Strategies for Post-Exercise Recovery

Impact

The main objective of this dissertation was to investigate the effect of several nutritional and non-nutritional strategies to improve post-exercise recovery in healthy adults. This thesis supports previous work that both carbohydrate and protein are important nutrients to support muscle recovery and facilitate skeletal muscle conditioning, by accelerating the replenishment of the body's energy stores (i.e., glycogen repletion), and by stimulating the recovery and growth of the structural components within muscle tissue (i.e., muscle protein synthesis). More specifically, in this thesis we presented the first quantitative evidence that ingesting ample amounts of carbohydrate during prolonged cycling exercise can fully prevent the lowering of glycogen stores in the liver. Furthermore, the work in this thesis supports the combined ingestion of fructose plus glucose as a means to further accelerate post-exercise liver glycogen repletion during recovery from endurance-type exercise. This thesis also showed that the ingestion of branched-chain amino acids as well as branched-chain keto acids both represent an effective means to stimulate muscle protein synthesis, but that the response is relatively short-lived when compared to the ingestion of a high-quality *intact* protein source. With respect to protein metabolism, we also reported that pre-heating of dietary protein (in this case eggs) before ingestion does not substantially impact the subsequent increase in muscle protein synthesis rates during recovery from exercise. Finally, the findings in this thesis do not support the common belief that either cooling or heating your muscles following a session of intense exercise will facilitate post-exercise recovery and/or the skeletal muscle conditioning in response to exercise. Whereas heating does not seem to impact this response at all, cooling is in fact *detrimental* for post-exercise muscle protein synthesis.

Post-exercise recovery is a fundamental principle of exercise training and adaptation and, as such, has gained increasing attention over the last few decades. As a result, many professional as well as recreational athletes are using several post-exercise recovery strategies after their workouts, despite a clear lack of knowledge on the effectiveness of many of these strategies. Hence, it is of importance to better understand the physiological mechanisms underlying such strategies and to determine their efficacy to facilitate post-exercise recovery. The (potential) impact of this dissertation in terms of scientific relevance, the target population and societal relevance, as well as the implications for translation into practice will be discussed below.

Scientific relevance

This thesis broadens our understanding on the physiology behind several commonly applied post-exercise recovery strategies. With this work, we have made substantial contributions to the scientific field in order to better understand the physiological impact of several of these strategies and their beneficial and/or detrimental effects on post-exercise recovery in healthy individuals. In particular, in contrast to common belief, we have shown that post-exercise

cooling may in fact be detrimental for myofibrillar protein synthesis, rather than beneficial, when applied during recovery from exercise.

The work in this thesis has opened up many new hypotheses and research questions that will hopefully be answered in the (near) future. It would for example be relevant to investigate whether the negative effects of cooling after strength exercise on myofibrillar protein synthesis rates would also translate into negative effects on mitochondrial protein synthesis rates when cooling is applied after endurance exercise. This is especially relevant given that previous work suggests that cooling after endurance exercise improves markers of mitochondrial biogenesis. Another topic of interest would be whether the application of heating strategies that elicit a higher temperature (compared to hot-water immersion) for a more prolonged duration may be beneficial during post-exercise recovery. With respect to nutritional strategies, it is relevant to investigate the dose of carbohydrates that is necessary to prevent liver glycogen depletion during exercise as well as whether carbohydrate ingestion can also prevent liver glycogen depletion at higher exercise intensities (as commonly performed by professional athletes). In addition, it would be relevant to further explore the exact mechanisms by which branched-chain keto acid ingestion can stimulate muscle protein synthesis as well as its potential relevance both in an athletic and in a more clinically compromised population. Taken together, there are many more questions based on this thesis that require more research.

All the work in this thesis has been presented at well-known international conferences, such as the American College of Sports Medicine (ACSM) and the European College of Sport Science (ECSS). Therefore, all results have been shared within the sports science and medicine field. All the presented data has been really well received by the different audiences, as also demonstrated by various prize nominations and prestigious awards (please refer to CV).

Target groups and societal relevance

All studies presented in this thesis were performed in healthy male adults in order to investigate the physiological impact in healthy volunteers. More specifically, the carbohydrate studies were performed in endurance trained young men, given that carbohydrate intake following exercise is primarily relevant for endurance trained athletes who need to recover fast after an exercise session. For the protein studies, the target groups were somewhat broader (i.e. healthy, recreationally active young and older individuals) given that protein intake is not only relevant as a recovery strategy for competitive athletes, but also for the general population to aid, for example, skeletal muscle conditioning and support muscle mass maintenance over the lifespan. The work on cooling and heating was primarily targeted to healthy young (recreationally active) volunteers, given that such strategies are most commonly applied by (recreational) athletes after exercise. Overall, the work from this

thesis is thus relevant for a broad spectrum of people, especially those that are active and aim to maintain a healthy lifestyle. Apart from (athletic) individuals, the results from this thesis are also highly relevant for sports coaches and sports organizations to improve their knowledge on post-exercise recovery strategies, as well as for the food industry to develop evidence-based food products that are relevant for sports performance and recovery.
Obviously, these target groups are not automatically reached through the standard academic routes of publishing and presenting at scientific conferences. Therefore, we have actively been involved in translating the findings to the generic public in various ways. The data presented in this thesis have received a lot of public and social media attention, as demonstrated by high Altmetric attention scores (e.g. a score of 643 for one of the papers). In addition, it led to several invitations for interviews (with newspapers and television programs) and podcasts. As an example, several well-known public newspapers (e.g. Reuters, Men's Health, de Volkskrant etc.) as well as national television programs (e.g. NPO and NOS) have been sharing results from this work. Overall, this clearly shows the popularity of the presented work for the wider public, alongside our ability to convey a 'practical' message to different audiences.

Translation into practice

Despite the scientific rigor, the accompanying practicality of the work in the present thesis, allows a relatively easy translation and application into practice. Most of the strategies that were investigated in this thesis are already applied in practice by many athletes, exercise enthusiasts and/or the general public. Our work has improved the physiological knowledge surrounding these strategies, while also opening up many new questions that we will continue trying to answer as to further broaden our understanding of post-exercise recovery. At the same time, we will continue informing the general public on the use and beneficial and/or detrimental effects of post-exercise recovery strategies that are, according to this author, often too quickly applied by individuals and sports organizations without proper insight into their actual effectiveness. In doing so, we hope to contribute to a better evidence-base and eventually enable a better-informed decision by many athletes and sports enthusiasts on the use of the various post-exercise recovery strategies.