spring and summer (Matchock).

OBJECTIVE

In view of the importance of cortisol as an endocrine hormone and the relative paucity of information about seasonal factors affecting levels, this study aimed to assess changes in serum cortisol in a large population over the period of 12 years, and assess the effect of a season and a 3 year daylight saving trial which occurred during the 12 year time frame.

RESULTS

Demographics
Of the total 33,362 records available for analysis, 64.3 % (n = 21,451) were female and 35.7 % (n=11,911) were males. The mean age of women was 44.9 years (18.9 SD) with men slightlyolder with mean age 47.5 (19.3 SD). Median cortisol (351 nmol/L) was 14 nmol/L, higher in women (2.5-97.5 centiles 25-945) than men with a median cortisol of 337 nmol/L (2.5-97.5 centiles 62-721).

Time of collection
The majority of the data (97.4%) was collected between 7:15 am and 5:30 pm with 70.2 % (23,439) being collected in the morning before 11:00 am. Cortisol was analysed in 15 min time bands where a minimum of 100 records were available from 7:15 am to 5:30 pm. (Figure 1A.) Cortisol median demonstrated a morning rise peaking at 7:45-8:00 am with the downward trend reversing briefly at 11:45 am (18 nmol/L rise) and 1:15 pm (23 nmol/L rise).

Seasonal effects
We excluded data from the months involved in daylight saving trials with 29,398 records remaining over 12 years. These were divided into seasons according to the solstice/equinox: Summer (21st Dec -20th Mar) Autumn (21st Mar – 20th Jun) Winter (21st Jun – 22nd Sept) Spring (23rd Sept - 20th Dec). Total median cortisol concentrations over the four seasons differed by 1 - 16 nmol/L, with the highest median cortisol in autumn (353 nmol/L), highest 97.5 centile in winter (818 nmol/L) and lowest median cortisol in spring (337 nmol/L). Median cortisol was determined over consecutive months for the 12 year period (Figure 3). Cortisol peaked in July (winter) with a steady decline to a nadir in December (summer) (357 ± 319 nmol/L, p=0.001).

DISCUSSION

In this large study population we found a statistically significant seasonal shift in the curve of median cortisol results, with lower curves in spring and summer compared to autumn and winter, however the difference in median cortisol between seasons overall was small (1-16 nmol/L) and not likely to be clinically significant. A larger change in median cortisol was detected over months of the year with the difference between peak median cortisol (in July winter) and lowest median cortisol (in December summer) being 36 nmol/L. We also detected a shift in the curve describing median cortisol over a daylight saving period of ~ 45 minutes.

Seasons
Many studies on seasonal effects on cortisol have been limited by small numbers. Persson et al found highest salivary cortisol in spring in 24 individuals, where as Hansen et al, found urinary free cortisol increased in winter (n=11) and Matchock et al found that in pubertal children salivary cortisol peaked in spring and summer (n=71-83). Maes et al studied 26 subjects and found yearly variation in total cortisol but did not identify a specific seasonal peak or nadir. King et al found higher salivary cortisol in winter and fall in 147 participants. We examined the patterns over both seasons and months. We found a significant pattern in median serum cortisol over the months with higher cortisol levels in colder/darker compared to warmer/lighter months and a maximum difference from July winter to December summer of 36nmol/L. Examining the seasonal data, in Autumn we captured the rise to peak cortisol and subsequent decline, but were not able to document the peak of the acrophase in other seasons suggesting this occurred earlier.

CONCLUSIONS

This study of a large population documented a shift in the curves of median cortisol over the morning in seasons and a shift in the curve of median cortisol with day light savings. The resilience of the HPA axis to external clock timing and the major role of light in the timing of the cortisol acrophase may be underlying these observed changes.

This study illustrates the crucial effects of time of sampling on assessment of serum cortisol but also highlights the relevance of season and day light saving in interpretation of cortisol results.

REFERENCES


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