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The Physiology of Comfort

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ABSTRACT

Comfort is a state of ease or well-being in body and mind. While highly prized, its physiology has received scant attention. Considerations regarding the physiology of comfort and discomfort are presented herein.

COMFORT, PLEASURE, AND PAIN

Comfort is an elusive concept. We know when we are comfortable, but it is difficult to define precisely what it is that makes us comfortable. Subjective by its very nature, comfort is transient and inextricably related to other moods and emotions.

Comfort is not a synonym for pleasure nor an antonym for pain. Pleasure is an enjoyable sensation that ranges from gratification to happiness. As defined by Freud, pleasure is any reduction of psychological or physical tension, and this could apply to comfort, too, though persons can be comfortable without particular pleasure. Pain is a sensation of hurting or mental distress, often associated with tissue injury. Although it may imply very strong discomfort, pain is distinct from discomfort in severity and overall character.

THE NEUROLOGY OF COMFORT

The neurology of comfort is yet to be traced, whereas that of pain has been well defined in terms of stimuli, nerve endings, and tracts carrying impulses via the spinal cord to areas of reception and conscious recognition in the brain. Degrees of pain appear to be genetically based and laid out via a definable set of pathways in prenatal development, resulting, among other things, in ethnic and gender differences in pain perception. Could there be analogous ethnic and gender differences in comfort levels, as well? With decoding of the human genome, it is possible, perhaps even likely, that genes associated with comfort will be identified and ultimately manipulated.

Pain reception originates in free nerve endings and not in well-defined receptors. It travels as nerve impulses, called action potentials, through specific tracts in the spinal cord. These tracts terminate first in a center within the brain called the thalamus, whence they radiate to conscious centers in the cerebrum. In the thalamus the pain impulses are changed to sensations which are crudely sensed (protopathic). This means that an individual, with pathways interrupted between thalamus and cerebrum, if stuck with a pin, with his eyes closed, can only say that something is hurting him. He cannot state the name of the object or its precise location or strength. If the nerve impulses radiate upward to specific pain centers in the cerebral cortex, they are translated to specific aspects of

consciousness (epicritic). The thalamus distributes almost all sensory information traveling to the cerebrum. It may regulate the emotional components of sensory experience reaching the cerebrum, suggesting that the thalamus may have a significant role in determining comfort.

Pain receptors tend to adapt with time. Adaptation means that the brain will not be cluttered excessively with impulses that outlive their function. Pain impulses, however, may never fully adapt. In contrast, discomfort tends to fade entirely, perhaps because there are too few stimuli or insufficiently strong stimuli to maintain it.

Much affective behavior is mediated by the limbic system. This includes a number of structures, mostly on the medial surface of each cerebral cortex. It plays an important part in memory, learning, pleasure, rage, olfaction, withdrawal, and other responses. Overall, limbic functions are essential for the behavioral expression of emotions. The specialized visceral aspect of emotions require the mediation of hormones and the autonomic nervous system.

While pleasure has been included in the list of limbic functions, comfort has been entirely disregarded. The distinction is not without social significance. In the mid-18th century in Philadelphia, the Quakers (Friends) disowned participants for infractions that included pleasure. Comfort, however, did not appear to cause them any anguish.

Neurological texts, in writings about sensation, pay no obvious attention to comfort or discomfort. In medicine, many, if not all, organ systems in the early stages of dysfunction are associated with signs or symptoms that involve discomfort. These feelings are often overlooked or disregarded because they are generally nonspecific, bearing little obvious relationship to diagnosis or treatment. Although comfort may be underappreciated in clinical diagnosis, it has significant physiologic importance.

RESPIRATION AND COMFORT

The respiratory system is physiologically responsive to changes in barometric pressure. At ordinary levels of barometric pressure, the lungs modify the oxygen demand in accordance with the degree of exercise. In rarefied atmospheres the partial pressure of oxygen (but not its percentage) progressively falls with increasing heights. This oxygen supplied to the tissues via the arteries is essential for the adequate burning of foods in cells, permitting the release of energy needed for normal bodily activities.

At elevations above 9,000 feet, a non-acclimated coastal dweller will often experience a decrease in comfort and well-being, a condition commonly known as mountain sickness. With time, the headaches, nausea, listlessness, and insomnia will resolve as the respiratory system compensates to maintain physiologic (and comfort) homeostasis.

With strenuous exercise, an individual may pass through a stage of discomfort, possibly to pain. An oxygen debt develops, which, like a monetary debt, must be satisfied. Even after the discomfort has subsided, physiologic respiratory mechanisms continue to compensate until the oxygen debt is repaid and oxygen supply and demand are once again equalized.

A clinical model for respiratory comfort may be found in hospital intensive care units. Mols et al (2000) found that artificial respiration via mechanical ventilators may be made more or less comfortable by changes in respiratory rate and tidal volume (the volume of air provided with each mechanical "breath").

THE HEART AND COMFORT

In instances where oxygen delivery to the tissues is insufficient due to cardiac failure, a patient may have to lie semierect to breathe more comfortably (orthopnea). This allows the lungs to expand gravitationally, permitting larger expansion of the air sacs to fill with oxygen.

Where the cardiac output from the left ventricle reaches a critically low level, due to pathology in rate, force or rhythm, sensory awareness arises with attendant discomfort followed by pain. Myocardial infarction (so-called "heart attack") provides the classic example. The coronary arteries, which carry blood and oxygen to the heart muscle, may be partly or wholly occluded. As a result oxygen is inadequately distributed to certain areas of the heart muscle. Failure in oxygenating the myocardial cells is called ischemia, and an acute infarction (death) of the myocardial cells may follow. Discomfort, a feeling of chest compression, and pain are the symptomatic hallmarks of this all too common event. Vague discomfort is often the earliest symptom, preceding more typically diagnostic severe, left-sided chest pain, underscoring the importance of comfort awareness by the patient and physician. Temporary relief may be made available by nasal oxygen, and drugs that produce dissolution of thrombi and vasodilation, allowing oxygenated blood to reperfuse the myocardium and alleviate the pain. Longer term relief may require cardiac surgery to bypass the occluded areas in the coronary arteries.

BLOOD VESSELS AND COMFORT

The heart plus the vessels form the cardiovascular system. The two are in a continuous series circuit. Until the 17th century, blood was thought to ebb and flow, like tides of an ocean. In 1620, William Harvey, widely considered the father of modern physiology, was the first to show that blood flowed in a circle, a closed circuit.

Vascular pathology is a common cause of discomfort and pain, particularly in the elderly. Symptoms may become obvious in patients who have varicose veins or in patients in whom the large saphenous veins have been harvested for coronary artery grafting. Blood returning from the feet to the heart becomes compromised; discomfort and pain result. Numerous other disorders may result in inadequate venous return to the right atrium, with subsequent inequality between input to the right heart and output from the left heart, resulting in chronic heart failure and discomfort.

Reduced arterial blood flow to the lower extremities with walking or exercise is a common cause of pain (claudication), limiting mobility and comfort. Often this is due to atherosclerotic narrowing of the abdominal aorta, femoral and popliteal arteries. Normally, arterial vessels expand as blood flows into them with ventricular systole (contraction) and contract during subsequent diastole (relaxation). In medical examinations this is

reflected by the quantitative readings on a sphygmomanometer. Arteries are like elastic bands that stretch when pulled, gaining potential energy. The process is called compliance. When the band is released, the energy changes to kinetic energy. This is called elasticity. Loss of compliance or elasticity may be due to a number of factors including atherosclerosis, calcification, and fibrosis. Discomfort and pain with walking are frequent accompaniments.

DIGESTIVE SYSTEM AND COMFORT

Discomfort often occurs following excess ingestion of food. A bloated stomach and production of gas are usually at cause. In the elderly, the emptying time of food from stomach to small intestine is delayed beyond that of the young adult (about 4 hours). Fermentation of the stomach contents can follow the delay, leading to the formation of carbon dioxide gas, particularly if the individual goes to bed directly after a full meal. When the brain goes to sleep, the stomach in a sense does the same.

There is occasionally a sensation of comfort localized in the lower abdomen following a stressful defecation. The individual senses a welcome relief that can be classified as comfortable. This is attributable to nerves in the colon that transmit an "all-clear" signal to the central nervous system.

MUSCULOSKELETAL SYSTEM AND COMFORT

Daily complaints of uncomfortable shoes, straps, and clothing are all too common. Women's heels, in particular, are a frequent source of discomfort in a trade-off for style. Backpacks are another daily source of discomfort, although appropriate backpack design can make our schoolchildren more comfortable (Jacobson and Jones, 2000).

Almost all musculoskeletal pathologies are associated with chronic discomfort, including arthritis, myopathies, sprains, and fractures. It is nearly impossible to be comfortable with aching joints or while wearing a bulky cast. Still, anti-inflammatory agents may allow an increased measure of comfort, albeit temporary, in patients with musculoskeletal disorders.

VISUAL AND AUDITORY COMFORT

We often describe glasses, sunglasses, and contact lenses in terms of comfort: Does the frame fit comfortably? Is the color too dark for comfort? Are the contact lenses sufficiently comfortable to wear all day?

Ambient noise is another source of discomfort. Urban dwellers regularly complain of "noise pollution". Loud music, construction equipment, and car horns strain our comfort levels. Office noises have proliferated along with fax machines, printers, and computers. Paradoxically, hospital environments provide no respite from discomforting noises. On the contrary, they are a hotbed of jangling, cacophonous noises. Interestingly, for caregivers in intensive care units, noise cancellation devices can mitigate the beeps, chimes and whirrs to provide an acoustically more comfortable environment (Akatar et al., 2000).

TEMPERATURE, HUMIDITY, LIGHT AND COMFORT

Comfort is intimately associated with certain physical events in the environment, especially temperature and relative humidity. Ambient temperature ultimately affects blood temperature, which, in turn, exerts a crucial influence on most physiologic processes and states of well being. Enzymes, which are essential chemical catalysts in the body, are generally only effective within narrow temperature ranges.

Humidity and wind also affect temperature perception to make a person more or less comfortable. We often hear the comment that a given climate is "hot, but dry," and weathermen routinely discuss the "wind-chill" factor. Heating engineers speak of a "comfort index" which defines the influence of temperature, humidity, and air flow on comfort. Patients afflicted with arthritis know only too well the discomfort of high relative humidify compounded by cold, windy air. Low atmospheric pressure is an additional factor affecting comfort. High storms have been claimed to cause inflation of tissue cells in joints. This exerts pressure against joints that are inflamed. Discomfort followed by degrees of pain can occur.

Enclosed, man-made environments, such as airplanes, submarines, and insulated high-rise buildings provide fascinating laboratories in which to isolate and study different variables affecting comfort. Airplane cabins, in particular, allow the unique study of barometric pressure, humidity, turbulence, prolonged immobility, and jet lag on passengers, as outlined in a fine review by Rayman (1997).

Adequate levels of performance can be physically dependent on narrow ranges of atmospheric conditions. An increase of two or three degrees Fahrenheit can induce aches, pains, or fever. Heat, rather than humidity, may be the more important factor. The thermoregulation of body temperature has been extensively studied in man and animals. Temperature regulation is among the highest priorities in physiologic homeostasis, involving many organ systems, especially the neural, endocrine, vascular, and musculoskeletal systems. A complex mixture of these is likely involved in most adaptive responses to thermal stress. Both core and surface temperature affect thermal comfort, while core temperature predominantly alters metabolic and autonomic functions. What appears to be a simple response to thermal stress is really a sophisticated, highly evolved set of physiologic responses to maintain thermal balance and comfort.

All of our energy exchanges in the body, collectively termed metabolism, appear as heat which may be measured in calories. Our lowest rate of heat production, the so-called basal metabolic rate, is measured in a fasting condition with the individual at rest. The typical basal metabolic rate is approximately 1 kcal./kg of body weight/hour, or about 70 kcal/hour in the average adult. Having measured an individual's basal metabolic rate, heat production with strenuous exercise or other conditions of activity may be evaluated. The body temperature in health is kept within narrow limits by a process called thermoregulation. We have a “thermostat” in the forebrain that, similar to a home thermostat, can be set to balance thermogenesis against thermolysis (heat loss). Conscious perception of thermal variations in the environment are often described in terms of comfort vs. discomfort.

The body has several innate processes to maintain temperature regulation. The nervous system, blood vessels and skin are importantly involved. Conduction, convection, and radiation allow us to transfer heat from regions of higher temperature to those of lower temperature. These are very effective regulators. Evaporation of sweat also allows cooling, as does the loss of warm, humid air with each respiratory exhalation. Excretion of urine and feces is of minor, but measurable, importance in terms of heat loss. With warming, heart rate and blood volume increase along with increased flow to dilated cutaneous blood vessels. Conduction, convection, and, most especially radiation, allow heat transfer from the warmer individual to the cooler environment.

Mechanisms to achieve temperature homeostasis, especially heat production, may be associated with temporary discomfort. Shivering -- involuntary, rapid contraction of skeletal muscle fibers -- to stay warm is usually uncomfortable. It is a normal, adaptive activity, producing the expenditure of energy, increasing body heat in cold environments. Whereas the posterior aspect of the hypothalamus in the forebrain is thought to mediate shivering, the anterior hypothalamus produces dilation of cutaneous blood vessels and may suppress shivering. These two closely apposed centers thereby partially balance heat production and loss within the central nervous system. In addition to this central control, there is a component of endocrine thermoregulation, as well. Epinephrine is secreted by the adrenal glands in response to cold, with a brief, subsequent increase in heat production due to an increased heart rate, and a decrease in heat loss due to peripheral vasoconstriction. Thyroid hormone has a more prominent and longer- lasting calorigenic effect. As a clinical consequence, patients with hypothyroidism are intolerant to cold, while patients with hyperthyroidism are intolerant to heat.

In fever, the body temperature rises. This is primarily a defensive process, a part of inflammation. With infectious pathogens, fever may represent a thermal "battlefield maneuver" between the body's defenses and the pathogen. All organisms thrive biologically at given temperatures and blood acidities. Inflammation and fever are essential processes for recovery to normal function, despite the discomfort they involve.

Behavioral thermoregulation, such as clothing selection, is regulated in large part to maintain comfort, especially in the elderly (Woon Seon Jeong, 1999). Thermal stresses, both heat and cold, alter sleep. In the process of falling asleep and maintaining it, the comfort of warm limbs is a factor. Warm extremities, especially the hind limbs, allow blood vessels to dilate, generally an act of comfort. Senior citizens learn this by experience. Use of heating pads, wooly socks or just placing a small blanket at the foot of the bed may significantly increase night-time comfort.

The comfort range in temperature varies among individuals. In homes, cars, and offices it is a common source of disagreement among the occupants. An adipose individual is well isolated from heat loss, and, like a whale in the Arctic ocean, may be overheated easily. In a given household, if one person is fat and another thin, either may attempt to set the thermostat to fulfill his/her own comfort level. Endocrine driven differences in acceptable room temperatures may arise with thyroid disease, menopause, and other conditions. The effects of mental states and organic pathology on temperature control need to be studied further.

Comfort and discomfort may be cultural. If an individual has resided for a long time in a cold or a hot environment, he or she may not be comfortable in a different climate. In addition, there is no significant short-term temperature adaptation: people do not adapt to hot or cold rooms after a short time therein. Most tend to express their feelings vigorously on this point.

The intensity, duration, and spectrum of ambient light are factors in comfort. This is an important consideration in industrial situations and in the psychopathology known as seasonal affective disorder ("SAD"). In dreary climates with overcast skies or long winters, a small percentage of persons may become depressed due to insufficient light exposure. Vacations to sunny climates or use of phototherapy may be curative.

MENTAL STATES AND COMFORT

There are many negative states of mind in opposition to comfort. Examples include anger, fear, depression, sadness, loneliness, agitation, anxiety, and grief. In contrast, positive states of mind can facilitate comfort. An example of a positive state is laughter. As described by Harris (1999), this was explored many centuries ago. Harris discusses the basis of tickle and the relationship between tickle and laughter. Apparently, an annoying light tickle can elicit laughter almost anywhere on the body whereas heavy tickling elicits laughter only when applied to certain ticklish spots. This behavior leads to some probable clues about the neural mechanisms involved.

Localizing the foci for the perception of comfort in the brain has not yet been achieved. However, the sensation of joy is thought to be localized in the front part of the brain,. The left side of the brain is claimed to be involved in happy feelings whereas the right side is thought to be involved in negative feelings. Surely, these tentative findings will be further explored and defined, perhaps uncovering a "comfort center" in the process. A possible means of localizing such a center in the brain is with positron emission tomography (PET). PET scans provide functional neuroimaging to complement anatomic data provided by computerized tomography (CT) or magnetic resonance imaging (MRI) scans. If brain metabolism increases focally with comfort, the sites of increased metabolism, possibly representing "comfort centers", could be pinpointed with such scans. There is controversy, however, whether foci of increased metabolism would correspond to relevant sites of perception.

Sexual fulfillment may be an aspect of comfort, especially in young persons. In older people, comfort in a mutual relationship may be a more important factor. There are gender and cultural differences in comfort, perhaps related to genetic and hormonal variances. Evolutionary pressures to maximize comfort might even be in play, though data are scanty. Could comfort play a role in preservation of the race as well as the individual?

Changes in comfort may be related to the diurnal (daily) rhythm that occurs in all individuals. Physiological processes change over a period of 24 hours. For example, blood pressure starts to rise to its peak about 9 a.m. along with the concentration of adrenalin

(epinephrine). Interestingly, most deaths occur at about this time of day, raising the question of possible associations.

Clinical understanding and manipulation of comfort may be seen in the manner that some hospitals use children's wards. In many hospitals, for example, clinical treatments are not performed in the rooms that the children occupy most of the time. The child is given treatments in a separate room and returns to his/her delegated room where he/she can feel comfortable and not threatened.

Sloan et al (2000) recently presented evidence for the association of religious activities with improved health and comfort in patients. However, negative aspects were also considered. It was noted that religious practices can at times be disruptive. Overemphasis on the predominant religion of a country could be a source of discomfort, as well.

SUMMARY

Comfort is poorly understood, with its physiological, emotional, social and cultural components. Yet comfort is universally desirable and an important aspect of our daily lives. Concerns regarding comfort have engaged a growing spectrum of professionals and businessmen, including architects, engineers, clothing designers, and hotel operators. Comfort garners an especially high priority on cruise ships and airlines, both isolated environments in which comfort translates into dollars. Lack of prior attention to comfort may be due to its seeming unimportance in the practice of medicine. Increasingly, however, in medical schools, future physicians are educated about the importance of patient comfort. Students, nurses, physicians, and hospice personnel are now routinely trained in the management of comfort for the terminally ill. With a greater understanding of the physiology of comfort, efforts to maximize comfort will undoubtedly become more successful.

LITERATURE CITED

Akatar, S., C.G.M.Weigle, E.Y. Cheng, et al. 2000. Use of noise cancellation devices in caregivers in the intensive care unit. Critical Care Medicine 28: 1157-1160.

Harris, Christine R. 1999. The mystery of ticklish laughter. American Scientist 87:344-351.

Jacobson, B., and K. Jones. 2000. Comparison of selected perceptual variables for backpacks with internal and external frames. Perceptual and Motor Skills 90:605-608.

Jeong, W.S. 1999. Clothing selection behavior of the aged women for thermal comfort. Applied Human Science 18:87-90.

Mols, G., B. von Ungern-Sternberg, E. Rohr, et al. 2000. Respiratory comfort and breathing pattern during volume proportional assist ventilation and pressure support ventilation: A study on volunteers with artificially reduced compliance. Critical Care Medicine 28: 1940-1946.

Rayman, R. B. 1997. Passenger safety, health, and comfort: A review. Aviation, Space, and Environmental Medicine 68:432-40.

Sloan, R.P., E. Bagiella, L. VandeCreek, et al. 2000. Should physicians prescribe religious activities? New England Journal of Medicine 342: 1913-1916.