A novel bioheat transfer model for a human body that includes heat convection and arterial flow

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Abstract

Arterial circulation is of vital importance for the dissipation of metabolic heat produced within a human body. A 1D thermo-fluid model, representing larger arterial vessels, is coupled with a multi-layer conduction model representing surrounding tissues. Using a comprehensive and detailed network of elastic vessels arterial flow is calculated. The coupling of both solid and fluid models requires classification of arterial vessels in central and peripheral areas of the body. It is assumed that heat exchange between tissue and arteries occurs by convection for central arteries and by perfusion for peripheral ones.

Temperature in the heart is set constant and it represents the inlet condition. The body exchanges heat with the environment through its external surfaces by convection and radiation. For organs and tissues in which metabolic reactions occur, different inner volumetric heats are assigned. Effects of exercise on muscle metabolism are accounted, as well as shivering, sweating, vasodilation and vasoconstriction.

The body thermo-regulatory centre acts as a control system in order to keep tissue temperature in a determined range. It involves perfusion and metabolic heat generations in the tissue and is a function of inner temperature. Temperature field evolutions are monitored in different points of arterial tree and in relative surrounding tissue layers; thus it has been possible to evaluate the relationship between solid and fluid temperature behaviors. The results from the proposed model are compared with ones obtained from a model that is only perfusion based. The results show a substantial difference between the comprehensive model proposed and the ones currently used by researchers.