SUMMARY

In recent years, high-intensity interval training (HIIT) has received considerable attention from the scientific community owing to its effectiveness in enhancing exercise performance and improving cardiovascular and metabolic health. HIIT promotes a number of adaptations resembling those associated with traditional endurance exercise, including quantitative and qualitative changes at the skeletal muscle mitochondrial level. However, the mechanisms underlying these similar adaptive responses in spite of divergent exercise stimuli are not completely clear. Hence, the examination of the skeletal muscle adaptive responses to HIIT with particular emphasis on the cellular pathways regulating mitochondrial quantity, quality and function would provide new insights into the physiological mechanisms involved in the performance- and health-enhancing effects of HIIT.

Thus, the overall purpose of the present PhD thesis was to investigate the acute and chronic effects of HIIT in humans with specific emphasis on the adaptations occurring at the skeletal muscle mitochondrial level. The thesis is based on three human studies, including one acute exercise study (study I) and two training intervention studies (study II and III).

Study I explored the metabolic and molecular responses to an acute exercise bout in young healthy men. Specifically, the early adaptive molecular events evoked by two work-matched low-volume high-intensity interval exercise regimes and a high-volume moderate-intensity continuous exercise protocol were examined in concert with the exercise-induced metabolic perturbations. It was observed that for a given volume of high-intensity exercise, the initial events associated with mitochondrial biogenesis depended on the degree of metabolic stress and that high-intensity exercise could compensate for reduced exercise volume only when marked metabolic perturbations occurred.

Study II investigated the effects of a period of HIIT on exercise performance and skeletal muscle mitochondrial adaptations in young healthy men, with specific emphasis on mitochondrial respiratory function. Mitochondrial respiratory capacity and mitochondrial coupling efficiency were quantified under both experimentally-induced normothermia and hyperthermia to resemble the muscle temperature at rest and during intense exercise, respectively. While no substantial training-induced improvements in mitochondrial respiratory function were detected at normothermia, increased mitochondrial maximal respiratory capacity and coupling efficiency were observed under hyperthermia, indicating that HIIT improved mitochondrial bioenergetics in a temperature-dependent manner. Furthermore, HIIT enhanced exercise performance, with substantial enhancements in mechanical efficiency and endurance exercise capacity.

Study III investigated the health-enhancing effects along with the skeletal muscle adaptations elicited by a period of HIIT in sedentary middle aged/older men with essential hypertension. Given the complex interplay between dysregulated blood pressure, oxidative stress and mitochondrial dysfunction, it was questioned whether essential hypertension was associated with impaired muscle mitochondrial turnover and anti-oxidant defences and whether HIIT was an effective strategy to ameliorate mitochondrial quality
and anti-oxidant protection. It emerged that skeletal muscle from hypertensive individuals was characterized by aberrant expression of markers of mitochondrial turnover and augmented oxidative damage and that HIIT partly reversed hypertension-related impairments in muscle mitochondrial turnover but not oxidative damage. Most importantly, HIIT lowered blood pressure and improved cardiorespiratory fitness and body composition.

In conclusion, the present PhD thesis demonstrated that high-intensity training is a viable strategy to promote substantial improvements in performance- and health-related parameters in humans, with high-intensity exercise-induced metabolic stress likely playing a key role in the hormetic response culminating in multiple mitochondrial adaptations at the skeletal muscle level. Moreover, the thesis elaborated on specific cellular pathways contributing to enhancements in muscle mitochondrial quantity, quality and function, thus providing novel physiological and clinical insights into the mechanisms underlying the beneficial effects of high-intensity exercise training. Taken together, the PhD thesis suggests a prominent role of skeletal muscle mitochondria in the performance- and health-enhancing effects of high-intensity exercise training in humans.