Comparative Stress in Human Societies

G Ainsworth Harrison

Institute of Biological Anthropology, University of Oxford, Oxford, U.K.

The term “stress” is varyingly defined in the literature: I will use it for a disturbance in homeostasis which causes or threatens a reduction in fitness (either physical, Darwinian or both). Of course all illness can be seen as a breakdown in homeostasis, but in the case of “stress” there is no recognised morbidity even though the consequences of stress may be morbid. The merit of such a definition is that it relates to the organism and not to the environment, since any particular environment can cause stress in one person but not in another. And by definition no amount of stress can be good for you; it is sometimes claimed that small amounts can be. It may however be noted that disturbed homeostasis can be adaptive: individuals who make the response are better off than those that do not, but nonetheless the response may be associated with a loss of fitness.

Stress can be caused by physical or psychological conditions, or of course through some combination of the two. There are various measures of physical stress of which childhood growth patterns are one of the best since satisfactory growth necessitates the integration of all homeostatic processes. In this paper however I will confine my attention to psychological stress which seems to be a condition of ever increasing concern in developed and acculturating societies. There are now a large number of questionnaire tests for psychological stress, especially in the work place, but they are of little value for cross-cultural comparison. Questions of great relevance in one culture are often totally meaningless in another. For population studies adrenaline needs to be measured in urine. Blood levels are too transitory and, anyway, usually profoundly affected by the collection process. Urine levels do average out over time but are themselves subject to secondary factors which disturb relations with actual gland secretion levels. Probably the most important of these is varying kidney function and the circadian factors which influence urine flow. Many of these factors will undoubtedly be different in different societies. These problems can be largely overcome by collecting all urine excreted over 24 hours. But
comprehensive collections are very difficult to obtain and may well intrude into normal daily activities. Further whilst they are certainly the best for comparing overall levels of stress in different populations, one is often interested in what is happening at some particular time of the day. Here one uses collections over some relatively short period (which are much easier to obtain) and makes statistical adjustments for such factors as urine flow rate. In using these samples for between population comparison, however, one must ensure that the time periods are truly equivalent in diurnal experience.

With the help of a few friends and colleagues (including Prof Tai Takemoto and Dr MP Kabuto of Nagasaki) we measured adrenaline in 24-hr urine samples in a number of populations (Jenner et al., 1987). The results demonstrate a remarkable range of levels. The groups with the most traditional life-styles are the Polynesians living in the Tokalau islands. Their made adrenaline levels are only around 1/3 of those found in professional groups in England and Japanese-Americans. Clearly at least some of this difference can be related to current lifestyles and occupation since the latter two groups are significantly higher in adrenaline levels than genetically similar English and Japanese in the urban working classes. These, on the other hand, are like working class urban Nigerians suggesting that racial differences are probably of little consequence.

We attempted to determine some of the components to adrenaline variation in a group of Oxfordshire villagers (Reynolds et al., 1981; Harrison et al., 1981). Here we used time samples with collections first thing in the morning, around mid-day, and in the early evening. In addition to the time of the collected urination subjects were also asked to record the time of the previous (usually uncollected) urination, which allowed urine formation rates to be calculated. Samples were collected on a typical work day and the usual rest day. The analysis revealed a marked diurnal rhythm with levels lowest in the morning, highest in the middle of the day and somewhat less in the evening. The mid-day and evening samples were also higher in adrenaline output in men on a workday than on a rest day but the overnight samples were not so differentiated. Associations were sought between individual levels and features of lifestyle and life quality as evidenced by questionnaires. Seventeen features (from about forty) in workday males showed significant association with the mid-day or evening hormone levels, or both: the occasions that yielded the greatest number of significant associations (Reynolds et al., 1981). They were:

1) type of occupation
2) number of years in the job
3) desire to change job
4) number of years with employer
5) number of years in the type of work
6) amount of contact with co-workers
7) sense of time pressure
8) frequency of boredom
9) degree of physical tiredness
10) degree of mental tiredness
11) frequency of pub going
12) extent of self-set deadlines
13) extent of doing two tasks at once
14) sense of life challenge
15) coffee consumption
16) tea consumption
17) cigarette consumption

A number of these characteristics are themselves, of course, intercorrelates and could be reduced in a factor analysis to six major factors: one dominated by occupation, mental tiredness and a sense of being under time pressure a second by coffee and tea consumption, a third by cigarette smoking; a fourth by perceived boredom levels, a fifth by undertaking two tasks at once and a sixth by desire to change one’s job. Respectively these factors explained 2.6%, 4.3%, 3.6%, 1.6%, 2.4%, and 3.4% of the adrenaline variance at mid-day and 1.7%, 4.8%, 7.7%, 2.5%, 0.2%, and 3.9% on the evenings. The totals 17.9% and 20.8% are not large but considering the intrinsic errors to the methods are quite remarkable.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Dominant factors</th>
<th>mid-day</th>
<th>evening</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>occupation, mental tiredness, sense of being under time pressure</td>
<td>2.6%</td>
<td>1.7%</td>
</tr>
<tr>
<td>2</td>
<td>coffee and tea consumption</td>
<td>4.3%</td>
<td>4.8%</td>
</tr>
<tr>
<td>3</td>
<td>cigarette smoking</td>
<td>3.6%</td>
<td>7.7%</td>
</tr>
<tr>
<td>4</td>
<td>perceived boredom levels</td>
<td>1.6%</td>
<td>2.5%</td>
</tr>
<tr>
<td>5</td>
<td>undertaking two tasks at once</td>
<td>2.4%</td>
<td>0.2%</td>
</tr>
<tr>
<td>6</td>
<td>desire to change one's job</td>
<td>3.4%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>17.9%</td>
<td>20.8%</td>
</tr>
</tbody>
</table>
In women far less of the variance was explained 7.2% the greatest on the rest-day morning - probably because the wrong questionnaire which focussed on employment, was used but in addition to the effects of coffee, tea and cigarettes, perceptions of satisfaction with life also showed association (Harrison et al., 1981). Interestingly there was no detectable relation between adrenaline output and the occupation of employed women. If, however, women were classed by their husbands occupation rather than their own a significant association appeared. Further this was strongest on the rest-day when spouses would tend to be together and when there is no detectable relation between men and their occupation!

Two other studies of Oxford based groups are relevant to understanding the causes of adrenaline variation. One of these was of children who surprisingly have been largely ignored by physiological anthropologists. In our study the same children were examined on a day when they were at school and on a day when they were at home (Long et al., 1993). Somewhat to our initial surprise adrenaline output levels were higher on the home-day than on the school-day. The school, however, was at the primary level and hardly intellectually demanding. It was also quite traditional with well-structured activities. Every child knew what was expected. It seems likely that uncertainty and even disorder would be greater on the home-day and there was some suggestion that on the home-day having other sibs in the household increased adrenaline levels.

Competition may also be a component of stress. We examined this in the physical sport of College rowing at Oxford (Pearson et al., 1995). Two crews from the same College took part in what is known as Eights' week racing. Racing occurs on four consecutive days when boats line up on the river 1 1/2 boat lengths apart. The object of the race is to touch (bump) the boat in front before the boat behind bumps you. When a bump occurs the boats exchange places in the following day's line-up. The mean adrenaline levels of both crews was markedly lifted over the racing period on race days as compared with non-racing days. Again in both crews the highest levels were found on the first day of racing. In one crew however they progressively decreased. In the other, levels on days 2 and 3 were down but on day 4 raised again. It is probably not without significance that the first boat was itself bumped on the second day. The other boat had wins on all four days and excitement was particularly great on the fourth when a further win would achieve the ultimate accolade. There can be little doubt that competition, at least physical competition, raises adrenaline levels which seem to be responsive to the importance of the occasion. We have also found raised adrenaline levels in students undertaking examinations (Ungpakorn and Harrison, 1995).

Relationships of adrenaline with occupation are not confined to modern developed societies. In a study in American Samoa quite marked differences were found, with students displaying highest levels, followed by employed workers and with traditional villagers having lowest outputs (James et al., 1987).

The Tokelauan study (already mentioned) also revealed some heterogeneity. It was not surprising that Tokelauans who had migrated to and were living in New Zealand showed highest adrenaline levels, but there were also significant differences between groups from the two main Tokelau islands Nukonoa and Fakaufo. The former, with much greater contact with New Zealand, was the more acculturated but it was the people from Fakaufo, which is more traditional, who had the significantly higher adrenaline. This seemed highly anomalous until we were informed by social anthropologists that during the period of study and urine collection wage labour was being introduced for the first time on both islands. Apparently this caused little difficulty on Nukonoa, but generated considerable social conflict on Fakaufo where it came as a shock (Jenner et al., 1987).

The importance of social conditions in highlighted in some recent work we have undertaken with Australian Aboriginal peoples in the Kimberley region of Western Australia. The circumstances under which many of these people live is a cause of great concern: they have lost much of their traditional culture, but have not and do not wish to adopt the dominant White one. There is clear evidence, especially in the towns, of deep social unrest with alcoholism, violence and other crime widespread. Recently groups have been encouraged to return or stay in small rural communities from which alcohol is usually banned by local consent - the out-station movement. We studied three groups: one from the town of Derby, an administrative centre, and two from outstations one a former mission station at Kalumburu and the other a cattle station at Kapungarri. Both of the outstations are "dry" with no alcohol allowed. Adrenaline output levels are greater in the town than in the two outstations, but they are higher in all three situations than in an Oxford population under a comparable urine collecting regime. Prior to this analysis the Oxford population had the highest adrenaline level on record (Schmitt et al., 1995 and 1998).

As I mentioned earlier we were only able to measure cortisol in populations somewhat later because of technical difficulties with our HPLC technique. It is customary nowadays to assay cortisol in populations by...
the use of radio-immune assay of saliva. We have ourselves employed this technique but because we had to measure adrenaline in urine we felt it desirable to determine cortisol in the same samples and in a similar way. Because of the delay in getting satisfactory techniques we missed the opportunity of obtaining cortisol estimations in the Oxfordshire villagers and in the global comparison of 24 hour outputs but we did undertake separate studies of cortisol in Oxford city in combination with life-style and psychological questionnaires (Pollard et al., 1992 and 1996). Far fewer associations with individual characteristics were found than in the case of adrenaline. No work-day - rest-day differences were detectable nor any relationships with occupation. Men who reported being under stress did show raised cortisol levels and in women there was an interesting association with reported “busyness”; those who reported being usually busy having lower cortisol levels. There is also a well known raising of cortisol in those reporting psychological depression. But no evidence was obtained of a hypothesised association with the interaction between ‘demand and control’ in work situations.

The patterns of cortisol variation in the primary school children and in the College rowers is essentially the same as for adrenaline: higher levels when the children are at home than at school, and higher levels in the rowers when racing than when not. However, this latter difference was less marked than in the case of adrenaline except for the fourth day in the boat that won all its races. On this day the rowers in that boat had their highest levels of output.

The cortisol situation is also interesting in the Australian Aborigine communities. As with adrenaline, levels of output are higher in all three populations than in a comparably measured Oxford one. However, in contrast with adrenaline, significantly higher levels occur in the two outstation groups than in the town of Derby where the social problems seem particularly extreme.

What do these patterns of hormone variation mean in terms of the comparative levels of stress in human societies? It seems to me that in terms of the definition of stress I offered at the outset adrenaline output is not necessarily measuring an individual or a population level of stress: that is to say it is not necessarily reflecting a pejorative physiological state. Its patterns of association are more explicable in terms of it being a measure of psychosocial mental arousal, and mental arousal can certainly be good as well as bad. I am particularly impressed to this view from such facts as the low adrenaline output in those who report being “frequently bored”: surely a stressed state. Aboriginal life is dominated by interpersonal relations and since these are frequently individually generated in their detail rather than prescribed may well produce high levels of mental arousal. It is also no doubt significant that card gambling is rife in many Aboriginal communities today and this is likely to generate mental arousal. The studies of the Oxfordshire children and rowers would also fit this kind of interpretation: mental arousal could well be higher in young children at home in broadly unprescribed situations than in an intellectually undemanding and well structured school regime. And racing rowers are mentally very alert especially if they have a chance of winning. If this interpretation is correct than the global and occupational patterns of adrenaline variation may have little to do with comparative stress and much more with the level of intellectual activity generated by life-style. The similarity between spouses in the Oxfordshire villages takes on quite a different meaning when seen in this light rather than a stress one.

The situation with cortisol is more problematic. Although cortisol and adrenaline outputs are quite often correlated, there is little similarity in their life-style associations. The fact that cortisol, unlike adrenaline, shows no relationship with occupation or with rest days as compared with work days probably indicates that it is not reflecting mental arousal. It could however be reflecting levels of emotional arousal, which is often but by no means always associated with mental activity. Its well established connection with depressive illness supports such a view and in our studies its association with reported stress also fits. It may also be relevant that women who claim to be very busy have low outputs with reported stress also fits. It may also be relevant that women who claim to be very busy have low outputs because there is certainly a commonly held view that work is an effective remedy for emotional upset. Racing rowers are obviously emotionally excited - especially if they win.

Emotions of course may be perceived as pleasant as well unpleasant, and it would be counter-intuitive to label the former as stress even if they did raise cortisol. Perhaps however pleasant emotions tend to be usually transitory while unpleasant ones like misery can often be persistent over long periods of time. Thus if cortisol is indicative of emotional arousal and chronic arousal is

<table>
<thead>
<tr>
<th>Table 2 Stress and stress hormone (by Harrison)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stress</strong>: disruption in homeostasis which causes or threatens a reduction in physical and/or Darwinian fitness</td>
</tr>
<tr>
<td><strong>Stressed</strong>: a pejorative physiological state</td>
</tr>
<tr>
<td><strong>Adrenaline</strong>: indicative of psychosocial mental arousal (the level of intellectual activity)</td>
</tr>
<tr>
<td><strong>Cortisol</strong>: indicative of emotional arousal</td>
</tr>
<tr>
<td><strong>Chronically high levels of cortisol</strong>: chronic emotional arousal</td>
</tr>
</tbody>
</table>

* indicative of stress
usually pejorative, chronically high levels of cortisol would usually be indicative of stress and cortisol could be properly viewed as a stress hormone.

This is clearly very speculative, but if true would have some important significance for, at least, Aboriginal societies in northern Australia. Our results would mean that not only were all the three groups we studied more stressed than people in Oxford - which would not be surprising, but also that the people in the outstations, where at first sight social situations look quite good, were significantly more stressed than those in the towns where social problems obviously abound. Here one needs to reflect on the effects of a near total loss of traditional culture in most Aboriginal groups today, an almost total reliance on social benefit, and little or no opportunity for work with endless days of doing nothing which is the dominant life-style on the outstations. At least in the towns there is plenty to do, even if it includes drinking and fighting. Certainly outstation people take every opportunity to get to “town” as for example after making substantial sums of money in the gambling. It could well be that in so doing they are reducing their levels of stress.

References


Received: December 20, 2000
Accepted: January 10, 2001
Correspondence to: G. Ainsworth Harrison, Institute of Biological Anthropology, University of Oxford, 58 Banbury Road, Oxford OX2 6QS, U.K.