Anabolism and catabolism—antagonistic partners in stress and strain

by Töres Theorell, MD [1]

Theorell T. Anabolism and catabolism—antagonistic partners in stress and strain. *SJWEH Suppl.* 2008;(6):136–143.

The importance of anabolism or regeneration is related to a lack or loss of control. A psychophysiological basis for such relationships is discussed. In several empirical examples, various indicators of anabolism or regeneration have paralleled improvement or deterioration in psychosocial conditions, in particular the lack or loss of control.

Key terms control; decision latitude; heart rate variability; prolactin; regeneration; review; testosterone.

An important underlying theory behind the establishment of the demand–control model was the theory on anabolism (regeneration), which constituted an important part of the demand–control formulation during the early years (1). Surprisingly, a relatively small amount of research has been performed on this part of the theory. Most studies in stress research, including demand–control research, have been performed on "arousal" and energy mobilization, whereas the "healthy" anabolism part has been less explored. In this presentation, some examples are presented that illustrate typical findings and possible future directions for research. Particular focus is placed on observations that illustrate variations in perceived control and how such variations correlate with measures of anabolism.

Theory of anabolism or regeneration

The regeneration of tissues is a central feature of a healthy organism. Regeneration takes place during periods of recovery. Broadly speaking, our body is constructed for swings between effort and recovery. Periods of an intense release of energy should be followed by periods of recovery during which energy is built up and tissues are restored. The first psychoendocrinologist who systematically described the balance between catabolism (release of energy) and anabolism (regeneration) was Mason (2). In his studies of monkeys exposed to restraint stress, he found that catabolic hormones were stimulated and anabolic hormones were inhibited in this situation. Other authors, for instance, Kiecolt Glaser and his collaborators, have shown that the healing of wounds is inhibited during long periods of energy release, for instance, in students facing a major examination period (3). Later theoretical formulations, for example, allostasis (4), also include this concept.

The "balance between catabolism and anabolism", as a general principle, has not only been applied to the body's general endocrinology, but also to psychological processes, and it could be applied to whole societies. Societies and communities can tolerate periods of intense rush in emergency situations. However, if support and maintenance are disregarded for long periods in rushed societies, they may become sick and even collapse.

Recovery takes place during sleep. Recent years of research have shown that sleep is of profound importance to the body. During deep sleep (mainly stage 4 sleep) the regenerative activities are maximized, and this process, of course, means that a loss of deep sleep increases the vulnerability of nearly all bodily tissues to damage. For instance, skeletal muscles become fragile or more easily injured during mechanical strain after long periods (months) of unusually high levels of energy release (5), particularly if there has been insufficient time for sleep (6). However, recovery in the 7-day cycle is also important. If there has been insufficient sleep during workdays, it can be compensated for during the weekend. Recovery on a longer time dimension (eg, summer vacation) has been less studied scientifically,

1 Stockholm, Sweden.

Reprint requests to: Professor emeritus Töres Theorell, Frescati Hagväg 16A, SE-104 05 Stockholm, Sweden. [E-mail: tores.theorell@stressforskning.su.se]

but may also be important. It has been convincingly shown that a long-lasting disturbance of sleep is an important feature of the "burnout syndrome", which is characterized by somatic and mental symptoms. Interestingly disturbed short-term memory is an important characteristic of burnout, possibly due to a lack of regenerative activity in the central nervous system (7). That job strain—the combination of high demands and low decision authority—is a strong predictor of burnout during a 2-year follow-up period has been recently shown by my colleagues and I (8).

To some extent, a stimulating environment can compensate for lack of sleep and weekend recovery, at least during shorter periods. This phenomenon has been insufficiently studied, but it may be due to the ability of the regenerative systems to override the effects of energy release. For instance, hormones governing regeneration could theoretically, under conditions of joy, counteract some of the effects of the energy-releasing processes. How this possibility relates to the demand–control model is the subject of this review.

Physiology of anabolism

Release and recovery are represented by two competing systems in the body, the HPA (hypothalamo-pituitary-adrenal) axis and the HPG (hypothalamo-pituitary-gonadal) axis, respectively. The regeneration of cells in the body is, to a great extent, governed by the same hormones that stimulate reproduction, the gonadal system. Whereas the peripheral endocrine organ representing the facilitation of the release of energy is the adrenal cortex, the corresponding peripheral organ representing regeneration is accordingly the testes and the ovaries. Michelson et al (9) have described the relationship between these systems in some detail. There is competition between them from the central nervous system to the peripheral tissues, from the hypothalamus and "downwards". The central hypothalamus, governing the corticotropin-releasing factor (CRF) inhibits the corresponding gonadotropin-releasing factor (GRF) on the same level, whereas glucocorticoids (eg, cortisol), which are central to stress reactions, suppress some receptor sites in the reproductive endocrine axis, including those of testosterone and estradiol. There is also an interplay backwards since glucocorticoids suppress GRF.

The reproductive steroid hormones are not only produced in gonads, they are also produced in the adrenal cortex, and this phenomenon explains why not only men, but also women, have testosterone. Furthermore, the adrenal cortex produces precursors of several of these hormones. The commanding factors in the hypothalamus and pituitary give complicated orders to the gonads and the adrenal cortex. The system is embedded in some of the complicated interplays with cell receptors in peripheral cells and in the central nervous system. The concentration of steroids in bodily fluids, therefore, only gives us a very crude estimate of energy release and regeneration. Both cortisol and testosterone are secreted to blood, where they exist both as "free" (dissolved in the fluid) and bound to proteins. The free part of them is secreted to saliva, where fluctuations in their concentration can be studied in that these fluctuations reflect those in blood.

Several of the steroids also have a direct effect on the central nervous system—neurosteroids. Dehydroepiandrosterone sulfate (DHEAS) is one of these (see the section on paradoxical effects), but cortisol, testosterone, and estrogen are also examples of neurosteroids.

A recent study by our group (10) showed that one of the anabolic steroid hormones (DHEAS)—also the precursor of two other anabolic hormones, testosterone and estradiol—is strongly correlated with the duration of disability after the acute onset of low-back pain in women—low DHEAS indicates slow rehabilitation. This phenomenon may be a very concrete indication of the importance of this hormone. The interpretation is that women with acute low-back pain who have low DHEAS activity will have a longer disability because their muscles do not heal as rapidly as those of other women. Disturbed sleep is associated with lowered testosterone excretion in men, as has been shown by Axelsson et al (11).

Our studies have also shown that there are strong negative correlations, particularly among men, between the serum concentration of DHEAS on one hand and age on the other. There is a strongly declining DHEAS concentration with increasing age (tables 1 and 2). There are similar correlations for testosterone in men and estradiol in women in the population. The male DHEAS–age correlation is the strongest one.

The tables also show, however, that, in both men and women, there is a significant decrease in the plasma concentration of prolactin with increasing age. Prolactin is an interesting hormone from several points of view. There is some scientific support for the assumption that prolactin, which is produced and secreted by the anterior part of the pituitary, may have a role in stimulating the organism's anabolism during periods of change combined with powerlessness (12). This possibility may explain why the serum prolactin concentration increases during such periods in both men and women. However, this hormone does not have the same role as other hormones with predominantly anabolic effects since prolactin seems to serve its protective role mainly in "powerless" situations. Perhaps increased prolactin excretion arises partly as a compensation for decreasing activity in other anabolic systems.

Table 1. Correlations between age and the plasma concentration of hormones with anabolic effects—from a study of employees in a Swedish insurance company (1998), data not published elsewhere. (DHEAS = dehydroepiandrosterone sulfate, NA = not applicable)

Hormone	Women (N=169)		Men (N=128)	
	Correlation	P-value	Correlation	P-value
Prolactin	–0.20	0.004	–0.19	0.03
Estradiol	–0.25	0.001	NA	·
Testosterone	NA	·	–0.26	0.006
DHEAS	–0.26	0.0001	–0.54	0.0001

Table 2. Correlations between age and the plasma concentration of hormones with anabolic effects—from the MUSIC Norrtälje Study (10). (DHEAS = dehydroepiandrosterone sulfate)

Hormone	Women (N=140)		Men (N=101)	
	Correlation	P-value	Correlation	P-value
Prolactin	–0.10	0.25	–0.19	0.06
DHEAS	–0.17	0.04	–0.46	0.001

Empirical example from research on the possible effects of a sudden loss of control on anabolism

Most research deals with the effects that stressors have on catabolic reactions. The effects of stressors are typically measured quantitatively in terms of an increase in cortisol or catecholamine excretion. Of equal potential importance, however, is the inhibition of anabolism that occurs during periods of long-lasting adverse conditions requiring energy mobilization. An illustration of the strong social effect of a major health threat to one member of a group is a recent study of two professional symphony orchestras (13). These orchestras were followed for 2 years with observations every 6th month. The health threat occurred immediately before the first observation. One of the solo wind players fainted during a concert in front of an audience. This happened twice, and it also happened during rehearsals on two occasions. The cardiological reason for the fainting was that the player had a tendency to develop a slow heart rhythm (bradycardia) during certain conditions. In particular, the carbon dioxide retention that arose during his playing of long phrases was such a condition. Our cardiological examination showed that he needed a pacemaker, which was installed. However, the other members of the group were also severely affected, and it was found that they needed group therapy, which was provided. The situation had returned to normal after half a year. The concentration of testosterone in saliva, which is assumed to reflect the serum concentration of "free" testosterone, differed dramatically in the two orchestras at the beginning. The concentration was perfectly normal in the comparison orchestra but strikingly low in the problem orchestra, with a highly significant two-way interaction in an analysis of variance (ANOVA). The measurement of testosterone was paralleled by the administration of a questionnaire, which showed that the members of the problem orchestra reported a low amount of influence, which improved significantly after half a year.

Electrocardiography was recorded during 24 hours, and particular emphasis was placed on heart rate variability. The most interesting finding was that very low frequency power (changes in heart rate occurring twice per minute or less frequently), which is assumed to reflect the activity of the parasymphatic system and, in particular, the sensitivity of the baroreceptor system—which has an important role in the downregulation of blood pressure elevation after stress reactions—seemed to react in the same way that saliva testosterone does, with low initial levels in the problem orchestra. Low variations in the frequency power of the heart rate are likely to be affected by slow changes in the activity of the vagal nerve, a strong component of the parasympathetic nervous system. Although the changes in this parameter were less dramatic than those of saliva testosterone, they were still statistically significant with a significant two-way interaction between group and time—the mean very low frequency power developed differently in the two groups. The crisis orchestra started on a low mean level, which increased after the intervention, whereas the comparison orchestra had a more stable level.

The changes in saliva testosterone and changes in the very low frequency power were also correlated ($r=0.56$, $N=20$, $P=0.01$), and this correlation probably reflects the fact that both of these dimensions mirror the activity of the parasympathetic system to some extent. In addition, the improvement in the very low frequency power during the first 6 months was significantly correlated with the improvement in the amount of influence the orchestra members had. One conclusion may be that the crisis was followed by inhibited parasympathetic activity. Saliva testosterone and the very low frequency power in heart rate variability may represent relatively easily accessible measures of "anabolic" activity. After the solution of the problem the parasympathetic activity increased.

That the part of the heart rate variability that is particularly strongly related to parasympathetic activity, high frequency power, is associated with a high degree of decision latitude has been shown recently by Collins & Karasek (14). Similar findings, also for very low frequency power, have been shown in relation to a high level of social support in life (15). Support is an important factor in health promotion and is, of course, also an integral part of the demand–control–support model.

Anabolic indicators during regional intervention for unemployment—disappointing results

Sometimes the follow-up of psychophysiological data may be useful because the development of such data may, in fact, point in a completely unexpected direction, which could help researchers to re-interpret findings from questionnaires and interviews. Altogether 21 participants in a special regional program for unemployed persons and for persons on long-term sick leave were followed for a year with repeated observations, including indicators of anabolism (16).

The program lasted for half a year, and the hypothesis was that it would improve health and that the participants would obtain an increased ability to find new jobs. The basic underlying idea was that those who participated would perceive an improved influence over their own lives. The participants were studied before, in the midst, and immediately after the end of the program, as well as after a 6-month follow-up period. The questionnaires regarding depression, anxiety, and control over life showed no significant changes over time, whereas both DHEAS and prolactin changes over time were significant and opposite to those expected. We had expected that DHEAS would increase (as an index of regeneration or anabolism) and prolactin would decrease (corresponding to decreased powerlessness as hypothesized from other studies). Contrary to our expectations and in line with our physiological findings, the program initially triggered unrealistic expectations. During the latter half of the year, the participants were disappointed that they had had to go back to unemployment. In this case, the anabolic measures confirmed an unexpected finding.

Increasing patient control in rehabilitation—effects on prolactin release

A high plasma prolactin concentration during powerlessness in change situations may be associated with low dopamine activity in the brain during such conditions. Dopamine has been regarded as the brain's reward hormone, and, if our theory is correct, the rise in prolactin excretion during powerlessness periods may be due to a lack of reward. Such "powerless" situations could be studied in patients undergoing rehabilitation after the onset of an illness causing major limitations in daily activities. Our study was based upon patients in a day-care stroke rehabilitation center. The patients spent 3 months in the rehabilitation process. We randomized these patients into two groups with 30 in each group (17). The first group participated in a group session twice a week under the supervision of an experienced nurse. During the first phase of the group sessions, the patients helped one another formulate attainable and reasonable individual rehabilitation goals. During the later phase, they helped and supported one another. This activity was intended to give the patients an increased feeling of control. The second (control) group received usual care. The patients in both groups had all recovered from the acute phase of the stroke.

The researchers used locus of control for assessing the program's effect on the patients' feeling of mastery and sense of control in this situation. Good rehabilitation aims at an increased "internal locus of control"; in other words, the patients would have the feeling that they can take command over situations in daily life themselves. A questionnaire-based measure of locus of control was used with "external" at one end (feeling the need to get help from others in most situations in daily life) and "internal" at the other end. Recordings of an external locus of control showed that both groups started at the external end (they had suffered a stroke some weeks before). This situation remained unchanged in the control group, but there was a pronounced movement towards a more internal locus in the control group. The difference between the groups became even more pronounced during the follow-up, which lasted for 3 months after the end of the rehabilitation period. The prolactin concentration increased continuously in the usual care group. In the intervention group, on the other hand, plasma prolactin decreased in the first phase and then returned to the initial values. The development differed statistically between the two groups (figure 1).

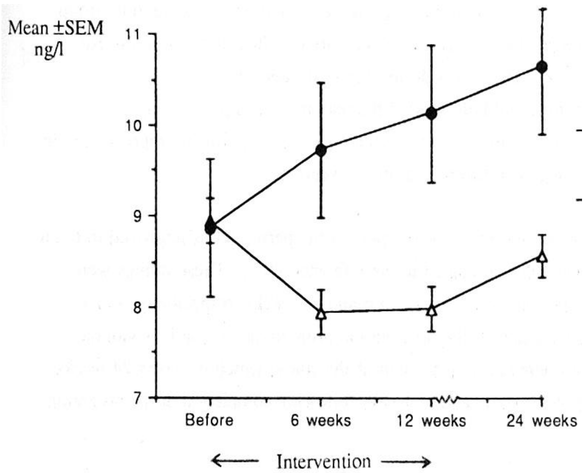

Figure 1. Serum prolactin in patients belonging to an intervention group (regular group sessions aiming at an increased feeling of control) and a control group within a stroke rehabilitation program in a day care center. (SEM = standard error of the mean, ● = reference group, Δ = intervention group)

Anabolic indicators during a psychosocial job intervention—computer-based individual stress management

Indicators of regeneration are of great interest in the evaluation of interventions. If it can be proved that regeneration is strengthened after psychosocial intervention, this may be a strong argument for that intervention. According to our theory, increased regeneration and anabolism are central to the body's ability to protect itself against stress. An example may illustrate this phenomenon. The results were partly supportive when anabolic indicators were analyzed.

The employees in four information technology and two media companies were offered web-based health promotion and stress management training intervention that would last 6 months. A similar control group of employees was established with 129 persons in the intervention group and 174 in the control group. In a follow-up examination after 6 months, there were significant interaction (time × group) effects for DHEAS and neuropeptide Y (NPY), an antistress hormone secreted in the same domain as noradrenaline. An immunologic marker, tumor necrosis factor (TNF) alpha (a widely utilized stress-sensitive immune marker), was also followed. It has a protective effect during stressful conditions and could thus be regarded as a "healthy" chemical agent" during stress conditions.

In the interpretation of the results of this study, it should be taken into account that the baseline data were collected during a season with low stress levels. The 6-month follow-up took place during a period with higher stress levels. It is well known that the activity of the HPA axis, the immune system, and anabolic functions are all affected by seasonal variation. We could expect a seasonal lowering of the levels of DHEAS, TNF alpha, and NPY under these circumstances. All of the measures developed more favorably in the intervention group than in the control group (significant two-way interactions in analyses of variance). In multivariate analyses, TNF alpha and NPY were the most robust indicators of a beneficial effect of the program. One interpretation could be that the program stimulated the production and release of NPY and that this prevented some of the seasonal decrease in TNF alpha. The findings for DHEAS were in the same direction—supporting the conclusion that the program stimulated anabolism (or rather prevented seasonal inhibition of anabolism). There were clear beneficial effects of the program at this stage with respect to the questionnaire-based variables (eg, stress management ability, mental energy, and social support). The importance of a control group is vividly illustrated in this example in which the intervention lasted 6 months and some of the behavioral and physiological variations were due to seasonal effects—without a control group the results would have been impossible to interpret. It should be pointed out that the effects of the intervention did not last for the next 6 months—all the intervention effects had disappeared after the 6 months following the end of the intervention! (18). This finding indicates that individual computer-based stress management programs may only have temporary effects. However, an increased sense of mastery and control in a person may be a stimulus to anabolism although more structural changes are needed for more lasting effects. If the organization supports the individual program, it is more likely to have sustainable effects. It should be pointed out that exercises in stress management may have to be repeated, as physical exercise is.

Table 3. Differences with respect to catabolism between 32 police officers during unemployment (due to reorganization) and during employment 3 years later. (LDL = low-density lipoprotein, HDL = high-density lipoprotein)

	Unemployment		Three years later	
	Mean	SD	Mean	SD
LDL-to-HDL ratio	3.03	0.92	2.73	0.91 [a]
Prolactin	8.07	3.63	5.82	2.51 [a]
Testosterone	12.04	7.61	13.86	8.40 [b]
Cortisol	342	157	473	106 [a]

[a] $P<0.001$.
[b] $P<0.01$.

Effects of unemployment on anabolic indicators

Feelings of lack of control and powerlessness are typical during unemployment, which should therefore be studied from an anabolic perspective. A study that was longitudinally designed and that seemed to be an example of such research is that of Grossi et al (19). Police officers were studied who had been fired because of organizational changes in a police district in Stockholm. Blood samples were drawn in the morning before work, first during the period of unemployment and second 3 years later. With regard to catabolism, the results showed that these men had a lowered serum cortisol level during the unemployment period with a clear increase by the time of the second occasion, when all of them were working again. This change may have been due to a low energy level during the unemployment period or to long-lasting stress with resulting exhaustion of the HPA axis. Interestingly, the total serum testosterone concentration increased after the participants started working again (table 3). There were other changes as well after the unemployment, namely, decreased atherogenic serum lipids (the unemployment period may have been catabolic) and decreased serum prolactin. An increased prolactin concentration during the unemployment phase fits the presented theory—indicating a state of powerlessness (19).

Paradoxical effects in persons with severe traumatic experiences

In a longitudinal study of the physiological effects of significant life changes on refugees from Iraq (20, 21), fluctuations in DHEAS were studied. Repeated observations were made during the first year following their permanent permit to stay in Sweden. Negative life events associated with relationships to family members and close relatives were associated with an increasing serum concentration of cortisol and thyroid hormone. For the total group, positive events occurring during the study year were associated with increasing serum DHEAS. However, in the refugees who had been diagnosed as having posttraumatic stress disorder (PTSD), it was observed that a deteriorating mental state with increasing PTSD symptoms was associated with an increasing DHEAS concentration. The explanation for this occurrence is complicated. DHEAS is produced in large amounts in the central nervous system, and it may have a role in decreasing the number of impulses to neurons in certain situations (22). An increase in DHEAS may accordingly be "protective" for the brain in mentally troubled participants, and it may therefore be mobilized in bad situations. Thus an increase in DHEAS may indicate something else for the more mentally healthy part of the population—an improving situation means more active anabolism in general (as has been found in other studies of healthy populations). This possibility again illustrates that steroid excretion in stressful situations may have different roles in different groups of people in the population.

Anabolism from other perspectives, results from longitudinal studies of spontaneous job variations

Periods of uncontrollable conditions at work were common during the 1990s in Sweden. In health care, downsizing took place in several waves during the whole decade. Employees were told that downsizing 1 year would not be followed by other similar experiences in the future. However an increasing sense of betrayal arose during this 10-year period, since downsizing took place again and again. Some studies were made of this phenomenon. At the Örebro regional hospital, repeated periods of downsizing and reorganization were followed by increasing long-term sick leaves and feelings of exhaustion (23). Thirty women employed at this hospital were followed for a year after the final reorganization during this period. Indicators of anabolism were studied in blood samples drawn immediately after decisions had been made and 1 year later (1998–1999). The difference between the morning and afternoon serum cortisol levels decreased, and this decrease could have been evidence of physiological exhaustion. The estradiol concentration decreased by an average of 35% (adjusted for menstrual cycle and menopause). This finding is in line with our general hypothesis that steroids with anabolic effects would decrease during periods of long-term negative stress. However, the serum concentration of two other chemical compounds was also studied, and significant changes were found for them as well. The serum concentration of the protein (apolipoprotein A1), which carries the protective cholesterol (which decreases the risk of atherosclerosis), decreased by an average of 13%, and the concentration of immunoglobulin G (a general marker of activity in the immune system) decreased by an average of 9%. The total picture thus indicates a loss of protective capacity in the body of these women during this period (24).

In another study by our group, spontaneous variations in job strain were studied in employees in six different occupations. These variations were followed during 1 year (with the participants starting during different seasons so as to minimize seasonal effects on the biological parameters). The workers served as their own controls. There were pronounced variations in job strain (ratio between psychological demands and decision latitude according to self-administered questionnaires distributed on four occasions during the year). Sleep disturbance became more common during peak periods of job strain lasting for some weeks, and systolic blood pressure during workhours increased progressively with increasing job strain among both the men and the women, the finding indicating increased levels of catabolism. The total serum testosterone level (which was the measure of anabolic steroids that we used for the men in the study) decreased with increasing job strain (table 4). The difference in the concentration between the two occasions with the most job strain and the two occasions with the least job strain averaged 14% (25).

Discussion

Within the strict context of the demand–control model, very little research has been published on changes in anabolism and regeneration. Using a wider analytical framework, including effects of gain or loss of control, we find more published research, however. The blood

Table 4. Mean plasma testosterone during the "least" and "next to least" periods of strain divided by the mean plasma testosterone during the "worst" and "next to worst" periods of strain—change (mean and SEM) in plasma testosterone in relation change in job strain. (SEM = standard error of the mean)

	Mean	SEM
Total group (N=44)	1.140	0.061
Sedentary group (N=23)	1.230	0.090
Physically strenuous group (N=21)	1.043	0.078

and saliva concentration of steroids with anabolic effects (DHEA, estradiol, and testosterone) have been shown to decrease during periods of lost control in several studies. Psychosocial interventions seem to have at least short-term beneficial effects on such anabolic processes. Chemical compounds related to anabolic effects are affected by psychosocial processes influencing the feeling of control. Examples are from the immune system, namely, immunoglobulin G and the protective cytokine TNF alpha, and from the catecholamine system (the "antistress" neuropeptide Y) and finally from the cardiovascular system (the carrier of "protective cholesterol", apolipoprotein A). There is growing knowledge in the field of heart rate variability, and this knowledge seems to offer possibilities to record changes in parasympathetic activity. In one of our studies, there seems to be a close relationship between changes in saliva testosterone and the very low-frequency power (VLFP) of heart rate variability. Other measures of heart rate variability, in particular high-frequency power, are well established indicators of parasympathetic activity.

Prolactin represents an interesting riddle. This is a hormone that has an anabolic role, but its concentration seems to increase during powerless crisis situations, and it does not follow the same pattern as the anabolic steroids for instance.

However, anabolism and regeneration are relatively "under-researched" concepts. Interventions aiming at improved anabolism can be grouped into three obvious areas of action, namely, improved conditions for sleep, physical exercise during leisure time, and cultural activities. Sleep has an important role in this context. For instance, Axelsson et al (11) showed that periods of poor sleep have a depressing effect on serum testosterone concentration. The anabolic effects of physical exercise are well documented. Both sleep and physical exercise can be beneficially affected by organizational interventions in workplaces. Anabolic effects of cultural activities have not been established, although there is indirect evidence indicating that such effects could occur (26, 27), but, obviously, this possibility could also be a basis for organizational intervention. Could cultural activities be related to the demand–control model? In an ongoing epidemiologic study of the work conditions of working men and women in Sweden (28), the relationship between the demand–control model and cultural activities organized by the workplace was examined (table 5). A low number of such activities (never or not more than once a year) was reported three times as frequently by female employees who reported low decision authority. Among the men, those who reported job strain (high demand and low decision authority) were twice as likely than the others to have "few cultural activities" at work. Accordingly, among the women, a "lack of cultural activities" was three times as frequent as among the employees in work situations described as relaxed (low demands and high decision authority), and for the men it was twice as frequent. These findings were adjusted for age, education, and type of employer (private or public). Low decision latitude seemed to be the most important component.

An anabolic perspective could be of help in job interventions, and physiological indicators could help when changes in anabolism are being followed. Anabolic processes protect the body against adverse effects of long-lasting arousal. There is no doubt that the anabolic perspective can be useful in health promotion work. For instance, the improvement of an organization's function with regard to such factors as performance

Table 5. Low occurrence of cultural events (never or once or twice per year) provided by the workplace in relation to the demand–control model according to gender. (OR = odds ratio, 95% CI = 95% confidence intervals)

	Men					Women				
	Total number	Number with low occurrence of cultural events	%	OR [a]	95% CI	Total number	Number with low occurrence of cultural events	%	OR [a]	95% CI
Low strain	482	458	95	1.0	..	452	410	91	1.0	..
Passive	404	390	97	1.22	0.61–2.43	483	469	97	2.90	1.54–5.48
Active	676	623	92	0.73	0.44–1.21	663	617	93	1.60	1.02–2.50
High strain	520	508	98	1.96	0.96–4.02	775	753	97	3.14	1.83–5.39

[a] Adjusted for age (10-year categories), education (five levels), and type of employer [private company, association or nonprofit organization, local government (district), local government (county or region), central government, other].

feedback, participatory management, skill development, and employee health has been shown to correlate with increasing testosterone excretion in employees (29). Such correlations support the importance of improved organizational function.

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