Table of Contents

List of Figures

List of Tables

Abstract

The aim of this thesis is to extend the current understanding of the impacts of heat stress on human physiology, cognition, behaviour, and capacity to perform physical work. In this respect, we conducted two systematic reviews and collected numerous data from hundreds of individuals who perform physical work in various environments. A series of field observations and interventions followed by experiments in laboratory settings, took place in Cyprus, Denmark, Greece, Qatar, and Spain. Additional datasets were provided from Australia, Canada, Slovenia, and the United States of America. This work led to seven studies which are presented as different chapters of the current thesis. Summarizing, the results of the current thesis show that environmental heat stress affects human health, physiology, cognition, and capacity to perform manual work, leading to significant economic implications which are projected to rise during the next decades. Performing manual work under the sun leads to added heat strain and more compromised cognitive function, even in circumstances when heat exposure is considered to be of the same intensity as performing manual work in shade. Encouraging individuals who perform work in the heat to self-pace must be a key element of any effective heat mitigation strategy. Additionally, interventions such as mechanization, work-rest cycles, hydration strategies, ice slurry consumption, and clothing strategies could play a significant role as a protective barrier against environmental heat stress. The use of appropriate thermal indices could act as an additional proactive measure aiming to protect human health and wellbeing.

General Introduction

Effects of heat on behavioral and physiological mechanisms of the human thermoregulatory system during rest, exercise, and work

Currently, nearly one-third of the world's population is regularly exposed to climate conditions that exceed human thermoregulatory capacity leading to major increases in morbidity and mortality.[1-3] Even if aggressive mitigation measures are adopted, one-half of the world's population will be exposed to such conditions by 2100[1] and a number of studies report that the resulting heat strain will directly threaten workers' health, with corollary negative impacts on productivity, poverty, and socio-economic inequality.[4-7] Therefore, the present PhD thesis incorporates seven studies (Fig. 1) aiming to improve the current understanding on the effects of heat strain on human health, physiology, cognition, and capacity to perform work in the heat.

As an introduction, in **Chapter 1**, a systematic review and meta-analysis was conducted to evaluate the available evidence on the impacts of occupational heat stress on workers' health and capacity to perform manual labor. A gap in literature was identified concerning the assessment of heat-induced labor loss in occupational settings. Thus, in **Chapter 2**, time-motion analysis was introduced for assessing the impact of occupational heat stress on workers' capacity to perform manual labor. Time-motion analysis is a qualitative method that has been used for some time for the assessment of physical performance and work intensity in elite team sports.[8,9] In occupational settings, it is one of the recommended methods by the American Conference of Governmental Industrial Hygienists to assess hand activity level threshold limit values,[10] and has been adopted to determine the degree of correlation

between hand activity/force ratings in various jobs.[11] In **Chapter 3**, time-motion analysis combined with continuous physiological data were collected in a series of field and lab studies to investigate the effects of sun exposure on human physiology and cognition during rest and physical work. In **Chapter 4**, time-motion analysis was utilized to examine the impact of occupational heat stress on the labour effort of agriculture workers while performing different jobs. The results from these time-motion experiments were combined with large-scale economic, climate, population, and labour datasets to model current and future global economic costs of heat-induced labour loss in agriculture. In **Chapter 5**, ten different heat mitigation strategies were tested to examine their capacity to mitigate the heat strain experienced by workers who work in key industries located in different countries (Cyprus, Greece, Qatar, and Spain) around the globe. In **Chapter 6**, a systematic review was conducted to identify all the thermal indices developed so far. A subsequent meta-analysis was conducted to examine the capacity of the identified thermal indices to quantify the magnitude of the heat strain experienced by workers who work in several industries around the globe (Australia, Canada, Cyprus, Denmark, Greece, Qatar, Slovenia, Spain, and United States of America). In **Chapter 7**, a new computer software was designed and implemented to calculate the predicted heat strain of individuals who perform physical work in the heat (ISO 7933:2018).

Figure 1 | *Schematic representation of the thesis structure.*