SYSTEM PROPERTIES, FEEDBACK CONTROL AND EFFECTOR COORDINATION OF HUMAN THERMOREGULATION

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- The final aim of thermoregulation is to protect body processes by establishing a relative constancy of deep body temperature in spite of external and internal influences on it.

- Thermoregulation is a distributed multi-sensor, multi-processor, multi-effector proportional feedback control-system.

- The effect of stressors is, via negative feedback, counteracted by the control processors.

- Nevertheless proportional control implies inherent deviations (“load errors”) of the controlled variable from the value observed in the thermoneutral zone, if stressors are present.

- The thermal state of the body, conveniently represented by a high weighted core temperature $T_c$ and low weighted peripheral temperatures $T_s$, may be regarded as controlled variable. This concept is equivalent to the control concept of “auxiliary control” using a main variable ($T_c$) together with an auxiliary variable ($T_s$).

- A steady-state in the closed loop results from the balance of the open-loop properties of the heat transfer processes with those of the thermoregulatory processors: “balance point”. It is achieved due to the inherent property of dynamical stability of the feedback loop.

- Changes of the balance point may be due to

  - changes of the properties in the heat transfer processes, e.g. induced by ambient conditions. Such changes may relieve the control-system, if not, the changes are counteracted by it. Particularly behavioural control relieves strain from the control-system.

  - changes of the properties of the processing units (sensors, central processing, effectors), e.g. induced by acclimation or fever, which result in a change of effector thresholds. Such changes are followed by the control-system!

- It is explained why the popular term “set-point” is inadequate and misleading in proportional thermoregulatory control. It is recommended to avoid it.

- Metabolic heat production and sweat production, though receiving the same information about the thermal state of the body, are independent effectors with different thresholds. Coordination between one of these effectors and the vasomotor effector is achieved by the fact that changes in the process evoked by vasomotor control are taken into account by the metabolic/sweat processor.