

Exercise Metabolism

SECOND EDITION

**Mark Hargreaves
Lawrence Spriet**

Editors

Contents

Contributors vii

Preface ix

Acknowledgments ix

Chapter 1 Overview of Exercise Metabolism 1

Lawrence L. Spriet, PhD, and Mark Hargreaves, PhD

Metabolic Fuels and Rates of ATP Production 2

Control of Metabolic Pathways 4

Signals Matching ATP Synthesis and ATP Demand 5

Chapter 2 Anaerobic Metabolism During Exercise 7

Lawrence L. Spriet, PhD

*Skeletal Muscle ATP Concentration Is Defended
During Exercise* 8

Importance of Anaerobic Metabolism 8

Sources of Anaerobic ATP 9

Regulation of Anaerobic Energy Provision 11

Carbohydrate 15

Phosphocreatine 18

Intermittent High-Intensity Exercise 19

Anaerobic Metabolism at the Onset of Exercise 22

Summary 26

Chapter 3 Skeletal Muscle Carbohydrate Metabolism During Exercise 29

Mark Hargreaves, PhD

*Muscle Glycogenolysis and Glucose Uptake
During Exercise* 29

Regulation of Muscle Glycogenolysis 32

Regulation of Muscle Glucose Uptake 35

Regulation of CHO Oxidation 40

Lactate Metabolism 41

Postexercise CHO Metabolism 43

Summary 44

Chapter 4 Hepatic Metabolism During Exercise 45

Michael Kjær, MD

<i>Hepatic Glucose Output During Exercise: Glycogenolysis and Gluconeogenesis</i>	<i>48</i>
<i>Feedback Regulation of Hepatic Glucose Output</i>	<i>50</i>
<i>Feed-Forward Regulation of Hepatic Glucose Output</i>	<i>54</i>
<i>Regulatory Hormonal and Neural Mechanisms in Hepatic Glucose Production</i>	<i>56</i>
<i>Hepatic Uptake of Gluconeogenic Precursors</i>	<i>65</i>
<i>Summary</i>	<i>68</i>

Chapter 5 Skeletal Muscle Lactate Transport and Transporters 71

Arend Bonen, PhD

<i>Lactate Transport System</i>	<i>71</i>
<i>Lactate Transport Proteins</i>	<i>73</i>
<i>MCT1 and MCT4 in Human Skeletal Muscle</i>	<i>78</i>
<i>Subcellular Distribution of MCT1 and MCT4 in Muscle</i>	<i>80</i>
<i>MCT1 and MCT4 Transporters and Lactate Transport</i>	<i>82</i>
<i>Effects of Training on MCT1 and MCT4</i>	<i>84</i>
<i>Possible Roles of MCTs</i>	<i>86</i>
<i>Summary</i>	<i>87</i>

Chapter 6 Adipose Tissue Lipid Mobilization During Exercise 89

Jeffrey F. Horowitz, PhD

<i>Regulation of Lipolysis in Adipose Tissue</i>	<i>89</i>
<i>Regional Lipolysis</i>	<i>92</i>
<i>Measuring Lipolysis In Vivo</i>	<i>95</i>
<i>Regulation of Adipose Tissue Blood Flow</i>	<i>97</i>
<i>Other Triglyceride Sources</i>	<i>98</i>
<i>Lipolytic Response During Endurance Exercise</i>	<i>99</i>
<i>Endurance Exercise Training</i>	<i>103</i>
<i>Summary</i>	<i>104</i>

Chapter 7 Skeletal Muscle Lipid Metabolism During Exercise 105

Lorraine P. Turcotte, PhD

<i>Plasma Long-Chain Fatty Acid Metabolism</i>	<i>105</i>
<i>Muscle Triacylglycerol Metabolism</i>	<i>126</i>

<i>Plasma Triacylglycerol Metabolism</i>	133
<i>Summary</i>	135

Chapter 8 Effect of Exercise on Skeletal Muscle Protein and Amino Acid Metabolism in Humans 137

Martin J. Gibala, PhD

<i>Protein Turnover and Exercise</i>	137
<i>Skeletal Muscle Amino Acid Metabolism During Exercise</i>	146
<i>Influence of Protein or Amino Acid Ingestion on Muscle Adaptation During Recovery</i>	154
<i>Summary</i>	160

Chapter 9 Metabolic Factors in Fatigue 163

Kent Sahlin, PhD

<i>Limits of Energetic Processes</i>	164
<i>Central Fatigue</i>	172
<i>Peripheral Fatigue</i>	174
<i>Integrated View of Fatigue During Static and Dynamic Exercise</i>	180
<i>Summary</i>	184

Chapter 10 Endurance Training-Induced Adaptations in Substrate Turnover and Oxidation 187

Stuart M. Phillips, PhD

<i>Study Design Considerations</i>	188
<i>Effect of Training on Substrate Turnover and Oxidation</i>	192
<i>Underlying Mechanisms of Training-Induced Adaptations</i>	205
<i>Summary</i>	212

References 215

Index 293

About the Editors 301