Swimming: Stress and training
Schwimmen: Streß und Training

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With 7 figures, 1 scheme and 1 table

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Summary
The short term and the training effects of water immersion and swimming on ventilatory and circulatory parameters of the human organism were described using our own results and data from the literature. It is suggested that swimming has not only the common positive effects on the physical efficiency observed in other types of sport but seems to improve the orthostatic regulation of the circulation. Furthermore, the physical effects of water immersion and the special pattern of muscular activity during swimming favour the adaptation of the heart to the circulatory demands. This advantage of swimming might explain its known beneficial effect in preventive and curative medical treatment.

In the history of mankind swimming is one of the types of sport in which the therapeutical effect was early recognized. But due to methodological problems it was difficult to obtain objective information about the reaction of the human body to water immersion and swimming and to confirm the subjective impression that swimming has a beneficial influence on the circulation and other body functions. Only within the last 10–20 years has the development of small electronic transducers and amplifiers as well as of biotelemetry made it possible to get reliable data on body reactions during swimming. In the following we will give a short review of the present knowledge.
Water immersion and swimming are interference values for some controlled variables of the organism. To preserve its homeostasis the body has to react and to adjust the corresponding circulation, respiration and metabolic parameters. In the following scheme these relations are shown using a cybernetic presentation.

**Effects of water immersion**

The buoyancy reduces the effective weight of a man during water immersion from e.g. 70 to 6.6 kp (Frank 1968). Thereby the load of the supporting apparatus is greatly diminished (cf. Witzleb 1962). The lower muscle tension results in a decrease in afferent impulse activity from tensoreceptors.

The circulation is influenced mainly by the hydrostatic pressure. During swimming the body is exposed to a pressure of about 0.03 kg/cm². If there is an open communication between the intrathoracal space and the air, the hydrostatic pressure squeezes blood out of the limbs into the thorax.

Gauer (1973) found an increase in the mean heart volume during water immersion from 770 to 920 ml. This increase is a favourable factor in the adaption to high circulatory demand.

The hydrostatic pressure – which increases with depth – additionally prevents the orthostatic shift of blood into the lower body regions, which is important, especially in the upright position. In the water the transmural pressure of arteries and veins does not depend on the position of the body.

The ventilation is also affected by the hydrostatic pressure. In the water the vital capacity is lowered by about 9% (Hüllemann 1972). The mean respiratory level is shifted during swimming in expiratory (breast-stroke) or inspiratory (backstroke) direction (cf. Frank 1972).

Another effect of water immersion is related to the high thermal conductance of water. The heat loss leads to a compensatory skin vasoconstriction, an increase in muscle tone and a release of epinephrine into the circulation.