

Reference

Chapter 1

1. Sherrington C. *Man on His Nature*. New York: Macmillan; 1941:6–8.
2. Byford WH. On the physiology of exercise. *Am J Med Sci*. 1855;30:32–42.
3. Brock AJ. *Greek Medicine*. London: Dent & Sons; 1929.
4. Tipton CM. Historical perspective: the antiquity of exercise, exercise physiology and the exercise prescription for health. In: Simopoulos SP, ed. *Nutrition and Fitness: Cultural, Genetic, and Metabolic Aspects*. Basel: Karger; 2008:198–245.
5. Tipton CM. Contemporary exercise physiology: fifty years after the closure of the Harvard Fatigue Laboratory. *Exerc Sport Sci Rev*. 1998;26:315–339.
6. Bainbridge FA. *The Physiology of Muscular Exercise*. London: Longmans, Green; 1919.
7. Roy SB. *Mohenjardo*. New Delhi: Institute of Chronology; 1982.
8. Wilson HH. *Rig-Veda Samhita*. Vols. I-VII. New Delhi: CosmosPublications; 1977.
9. Bahita SL. *A History of Medicine with Special Reference to the Orient*. New Delhi: Office of the Medical Council of India; 1977.
10. Kutambiah P. *Ancient Indian Medicine-Orient*. Madras: Longmans; 1962.
11. Ray P, Gupa H, Roy M. *Susruta Samhita*. New Delhi: Indian National Science Academy; 1980.
12. Bhisagratna KK. *The Sushruta Samhita*. Vol. II, 2nd ed. Varanasi, India: Chowkhamba Sankrist Series Office; 1963.
13. Tipton CM. Susruta of India: an unrecognized contributor to the history of exercise physiology. *J Appl Physiol*. 2008;104:1553–1557.
14. Bhisagratna KK. *The Sushruta Samhita*. Vol. I, 2nd ed. Varanasi, India: Chowkhamba Series Office; 1963.
15. Bhisagratna KK. *The Sushruta Samhita*. Vol. III, 2nd ed. Varanasi, India: Chowkhamba Series Office; 1963.
16. Raja V. Susruta of ancient India. *J Ophthal*. 2003;51:2–7.
17. Das S. Susruta, the pioneer urologist of antiquity. *J Urol*. 2001;165:1405–1408.
18. Sharma RK, Dash VB. *Angivesa's Caraka Samhita*. Vol. I. Varanasi, India: Chowkhamba Series Office; 1977.
19. Sharma RK, Dash VB. *Angivesa's Caraka Samhita*. Vol. III. Varanasi, India: Chowkhamb Series Office; 1977.
20. Gordon BL. *Medicine throughout Antiquity*. Philadelphia: Davis; 1949.
21. Amoit JM. *Memoires concernant l'histoire, les sciences, les arts, les moeurs, les usages, des chinois par les missionnaires de Pekin*. Vol. IV Paris: Saint-de Beauvis vis-à-vis le College; 1779:1–519.
22. Veith I. *The Analysis of the Huang Ti Nei Chung SuWen [The Yellow Emperor's Classic of Internal Medicine]*. Berkeley: University of California Press; 2002.
23. Wong KC, Lien-Teh W. *History of Chinese Medicine*. 2nd ed. Shanghai: National Quarantine Service; 1936.
24. Harper DJ. *Early Chinese Medical Literature (The Mawangdui Medical Manuscripts)*. London: Kegan Paul International; 1998.
25. Biers WR. *The Archaeology of Greece: An Introduction*. Ithaca: Cornell University Press; 1980.
26. Robinson RS. *Sources for the History of Greek Athletics*. Chicago: Ares Publishers; 1981.
27. Nicoll A. *Chapman's Homer: The Iliad*. Vol. I. New York: Bolingen Foundation Pantheon Books; 1956.
28. Mitchell H. *Sparta*. Westport, CT: Greenwood Press; 1985.
29. Wright FA. *Greek Athletics*. London: Cape; 1925.
30. Hooker JT. *Ancient Spartans*. London: Dent; 1980.
31. Barnes J. *The Presocratic Philosophers*. Vol. I. London: Routledge & Kegan; 1979.
32. Kirk GS, Raven JE, Schofield M. *The Presocratic Philosophers*. 2nd ed. Cambridge: Cambridge University Press; 1983.
33. Vogel CJ. *Pythagoras and the Pythagorean Society*. Assen: Royal Van Gorcum & Co; 1996.
34. Lambridis H. *Empedocles, A Philosophical Investigation*. Alabama: The University of Alabama Press; 1976.
35. Garrison FH. *An Introduction to the History of Medicine*. 2nd ed. Philadelphia: Saunders; 1917.
36. *Hippocrates*. Vol. I. Jones WH, trans-ed. Cambridge, MA: Harvard University Press; 1923.
37. Elliott JS. *Outlines of Greek and Roman Medicine*. Boston: Milford House; 1971.
38. Park R. *An Epitome on the History of Medicine*. Philadelphia: Davis; 1997.
39. Olivova V. *Sports and Games in the Ancient World*. London: Orbis Publishing Co; 1984.
40. Licht S. *Therapeutic Exercise*. New Haven: Elizabeth Licht Publisher; 1965.
41. Jowett B. *Book III: The Republic of Plato*. London: The Colonial Press; 1901.
42. Harris HA. *Greek Athletes and Athletics*. London: Hutchinson; 1964.
43. Miller SG. *Arete, Greek Sports from Ancient Sources*. Berkeley: University of California Press; 1991.
44. Woody T. Philostratus: concerning gymnastics. *Res Quart*. 1943;17:127–137.
45. Lund FB. *Hippocrates*. New York: Hoeber; 1936.
46. Haggard HW. *Mystery, Magic and Medicine, The Rise of Medicine from Superstition to Science*. Garden City, NY: Doubleday; 1933.
47. Rothsuh KE. *History of Physiology*. Huntington, NY: Krieger Publishing; 1973.
48. *Hippocrates*, Vol. IV. Jones WHS, trans-ed. Cambridge, MA: Harvard University Press; 1923.
49. *Hippocrates*, Vol. VI. Potter P, trans-ed. Cambridge, MA: Harvard University Press; 1988.
50. Levine EB. *Hippocrates*. New York: Twayne; 1971.
51. *Hippocrates*, Vol II. Jones WHS, trans-ed. Cambridge, MA: Harvard University Press; 1923.
52. Worthington ET. *Hippocratic Writings*. New York: Penquin Books; 1950.
53. Jowett B. *The Dialogues of Plato*. Vol. III, 3rd ed. London: Oxford University Press; 1931.

54. Edelstein L. *Ancient Medicine: Selected Papers of Ludwick Edelstein*. Baltimore: Johns Hopkins Press; 1967.
55. Longrigg, J. *Greek Medicine, A Source Book*. London: Duckworth & Co; 1998.
56. Scarborough J. *Roman Medicine*. Ithaca: Cornell University Press; 1969.
57. Webster G. *The Roman Imperial Army*. 3rd ed. Norman, OK: The University of Oklahoma Press; 1998.
58. Watson GR. *The Roman Soldier*. Bristol: Thames & Hudson; 1969.
59. Whipp BJ, Ward SA, Hassall MWC. Paleo-bioenergetics: the metabolic rate of marching Roman legionaries. *Br J Sports Med*. 1998;32:261–262.
60. Kohne E, Ewigleiben E, eds. *Gladiators and Caesars*. Berkeley: University of California Press; 2000.
61. Vegetius. *Epitome of Military Science*. Milner NP, trans-ed. Liverpool: Liverpool University Press; 1993.
62. Nutton V. *Ancient Medicine*. London: Routledge; 2004.
63. May MT. *Usefulness of the Parts of the Body: De Usu Partium*. Ithaca: Cornell University Press; 1958.
64. Berryman JW. Ancient and early influences. In: Tipton CM, ed. *Exercise Physiology: People and Ideas*. New York: Oxford University Press; 2003:1–38.
65. Green RM. *A Translation of Galen's Hygiene (De sanitate tuenda)*. Springfield, MO: Charles C. Thomas; 1951.
66. Galen. *Selected Works*. Singer PN, trans-ed. New York: Oxford University Press; 1997.
67. Lyons AS, Petrucelli RJ. *Medicine: An Illustrated History*. New York: Harry Abrams; 1978.
68. Grunner OC. *A Treatise on the Canon of Medicine of Avicenna, Incorporating a Translation of the First Book*. New York: Augustus M. Kelley; 1970.
69. Krueger HC. *Avicenna's Poem on Medicine*. Springfield, MO: Charles C. Thomas; 1963.
70. Osler W. *The Evolution of Modern Medicine*. New York: Arno Press; 1922.
71. Mendez C. *Book of Bodily Exercise (1553)*. Copyright Elizabeth Licht. Baltimore: Waverly Press; 1960.
72. Harvey W. *Exercitatio Anatomica De Motu Cordis et Sanguinis in Animalibus*. 3rd ed. Presented by Leake CD. Springfield, IL: Charles C. Thomas; 1941.
73. Lower R. *A treatise on the heart on the movement and colour of the blood and on the passage of the chyle in the blood*. London: Printed by John Redmayne for James Allestry at the sign of the Rose and Crown in the street commonly called Duck Lane; 1669. In: Gunther RT. *Early Science in Oxford*. Oxford: Printed for the Subscribers; 1932.
74. Frank RG Jr. *Harvey and the Oxford Physiologists*. Berkeley: University of California Press; 1980.
75. Boyle RA. *Defense of the doctrine touching the spring and weight of the air*. London: Printed by F.G. for Thomas Robinson Bookseller in Oxon; 1662.
76. Foster M. *Lectures on the History of Physiology During the Sixteenth, Seventeenth, and Eighteenth Centuries*. London: Dover Publications; 1970.
77. Mayow J. *Medico-physical Works, Being a Translation of Tractatus Quinque Medico Physici; 1674*. Edinburgh: Printed for James Thin, republished by the Alembic Club in London by Simpkin, Marshall, Hamilton, Kent; 1907.
78. Isler H. *Thomas Willis, 1621–1675, Doctor and Scientist*. New York: Hafner; 1968.
79. Bernoulli J. *Dissertations on the Mechanics of Effervescence and Fermentation and on the Mechanics of the Movement of the Muscles by Johann Bernoulli*. Philadelphia: American Philosophical Society; 1997.
80. Wilson LG. *William Croone's theory of muscular contraction: notes and records*. Royal Society of London. 1961;16:158–178.
81. Santorio S. *Medicina Statica, or, Rules of Health in Eight Sections of Aphorisms*. London: Printed for John Starkey; 1636.
82. Finney G. *Fear of exercising the lungs related to iatro-mechanics 1675–1750*. *Bull Hist Med*. 1971;45:341–366.
83. Berryman JW. *Exercise and the medical tradition from Hippocrates through antebellum America: a review essay*. In: Berryman JW, Park RJ, eds. *Sport and Exercise Sciences: Essays in the History of Sport Medicine*. Urbana: University of Illinois; 1992:1–57.
84. Seguin A, Lavoisier A. *Premier Memoire sur las Respiration des Animaux*. *Mem Acad R Sci*. 1789:566–584.
85. Floyer SJ. *The Physician's Pulse-Watch; or, An Essay to Explain the Old Art of Feeling the Pulse, and to Improve it by the Help of a Pulse Watch*. London: Printed for Sam Smith and Benj. Walford; 1707.
86. Robinson BA. *A Treatise of the Animal Oeconomy*. 2nd ed. Dublin: Printed by S. Powell for George Ewing and William Smith; 1734.
87. Hales S. *Statical Essays: Containing Haemastaticks*. New York: Hafner; 1964.
88. Keill J. *An Account of Animal Secretion, the Quantity of Blood in the Humane Body, and Muscular Motion*. London: Printed for George Strahan; 1708.
89. Hall AR. *John Theophilus Desaguliers, 1663–1744*. In: Gillispie CC, ed. *Dictionary of Scientific Biography*. Vol. V. New York: Charles Scribner & Sons; 1971:43–46.
90. Pearn J. *Two early dynamometers: an historical account of the earliest measurements to study human muscular strength*. *J Neurobiol Sci*. 1978;37:127–134.
91. Tissot J-C. *Gymnastique Medicinale et Chirurgicale*. Licht E, Licht S, trans-ed. New Haven: Elizabeth Licht; 1964.
92. Renbourn ET. *The natural history of insensible perspiration: a forgotten doctrine of health and disease*. *Med History*. 1960;4:135–152.
93. Sinclair J. *The Code of Health and Longevity; or, A Concise View of the Principles Calculated for the Preservation of Health and the Attainment of Long Life*. Edinburgh: Arch, Constable and Co; 1807.
94. Park RJ. *Athletes and their training in Britain and America, 1800–1914*. In: Berryman JW, Park RJ, eds. *Sport and Exercise Science*. Urbana: University of Illinois; 1992.
95. Beaumont W. *Experiments and observations on the gastric juice and the physiology of digestion*. In: Osler W, ed. *A Pioneer American Physiologist (facsimile of the original edition of 1833 with a biographical essay)*. New York: Dover Publications; 1959.
96. Combe A. *The Principles of Physiology Applied to the Preservation of Health, and to the Improvement of Physical and Mental Education*. New York: Harpe; 1836.
97. Dunglison R. *On the Influence of Atmosphere and Locality; Change of Air and Climate; Seasons; Food; Clothing; Bathing; Exercise; Sleep; Corporeal and Intellectual Pursuits, etc. on Human Health; Constituting Elements of Hygiene*. Philadelphia: Carey, Lea & Blanchard;

98. Flint A. *A Textbook of Physiology*. 4th ed. New York: Appleton; 1896.
99. Flint A Jr. *On the Physiological Effects of Severe and Protracted Muscular Exercise: With Special Reference to Its Influence Upon the Excretion of Nitrogen*. New York: Appleton-Century-Crofts; 1871.
100. Flint A Jr. *On the Source of Muscular Power*. New York: Appleton; 1878.
101. Hartwell EM. *On the physiology of exercise (part 1)*. *Boston Med Surg J*. 1887;116:297–302.
102. Hartwell EM. *On the physiology of exercise (part 2)*. *Boston Med Surg J*. 1887;116:321–324.
103. Kolb G. *Physiology of Sport*. 2nd ed. London: Krohne & Sesemann; 1893.
104. Lagrange F. *Physiology of Bodily Exercise*. New York: Appleton; 1893.
105. Fitz GW. *American physical education review, 1897*;2:56. In: McArdle WA, Katch FI, Katch VL. *Exercise Physiology*. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2001.
106. McArdle WA, Katch FI, Katch VL. *Exercise Physiology*. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2001.
107. Park RJ. *The rise and demise of Harvard's B.S. program in anatomy, physiology, and physical training: a case of conflicts of interest and scarce resources*. *Res Quart Exerc Sport*. 1992;63:246–260.
108. Buskirk ER, Tipton CM. *Exercise physiology*. In: Massengale JD, Swanson RA, eds. *The History of Exercise and Sport Science*. Champaign, IL: Human Kinetics; 1997:367–438.
109. Geppert J, Zuntz N. *Über die Regulation der Atmung*. *Arch Ges Physiol*. 1888;42:189–244.
110. Johansson JE. *Über die Einwirkung der Muskelthatigkeit auf die Athmung und die Herzthatigkeit*. *Skan Arch Physiol*. 1893;5:20–66.
111. Krogh A, Lindhard J. *The regulation of respiration and circulation during the initial stages of muscular work*. *J Physiol (Lond)*. 1904;31:112–133.
112. Herring HE. *Über die Beziehung der extracardialen Herznerven zur Steigerung der Herzschlagzahl bei Muskelthatigkeit*. *Pflügers Arch Ges Physiol*. 1895;40:429–492.
113. Bowen WP. *Changes in heart-rate, blood pressure, and duration of systole resulting from bicycling*. *Am J Physiol*. 1904;11:59–77.
114. Gasser HS, Meek WJ. *A study of the mechanisms by which muscular exercise produces acceleration of the heart*. *Am J Physiol*. 1914;34:48–71.
115. Cannon WB, de la Paz D. *Emotional stimulation of adrenal secretion*. *Am J Physiol*. 1911;28:64–70.
116. Park RJ. *Physiologists, physicians, and physical educators: nineteenth century biology and exercise, hygienic and educative*. *J Sport Hist*. 1987;14:28–60.
117. Mosso A. *Fatigue*. Drummond M, Drummond WB, trans-ed. London: George Allen & Unwin; New York: Putnam's Sons; 1915.
118. Waller A. *The sense of effort: an objective study*. *Brain*. 1891;14:179–249.
119. Hough T. *Ergographic studies in muscular soreness*. *Am J Physiol*. 1902;7:76–92.
120. Hough T. *Ergographic studies in neuromuscular fatigue*. *Am J Physiol*. 1901;5:240–265.
121. Ryffel JH. *Experiment on lactic acid formation in man*. *J Physiol (Lond)*. 1910;39:xxix–xxxii.
122. Hill AV. *The absolute mechanical efficiency of the contraction of an isolated muscle*. *J Physiol (Lond)*. 1913;46:435–469.
123. Morpurgo B. *Über Activitäts-Hypertrophie der wirklichen Muskeln*. *Virchows Arch*. 1897;150:522–544.
124. Hedvall B. *Fatigue and training*. *Skan Arch Physiol*. 1915;32:115.
125. Lowsley OS. *The effects of various forms of exercise on systolic, diastolic and pulse pressures and pulse rate*. *Am J Physiol*. 1911;27:446–466.
126. Hill L. *Arterial pressure in man while sleeping, resting, working, bathing*. *J Physiol (Lond)*. 1898;22:xxvi–xxx.
127. McCurdy JH. *The effect of maximum muscular effort on blood-pressure*. *Am J Physiol*. 1901;5:95–103.
128. Hooker DR. *The effect of exercise on venous blood pressure*. *Am J Physiol*. 1911;28:235–247.
129. Rowell LB. *The cardiovascular system*. In: Tipton CM, ed. *Exercise Physiology: People and Ideas*. New York: Oxford University; 2003:98–137.
130. Zuntz N, Hagermann O. *Untersuchungen über den Stoffwechsel des Pferdes bei Ruhe und Arbeit*. *Landw Jb*. 1898;27(Erganz Bd 3):371–412.
131. Lindhard J. *Über das Minutenvolumen des Herzens bei Ruhe und bei Muskelarbeit*. *Pflügers Arch*. 1915;161:233–383.
132. Williamson CS. *The effects of exercise on the normal and pathological heart: based on the study of one hundred cases*. *Am J Med Sci*. 1915;149:492–503.
133. Chauveau A, Kaufman M. *Expériences pour la détermination du coefficient de l'activité nutritive et respiratoires des muscles en repos et en travail*. *C R Acad Sci (Paris)*. 1887;104:1126.
134. Krogh A. *The supply of oxygen to the tissues and the regulation of the capillary circulation*. *J Physiol (Lond)*. 1919;52:457–474.
135. Darling E. *The effects of training: a study of the Harvard University crew*. *Boston Med Surg J*. 1899;141:229–233.
136. Darling E. *The effects of training: second paper*. *Boston Med Surg J*. 1901;144:550–559.
137. Chapman CB. *Edward Smith (? 1818–1874) physiologist, human ecologist, reformer*. *J Hist Med Allied Sci*. 1967;22:1–26.
138. Smith E. *Inquiries into the quantity of air inspired throughout the day and night and under the influence of exercise, food, medicine, temperature*. *Proc Royal Soc*. 1857;8:451–454.
139. Smith E. *Experimental inquiries into the chemical and other phenomena of respiration, and their modifications by various physical agencies*. *Phil Trans*. 1859;149:681–714.
140. Douglas CG, Haldane JS. *The capacity of the air passages under varying physiological conditions*. *J Physiol (Lond)*. 1912;45:235–238.
141. Hough T. *The influence of muscular activity upon the alveolar tensions of oxygen and carbon dioxide*. *Am J Physiol*. 1912;30:18–36.
142. Douglas CG, Haldane JS. *The regulation of breathing*. *J Physiol (Lond)*. 1908;38:420–440.
143. Krogh M. *The diffusion of gases through the lungs of man*. *J Physiol (Lond)*. 1915;49:271–300.
144. Benedict FG, Cathcart EF. *Muscular Work*. Washington: Carnegie Institute of Washington; 1913.
145. Katzenstein G. *Über die Einwirkung der Muskelthatigkeit auf den Stoffverbrauch des Menschen*. *Pflügers Arch Ges Physiol*. 1891;49:330–404.

146. Chauveau A. Source et nature du potentiel directment utilisé dans le travail musculaire, d'après les échanges respiratoires, chez l'homme en état d'abstinence. *C R Acad Sci (Paris)* . 1896;122:1163–1221.
147. Mitchell JK. The effect of massage on the number and hemoglobin value of red blood cells. *Am J Med Sci* . 1894;107:502–515.
148. Zuntz N, Schumberg W. *Studien zu einer Physiologie des Marsches* . Berlin: Hirschwald; 1901.
149. Hawk PB. On the morphological changes in the blood after muscular exercise. *Am J Physiol* . 1904;10:384–400.
150. Schneider EC, Havens LC. Changes in the blood after muscular activity and during training. *Am J Physiol* . 1915;36:239–259.
151. Boothby W, Berry FB. The effect of work on the percentage of haemoglobin and numbers of red corpuscles in the blood. *Am J Physiol* . 1915;37:378–382.
152. Krogh A. On the combination of hemoglobin with mixtures of oxygen and carbonic oxide. *Skand Arch Physiol* . 1910;23:217–223.
153. Barcroft J, Peters RA, Roberts FF, et al. The effect of exercise on the dissociation curve of blood. *J Physiol (Lond)* . 1912;45:xiv.
154. Renbourn ET. The history of sweat and the sweat rash from the earliest times to the end of the 18th century. *J Hist Med Allied Sci* . 1959;14:202–227.
155. Maclaren A. *Training in Theory and Practice* . London: Macmillan; 1866.
156. Hunt EH. The regulation of body temperature in extremes of dry heat. *J Hygiene* . 1912;12:479–488.
157. Pembry MS, Nicol BA. Observations upon the deep and surface temperature of the human body. *J Physiol (Lond)* . 1898;23:386–406.
158. Barauch JH. Physiological and pathological effects of severe exertion (the marathon race). *Am Phys Ed Rev* . 1912;16:1–11,144–150,200–205,262–268,325–334.
159. Von Leube W. Über die ausscheidung von eiweiss im harn gesunden Menschen. *Virchow Archiv Pathol Anat Physiol Klin Med* . 1878; 72:145–157.
160. Baldes, Heishelheim, Metzger. Untersuchungen über den einfluss grosser koperanstrengungen auf zirkulationapparat, nieren und nervensystem. *Muenchen Med Wschr* . 1906;53:1865–1866.
161. Carlson AJ. *The Control of Hunger in Health and Disease* . Chicago: University of Chicago; 1916.
162. Jacoby C. Beiträge zur physiologischen und pharmakologischen Kenntniss der Darmbewegungen mit besonderer Berücksichtigung der Beziehung der Nebenniere zu denselben. *Arch Exp Pathol Pharmacol* . 1892;29:71–211.
163. Oliver G, Schafer EA. The physiological effects of extracts of the suprarenal capsules. *J Physiol (Lond)* . 1895;18:230–276.
164. Cannon WB, Nice LB. The effect of adrenal secretion on muscular fatigue. *Am J Physiol* . 1913;32:44–60.
165. Brown-Sequard CE. Recherches expérimentales sur la physiologie et la pathologie des capsules surrenales. *C R Acad Sci* . 1856;43:422–425.
166. Paul WE. *Fundamental Immunology* . 3rd ed. New York: Raven Press; 1993.
167. Jokl E. *Physiology of Exercise* . Springfield, IL: Charles C. Thomas; 1964.
168. McKinze RT. *Exercise in Education and Medicine* . Philadelphia: Saunders; 1910.

Chapter 2

1. Licher RL. *Skeletal Muscle Structure and Function*. Baltimore: Williams & Wilkins; 1992:303.
2. Roy RR, Edgerton VR. Skeletal muscle architecture and performance In: Komi PV, ed. *Strength and Power in Sport: Encyclopedia of Sports Medicine*. Oxford: Blackwell Scientific Publications; 1992:115–129.
3. Bodine-Eowler S, Garfinkel A, Roy RR, et al. Spatial distribution of muscle fibers within the territory of a motor unit. *Muscle Nerve*. 1990; 13: 1133–1145.
4. Burke RE, Levine DN, Tsairis P, et al. Physiological types and histochemical profiles in motor units of the cat gastrocnemius. *J Physiol*. 1973;234:723–74B.
5. PeterJB, Barnard RJ, EdgertonVR, et al. Metabolic profiles of three fiber types of skeletal muscle in guinea pigs and rabbits. *Biochemistry*. 1972;11:2627–2633.
6. Ounjian M, Roy RR, Eldred fi, et al. Physiological and developmental implications of motor unit anatomy. *J Neurobiol*. 1991 ;22:547–559.
7. Bodine SC, Garfinkel A, Roy RR, et al. Spatial distribution of motor unit fibers in the cat soleus and tibialis anterior muscles: local interactions. *J Neurosci*. 1988;8:2142–2152.
8. Ishihara A, Roy RR, Edgerton VR. Succinate dehydrogenase activity and soma size of motoneurons innervating different portions of the rat tibialis anterior. *Neuroscience*. 1995;68:813–822.
9. Henneman E, Mendell EM. Eunctional organization of motoneuron pool and its input. In: Mountcastle JM, Brooks VB, eds. *Handbook of Physiology, Section 1, Vol. II, The Nervous System, Motor Control, Part 1*. Bethesda, MD: American Physiological Society; 1981:423–507.
10. Henneman E, Olson Cf. Relations between structure and function in the design of skeletal muscles. *JNeurophysiol*. 1965;28:581–598.
11. Henneman E, Somjen G, Carpenter DO. Eunctional significance of cell size in spinal motoneurons. *JNeurophysiol*. 1965;28:560–580.
12. Cope TC, Clark BD. Motor-unit recruitment in the decerebrate cat: several unit properties are equally good predictors of order. *J Neurophysiol*. 1991;66:1127–1138.
13. Pinter MJ, Curtis RL, Hosko MJ. Voltage threshold and excitability among variously sized cat hindlimb motoneurons. *J Neorophysiol*. 1983;50:644–657.
14. Kukulka CG, Clamann HR. Comparison of the recruitment and discharge properties of motor units in human brachial biceps and adductor pollicis during isometric contractions. *Brain Res*. 1981;219:45–55.
15. Burke RE, Rudomin R, Zajac FE III. Catch property in single mammalian motor units. *Science*. 1970;168: 122–124.
16. Burke RE, Rudomin P, Zajac FE III. The effect of activation history on tension production by individual muscle units. *Brain Res*. 1976;109:515–529.
17. Van Cutsem M, Duchateau J, Hainaut K. Changes in single motor unit behaviour contribute to the increase in contraction speed after dynamic training in humans. *J Physiol*. 1998;513 (pt 1):295–305

18. Enoka RM, Euglevand AJ. Motor unit physiology: some unresolved issues. *Muscle Nerve*. 2001 ;24:4—17.
19. Stephens JA, Garnett R, Buller NP. Reversal of recruitment order of single motor units produced by cutaneous stimulation during voluntary muscle contraction in man. *Nature*. 1978;272:362—364.
20. Desmedt JE, Godaux E. Fast motor units are not preferentially activated in rapid voluntary contractions in man. *Nature*. 1977;267:717—719.
21. Nardone A, Romano C, Schieppati M. Selective recruitment of high-threshold human motor units during voluntary isotonic lengthening of active muscles. *J Physiol*. 1989;409:451—471.
22. Smith JL, Betts B, Edgerton VR, et al. Rapid ankle extension during paw shakes: selective recruitment of fast ankle extensors. *J Neurophysiol*. 1980;43:612—620.
23. Eallentin N, Jorgensen K, Simonsen EB. Motor unit recruitment during prolonged isometric contractions. *Eur J Appl Physiol Occup Physiol*. 1993;67:335—341.
24. Tamaki H, Kitada K, Akamine T, et al. Alternate activity in the synergistic muscles during prolonged low-level contractions. *J Appl Physiol*. 1998;84:t943—1951.
25. Bawa P, Pang MY, Olesen KA, et al. Rotation of motoneurons during prolonged isometric contractions in humans. *J Neurophysiol*. 2006;96:1135—1140.
26. Bodine SC, Roy RR, Meadows DA, et al. Architectural, histochemical, and contractile characteristics of a unique biarticular muscle: the cat semitendinosus. *J Neurophysiol*. 1982;4B:192—201.
27. English AW. An electromyographic analysis of compartments in cat lateral gastrocnemius muscle during unrestrained locomotion. *J Neurophysiol*. 1984;52:114—125.
28. Akima H, Ito M, Yoshikawa H, et al. Recruitment plasticity of neuromuscular compartments in exercised tibialis anterior using echo-planar magnetic resonance imaging in humans. *Neurosci Lett*. 2000;296:133—136.
29. Garfinkel S, Cafarelli E. Relative changes in maximal force, EMG, and muscle cross-sectional area after isometric training. *Med Sci Sports Exerc*. 1992;24(11):1220—1227.
30. Herbert RD, Dean D, Gandevia SC. Effects of real and imagined training on voluntary muscle activation during maximal isometric contractions. *Acta Physiol Scand*. 1998;163:361—368.
31. Huber A, Suter E, Herzog W. Inhibition of the quadriceps muscles in elite male volleyball players. *J Sports Sci*. 1998;16:28t—289.
32. Knight CA, Kamen G. Adaptations in muscular activation of the knee extensor muscles with strength training in young and older adults. *J Electromyogr Kinesiol*. 2001;t 1f6):405—412.
33. Pensini M, Martin A, Matfieuette NA. Central versus peripheral adaptations following eccentric resistance training. *Int J Sports Med*. 2002;23(8):567—574.
34. Cope TC, Sokoloff AJ. Orderly recruitment among motoneurons supplying different muscles. *J Physiol Paris*. 1999;93:81—85.
35. Grillner S. Control of locomotion in bipeds, tetrapods, and fish. In: Brookhart JM, Mountcastle VB, eds. *Handbook of Physiology, Section 1, Vol. II, The Nervous System, Motor Control, Part 1*. Bethesda, MD: American Physiological Society; 1981:1179—1236.
36. Shik ML, Orlovsky GN. Neurophysiology of locomotor automatism. *Physiol Rev*. 1976;56:465—501.
37. Halbertsma JM. The stride cycle of the cat: the modelling of locomotion by computerized analysis of automatic recordings. *Acta Physiol Scand Suppl*. 1983;521:1—75.
38. Goslow GE Jr, Reinking RM, Stuart DG. The cat step cycle: hind limb joint angles and muscle lengths during unrestrained locomotion. *J Morphol*. 1973;141:1—41.
39. Hoyt D, Taylor R. Gait and the energetics of locomotion in horses. *Nature*. 1981;292:239—240.
40. Whiting WC, Gregor RJ, Roy RR, et al. A technique for estimating mechanical work of individual muscles in the cat during treadmill locomotion. *J Biomech*. 1984;17:685—694.
41. Gregor RJ, Roy RR, Whiting WC, et al. Mechanical output of the cat soleus during treadmill locomotion: in vivo vs in situ characteristics. *J Biomech*. 1988;21:721—732.
42. Teach PA, Dudley GA, Duvoisin MR, et al. Force and EMG signal patterns during repeated bouts of concentric or eccentric muscle actions. *Acta Physiol Scand*. 1990;138:263—271.
43. Ryschon TW, Fowler MD, Wyssong RE, et al. Efficiency of human skeletal muscle in vivo: comparison of isometric, concentric, and eccentric muscle action. *J Appl Physiol*. 1997;83:867—874.
44. Vollestad NK, Vaage O, Hermansen L. Muscle glycogen depletion patterns in type I and subgroups of type II fibres during prolonged severe exercise in man. *Acta Physiol Scand*. 1984;122:433—441.
45. Vollestad NR, Blom PC. Effect of varying exercise intensity on glycogen depletion in human muscle fibres. *Acta Physiol Scand*. 1985;125:395—405.
46. Edgerton VR, Tillakaratne N, Bigbee A, et al. Plasticity of spinal circuitry after injury. *Anon Rev Neurosci*. 2004;27:145—167.
47. Parker D, Grillner S. Neuronal mechanisms of synaptic and network plasticity in the lamprey spinal cord. *Prog Brain Res*. 2000;125:381—398.
48. Peldman JL, Mitchell CS, Nattie EE. Breathing: rhythmicity, plasticity, chemosensitivity. *Anon Rev Neurosci*. 2003;26:239—266.
49. Edgerton VR, Grillner S, Sjöström A, et al. Central generation of locomotion in vertebrates. In: Herman RM, Grillner S, Stein PSG, Stuart DG, eds. *Neural Control of Locomotion*. New York: Plenum Publishing Corporation; 1976:439—464.
50. Lovely RO, Gregor RJ, Roy KR, et al. Effects of training on the recovery of full-weight-bearing stepping in the adult spinal cat. *Exp Neural*. 1986;92:421—435.
51. Porssberg H. Stumbling corrective reaction: a phase-dependent compensatory reaction during locomotion. *J Neurophysiol*. 1979;42:936—953.
52. Edgerton VR, Leon RD, Harkema SJ, et al. Retraining the injured spinal cord. *J Physiol*. 2001;533:15—22.
53. Hodgson JA, Roy RR, de Leon R, et al. Can the mammalian lumbar spinal cord learn a motor task? *Med Sci Sports Exerc*. 1994;6:1491—1497.

54. Hutton RS, Atwater SW. Acute and chronic adaptations of muscle proprioceptors in response to increased use. *Sports Med.* 1992;14:406—421.
55. Prochazka A. *Proprioceptive Feedback and Movement Regulation.* New York: Oxford University Press; 1996:89—127.
56. Nelson SC, Mendell LM. Projection of single knee flexor Ia fibers to homonymous and heteronymous motoneurons. *J Neurophysiol.* 1978;41:778—787.
57. Botterman B, Binder M, Stuart D. Functional anatomy of the association between motor units and muscle receptors. *Am Zool.* 1978; 18: 135—152 .
58. Andersson O, Porssberg H, Crillner S, et al. Phasic gain control of the transmission in cutaneous reflex pathways to motoneurons during 'fictive' locomotion. *Brain Res.* 1978;149:503—507.
59. Nichols IR. Receptor mechanisms underlying heterogenic reflexes among the triceps surae muscles of the cat.] *Neurophysiol.* 1999;81:467—478.
60. Capaday C. The special nature of human walking and its neural control. *Trends Neurosci.* 2002;25:370—376.
61. Simonsen LB, Dyhre-Poulsen R Amplitude of the human soleus H reflex during walking and running.] *Physiol.* 1999;515 (pt 3):929—939.
62. Harkema SJ, Hurley SL, Patel UK, et al. Human lumbosacral spinal cord interprets loading during stepping.] *Neurophysiol.* 1997;77:797—811.
63. Edgerton VR, Roy RR, de Leon RD. Neural darwinism in the mammalian spinal cord. In: Grau JW, Patterson MM, eds. *Spinal Cord Plasticity: Alterations in Reflex Function.* Boston: Kluwer Academic Publishers; 2001:185—206.
64. Prochazka A, Corassini M. Ensemble firing of muscle afferents recorded during normal locomotion in cats.] *Physiol.* 1998;507 (pt 1):293—304.
65. Edgerton VR, de Cuzman CP, Cregor Rj, et al. Trainability of the spinal cord to generate hindlimb stepping patterns in adult spinalized cats. In: Shimamura M, Crillner S, Edgerton VR, eds. *Neurobiological Basis of Human Locomotion.* Tokyo: Japan Scientific Societies Press; 1991:411—423.
66. Orlovsky C, Deliagina T, Crillner S. *Neuronal Control of Locomotion: From Mollnar to Mon.* Oxford: Oxford University Press; 1999.
67. Crillner S. The motor infrastructure: from ion channels to neuronal networks. *Nat Rev Neurosci.* 2003;4:573—586.
68. Vilensky JA, Moore AM, Eidelberg E, et al. Recovery of locomotion in monkeys with spinal cord lesions.] *Mot Behav.* 1992;24:288—296.
69. Shik ML, Orlovskii ON, Severin PV. Organization of locomotor synergism. *Biofizika.* 1996;11:879—886.
70. Harkema Si. Neural plasticity after human spinal cord injury: application of locomotor training to the rehabilitation of walking. *Neuroscientist.* 2001;7:455—468.
71. Wernig A, Muller S. Laufband locomotion with body weight support improved walking in persons with severe spinal cord injuries. *Paraplegia.* 1992;30:229—238.
72. Eagleman DM. Neuroscience. The where and when of intention. *Science.* 2004;303:1144—1146.
73. Baev K. *Biological Neural Networks: The Hierarchical Concept of Brain Function.* Boston: Birkhauser; 1998.
74. Sirota MG, Shik ML. The cat locomotion elicited through the electrode implanted in the mid-brain. *Sechenov Physiological Journal of the USSR.* 1973;59:1314—1321.
75. Gerasimenko YP, Avelev VO, Nikitin OA, et al. Initiation of locomotor activity in spinal cats by epidural stimulation of the spinal cord. *Neurosci Behav Physiol.* 2003;33:247—254.
76. Oimitrijevic MR, Cerasimenko Y, Pinter MM. Evidence for a spinal central pattern generator in humans. *Ann N Y Acad Sci.* 1998;860:360—376.
77. Crillner S, Lkeberg A, El Manira A, et al. Intrinsic function of a neuronal network vertebrate central pattern generator. *Brain Res Brain Res Rev.* 1998;26:184—197.
78. Prochazka A, Critsenko V, Yakovenko S. Sensory control of locomotion: reflexes versus higher-level control. *Adv Exp Med Biol.* 2002;508:357—367.
79. Timoszyk WK, De Leon RD, London N, et al. The rat lumbosacral spinal cord adapts to robotic loading applied during stance.] *Neurophysiol.* 2002;88:3108—3117.
80. de Leon RO, Reinkensmeyer QI, Timoszyk WK, et al. Use of robotics in assessing the adaptive capacity of the rat lumbar spinal cord. In: McKerracher L, Doucet C, Rossignol S, eds. *Progress in Brain Research.* Netherlands: Elsevier Science B.V.; 2002:141—149.
81. Jindrich DL, Joseph MS, Otsoshi CR, et al. Spinal learning in the adult mouse using the Horridge paradigm.] *Neurosci Meth.* 2009;182:250—254.
82. Carraway SM, Hochman S. Serotonin increases the incidence of primary afferent-evoked long-term depression in rat deep dorsal horn neurons.] *Neurophysiol.* 2001;85:1864—1872.
83. de Leon RD, Hodgson JA, Roy RR, et al. Full weight-bearing hindlimb standing following stand training in the adult spinal cat.] *Neurophysiol.* 1998;80:83—91.
84. de Leon RD, Hodgson JA, Roy KR, et al. Locomotor capacity attributable to step training versus spontaneous recovery after spinalization in adult cats.] *Neurophysiol.* 1998;79: 1329—40.
85. de Leon RD, Hodgson JA, Roy KR, et al. Retention of hindlimb stepping ability in adult spinal cats after the cessation of step training.] *Neurophysiol.* 1999;81:85—94.
86. Courtine C, Cerasimenko YP, van den Brand R, et al. Transformation of nonfunctional spinal circuits into functional and adaptive states after the loss of brain input. *Nature Neurosci.* 2009;12:1333—1342.
87. Gandevia SC, Petersen N, Butler JE, et al. Impaired response of human motoneurons to corticospinal stimulation after voluntary exercise.] *Physiol.* 1999;521 (pt 3):749—759.
88. Andersen B, Westlund B, Krarup C. Failure of activation of spinal motoneurons after muscle fatigue in healthy subjects studied by transcranial magnetic stimulation.] *Physiol.* 2003;551:345—356.
89. Asmussen F, Mazin B. Recuperation after muscular fatigue by "diverting activities." *Exp Appl Physiol Occup Physiol.* 1978;38:1—7.
90. Todd C, Taylor JL, Gandevia SC. Measurement of voluntary activation of fresh and fatigued human muscles using transcranial magnetic

stimulation.] *Physiol.* 2003;551 :661—671.

91. Enoka KM, Stuart DC. Neurobiology of muscle fatigue.] *Appl Physiol.* 1992;72:1631—1648.

92. Garland SJ. Role of small diameter afferents in reflex inhibition during human muscle fatigue.] *Physiol.* 1991;435:547—558.

93. Davis JM, Bailey SP. Possible mechanisms of central nervous system fatigue during exercise. *Med Sri Sports Exerc* 1997;9:45—57.

94. Dishman KR. Brain monoamines, exercise, and behavioral stress: animal models. *Med Sri Sports Exerc.* 1997;29:63—74.

95. Germ C, Becquet D, Privat A. Direct evidence for the link between monoaminergic descending pathways and motor activity, I: a study with microdialysis probes implanted in the ventral funiculus of the spinal cord. *Brain Res.* 1995;704:191—201.

96. Dwyer D, Browning J. Endurance training in Wistar rats decreases receptor sensitivity to a serotonin agonist. *Arta Physiol Sraod.* 2000 ; 170 :211—216.

97. Weicker H, Struder HK. Influence of exercise on serotonergic neuromodulation in the brain. *Amino Acids.* 2001;20:35—47.

98. Chennaoui M, Drogou C, Gomez-Merino D, et al. Endurance training effects on 5-HT(1B) receptors mRNA expression in cerebellum, striatum, frontal cortex and hippocampus of rats. *Neurosci Lett.* 2001 307:33—36.

99. Tumer N, Demirel HA, Serova L, et al. Gene expression of catecholamine biosynthetic enzymes following exercise: modulation by age. *Neuroscience.* 2001;103:703—711.

100. De Souza CG, Michelini LC, Fior-Chadi DR. Receptor changes in the nucleus tractus solitarius of the rat after exercise training. *Med Sri Sports Exerc.* 2001 33:1471—1476.

101. Jasmin BJ, Lavoie PA, Gardiner PF. Fast axonal transport of labeled proteins in motoneurons of exercise-trained rats. *AmJ Physiol.* 1988;255:C731—C736.

102. Jasmin BJ, Lavoie PA, Gardiner PF. Fast axonal transport of acetylcholinesterase in rat sciatic motoneurons is enhanced following prolonged daily running, but not following swimming. *Neurosci Lett.* 1987;78:156—160.

103. Roy RR, Baldwin KM, Edgerton VR. The plasticity of skeletal muscle: effects of neuromuscular activity. In: Holloszy J, ed. *Exercise and Sports Sciences Reviews.* Baltimore: Williams and Wilkins; 1991:269—312.

104. Martin TP, Bodine-Fowler S, Roy RR, et al. Metabolic and fiber size properties of cat tibialis anterior motor units. *AmJ Physiol.* 1988;255:C43—C50.

105. Burke RE, Edgerton VR. Motor unit properties and selective involvement in movement. *Exerc Sport Sci Rev.* 1975;3:31—81.

106. Edgerton VR, Goslow GE Jr., Rasmussen SA, et al. Is resistance of a muscle to fatigue controlled by its motoneurons? *Nature.* 1980;285:589—590.

107. Cope TC, Bodine SC, Fournier M, et al. Soleus motor units in chronic spinal transected cats: physiological and morphological alterations. *J Neurophysiol.* 1986;55: 1202—1220.

108. Roy RR, Zhong H, Hodgson JA, et al. Influences of electromechanical events in deforming skeletal muscle properties. *Muscle Nerve.* 2002;26:238—251.

109. Winiarski AM, Roy RR, Alford FR, et al. Mechanical properties of rat skeletal muscle after hind limb suspension. *Exp Neural.* 1987;96:650—660.

110. Shields RK. Fatigability, relaxation properties, and electromyographic responses of the human paralyzed soleus muscle. *J Neurophysiol.* 1995;73:2195—2206.

111. Alaimo MA, Smith JL, Roy RR, et al. EMG activity of slow and fast ankle extensors following spinal cord transection. *J Appl Physiol.* 1984;56:1608—1613.

112. Hensbergen E, Kernell D. Daily durations of spontaneous activity in cat's ankle muscles. *Exp Brain Res.* 1997;115:325—332.

113. Roy KR, Zhong H, Monti RJ, et al. Mechanical properties of the electrically silent adult rat soleus muscle. *Muscle Nerve.* 2002;26:404—412.

114. Hodgson JA, Wichayanuparp S, Recktenwald MR, et al. Circadian force and FMG activity in hindlimb muscles of rhesus monkeys. *J Neurophysiol.* 2001;86:1430—1444.

115. Edgerton VR, McCall GE, Hodgson JA, et al. Sensorimotor adaptations to microgravity in humans. *J Exp Biol.* 2001;204:3217—3224.

116. Hodgson JA, Roy RR, Higuchi N, et al. Does daily activity level determine muscle phenotype? *J Exp Biol.* 2005;208:3761—3770.

117. Edelman GM. *Neural Darwinism: The Theory of Neuronal Group Selection.* New York: Basic Books Inc.; 1987.

118. Durkovic RG, Damianopoulos FN. Forward and backward classical conditioning of the flexion reflex in the spinal cat. *J Neurosci.* 1986;6:2921—2925.

119. Buerger AA, Fennessy A. Learning of leg position in chronic spinal rats. *Nature.* 1970;225:751—752.

120. Grau JW, Joyes RL. Pavlovian and instrumental conditioning within the spinal cord: methodological issues. In: Patterson JWE, ed. *Spinal Cord Plasticity: Alterations in Reflex Function.* Boston, MA: Kluwer - Academic Publishers; 1977.

121. Ncsmeyanova T. *Experimental Studies in Regeneration of Spinal Neurons.* New York: John Wiley & Sons; 1977.

122. Shurrager P, Cnller F. Conditioning in the spinal dog. *J Exp Psychol.* 1940;26:133—159.

123. Barbeau H, Rossignol S. Recovery of locomotion after chronic spinalization in the adult cat. *Brain Res.* 1987;412:84—95.

124. Lovely RG, Gregor RJ, Roy RR, et al. Weight-bearing hindlimb stepping in treadmill-exercised adult spinal cats. *Brain Res.* 1990;514:206—218.

125. Wolpaw JR, Tennissen AM. Activity-dependent spinal cord plasticity in health and disease. *Annu Rev Neurosci.* 2001;24:807—843.

126. Beaumont E, Gardiner R. Effects of daily spontaneous running on the electrophysiological properties of hindlimb motoneurons in rats. *J Physiol.* 2002;540:129—138.

127. Kording KP, Wolpert DM. Bayesian integration in sensorimotor learning. *Nature.* 2004;427:244—247.

128. Scheidt RA, Dingwell JB, Mussa-Ivaldi FA. Learning to move amid uncertainty. *J Neurophysiol.* 2001;86:971—985.

129. Yue G, Cole KJ. Strength increases from the motor program: comparison of training with maximal voluntary and imagined muscle contractions. *J Neurophysiol.* 1992;67:1114—1123.

130. Hortobagyi T, Lambert NJ, Hill JR Greater cross education following training with muscle lengthening than shortening. *Med Sri Sports Exere.* 1997;29:107—112.
131. Hortobagyi T, Scott K, Lambert J, et al. Cross-education of muscle strength is greater with stimulated than voluntary contractions. *Motor Control.* 1999;3:205—219.
132. Zhou S. Chronic neural adaptations to unilateral exercise: mechanisms of cross education. *Exere Sport Sri Rev.* 2000;28:177—184.
133. Lee M, Gandevia SC, Carroll TJ. Unilateral strength training increases voluntary activation of the opposite untrained limb. *Chn Neurophysiol.* 2009;120:802—808.
134. Leonard CT, Kane J, Perdaems J, et al. Neural modulation of muscle contractile properties during fatigue: afferent feedback dependence. *Electroenrephalogr Clin Neurophysmol.* 1994;93(3):209—217.
135. Duchateau J, Hainaut K. Behaviour of short and long latency reflexes in fatigued human muscles. *J Physmol.* 1993;471:787—799.
136. DuchateauJ, Balestra C, Carpentier A, et al. Reflex regulation during sustained and intermittent submaximal contractions in humans. *J Physmal.* 2002;541(3):959—967.
137. Aagaard P. Training-induced changes in neural function. *Exere Sport Sri Rev.* 2003;31:61—67.
138. Casabona A, Polizzi MC, Perciavalle V. Differences in H-reflex between athletes trained for explosive contractions and non- trained subjects. *EurJAppI Physmol Orrup Physiol.* 1990;61:26—32.
139. Gandevia SC. Mind, muscles and motoneurons. *JSri Med Sport.* 1999;2:167—180.
140. CooteJH, Hilton SM, Perez-GonzalezJP. The reflex nature of the pressor response to mnsclular exercise. *J Physiol.* 1971;215:789—804.
141. McCloskey DI, Mitchell JH. Reflex cardiovascular and respi ratory responses originating in exercising muscle. *J Physmol.* 1972;224:173—186.
142. Kaufman MP, Rybicki KJ. Discharge properties of group III and IV muscle afferents: their responses to mechanical and metabolic stimuli. *Cire Res.* 1987;61:160—165.
143. Rotto DM, Kaufman MR Effect of metabolic products of muscular contraction on discharge of group III and IV afferents. *J AppI Physmal.* 1988;64:2306—2313.
144. Martin PG, SmmthJL, BotlerJE, et al. Patigue-sensitive afferents inhibit extensor but not flexor motorneurons in humans. *J Neuman.* 2006;26(18):4796—4802.
145. TaylorJL, Gandevia SC. A comparison of central aspects nf fatigue in submaximal and maximal voluntary contractions. *JAppI Physmol.* 2008;104:542—55fl.
146. VissioJ, Andersen M, Diemer NH. Exercise-induced changes in local cerebral glucose utilization in the rat. *J Cereb Blood Flow Metah* 1996;16:729—736.
147. Carroll TJ, Barry B, Riek S, et al. Resistance training enhances the stability of sensorimotor coordination. *Pror R Sor Land B Bmol Sri.* 2001;268:221—227.
148. Cohen LG, Zmemann U, Chen R, et al. Studies nf neuroplasticity with transcranial magnetic stimulation. *J Clin Neuraphysmal.* 1998;15:305—324.
149. Nudo RJ, Milliken GW, Jenkins WM, et al. Use-dependent alterations of movement representations mn primary motor cortex of.
150. Jenkms IH, Brooks DJ, Nixon PD, el al. Motor sequence learning: a study with positron emission tomography. *J Nettrosci.* 1994;14:3775—3790.
151. Dettmers C, Ridding MC, Stephan KM, et al. Comparison of regional cerebral blood Dow with transcranial magnetic stimulation at different forces.] *AppI Physiol.* 1996;81:596—603.
152. van Mier H, Tempel LW, PerlmutterJ, et al. Changes in brain activity during motor learning measured with PET: effects of band of performance and practice. *J Neurophysiol.* 1998;80:2 177—2 199.
153. Cramer SC, Weisskoff RM, SehaechterjD, et al. Motor cortex activation is related to force of squeezing. *Hum Brain Mapp.* 2002; 16: 197—205.
154. Karni A, Meyer G, Jezzard P, et al. Functional MRI evidence for adult motor cortex plasticity during motor skill learning. *Nature.* 1995;377:155—158.
155. Fascual-Leone A, Nguyet D, Cohen LG, et al. Modulation of muscle responses evoked by transcranial magnetic stimulation during the acquisition of new fine motor skills. *J Neurophysiol.* 1995;74:1037—1045.
156. Pearce AJ, Thiekbroom GW, Byrnes ML, et al. Functional reor ganisation of the corticomotor projection to the hand in skilled racquet players. *Exp Brain Res.* 2000;130:238—243.
157. Patten C, Kamen G. Adaptations in motor unit discharge activity with force control training in young and older human adults. *EurJ AppI Physiol.* 2000;83:128—143.
158. Suzuki S, Hayami A, Suzuki M, et al. Reductions in recruitment force thresholds in human single motor units by successive voluntary contractions. *Exp Brain Res.* 1990;82:227—230.
159. Akima H, Takahashi H, Kuno SY, et al. Early phase adaptations of muscle use and strength to isokinetic training. *Med Sri Sports Fxerc.* 1999;31:588—594.
160. Sale DG. Neural adaptation to resistance training. *Med Sei Sports Exerr.* 1988;20:S135—S145.
161. Milner-Brown HS, Stein RB, Lee RG. Synchronization of human motor units: possible roles of exercise and supraspinal reflexes. *Electroen-cephalogr Clin Neurophysiol.* 1975;38:245—254.
162. Upton A, Radford P. Motoneuron excitability in elite sprinters. In: Komi PV, cd. *fiomechanics V-A.* Baltimore: University Park Press; 1975:82—87.
163. Schmied A, Pagni S, Sturm H, et al. Selective enhancement of motoneurone short-term synchrony during an attention-demanding task. *Exp Brain Res.* 2000;133:377—390.
164. SemmlerjG, Kornatz KW, Dinunno DV, et al. Motor unit synchronisation is enhanced during slow lengthening contractions of a hand muscle.] *Phyaiol.* 2002;545:681—695.
165. SemmlerjG, Nordstrom MA. Motor unit discharge and force tremor in skill- and strength-trained individuals. *Exp Brain Res.* 1998;1

19:27—38.

166. Taylor AM, Steege JW, Enoka RM. Motor-unit synchronization alters spike-triggered average force in simulated contractions. *J Neurophysiol.* 2002;88:265—276.
167. Farmer SF, Bremner ED, Halliday DM, et al. The frequency content of common synaptic inputs to motoneurons studied during voluntary isometric contraction in man. *J Physiol.* 1993;470:127—155.
168. Ichiyama RM, Courtine G, Gerasimenko YP, et al. Step training reinforces specific spinal locomotor circuitry in adult spinal rats. *J Neurosci.* 2008;28:7370—7375.
169. Gomez-Pinilla P, Ying Z, Opazo P, et al. Differential regulation by exercise of BDNF and NT-3 in rat spinal cord and skeletal muscle. *Eur J Neurosci.* 2001;13:1078—1084.
170. Neeper SA, Gomez-Pinilla F, Choi J, et al. Exercise and brain neurotrophins. *Nature.* 1995;373:109.
171. van Praag H, Kempermann G, Gage FH. Running increases eED proliferation and neurogenesis in the adult mouse dentate gyrus. *Nat Neurosci.* 1999;2:266—270.
172. Kitamura T, Mishina M, Sugiyama H. Enhancement of neurogenesis by running wheel exercises is suppressed in mice lacking NMDA receptor epsilon 1 subunit. *Neurosci Res.* 2003;47:55—63.
173. Cotman CW, Berchtold NC. Exercise: a behavioral intervention to enhance brain health and plasticity. *Trends Neurosci.* 2002;25:295—301.
174. Lee TH, Jang MH, Shin MC, et al. Dependence of rat hippocampal c-Fos expression on intensity and duration of exercise. *Life Sci.*
175. Ivy AS, Rodriguez FG, Garcia C, et al. Noradrenergic and serotonergic blockade inhibits BDNF mRNA activation following exercise and antidepressant. *Pharmacol Biochem Behav.* 2003;75:81—88.
176. Anderson BJ, Alcantara AA, Greenough WT. Motor-skill learning: changes in synaptic organization of the rat cerebellar cortex. *Neurobiol Learn Mem.* 1996;66:221—229.
177. Swain RA, Harris AB, Wiener EC, et al. Prolonged exercise induces angiogenesis and increases cerebral blood volume in primary motor cortex of the rat. *Neuroscience.* 2003;117:1037—1046.
178. Ploughman M. Exercise is brain food: the effects of physical activity on cognitive function. *Dev Neurorehabil.* 2008;11:236—240.
179. Gomez-Pinilla P, Vaynman S, Ying Z. Brain-derived neurotrophic factor functions as a metabotrophin to mediate the effects of exercise on cognition. *Eur J Neurosci.* 2008;28:2278—2287.
180. Zoladz JA, Pile A, Majerczak J, et al. Endurance training increases plasma brain-derived neurotrophic factor concentration in young healthy men. *J Physiol Physiol-moral.* 2008;59 (suppl 7):119—132.
181. Griesbach GS, Hovda DA, Gomez-Pinilla F. Exercise-induced improvement in cognitive performance after traumatic brain injury in rats is dependent on BDNF activation. *Brain Res.* 2009;1288:105—115.
182. van den Broek M, Collins KA, Fitterling HL. Physical exercise and depression. *Mt Sinai J Med.* 2009;76:204—214.
183. Ying Z, Roy RR, Zhong H, et al. BDNF-exercise interactions in the recovery of symmetrical stepping after a cervical hemisection in rats. *Neuroscience.* 2008;155:1070—1078.
184. Gomez-Pinilla F, Dan L, So V. Physical exercise induces FGF-2 and its mRNA in the hippocampus. *Brain Res.* 1997;764:1—8.
185. Black JE, Isaacs KR, Anderson BJ, et al. Learning causes synaptogenesis, whereas motor activity causes angiogenesis, in cerebellar cortex of adult rats. *Proc Natl Acad Sci USA.* 1990;87:5568—5572.
186. Sherrington C. *The Integrative Action of the Nervous System.* New Haven: Yale University Press; 1906.
187. Edgerton VR, Bodine-Fowler S, Roy RR, et al. Neuromuscular adaptation. In: Shepherd JT, Rowell LB, eds. *Handbook of Physiology*. Section 12. Exercise: Regulation and Integration of Multiple Systems. New York: Oxford University Press; 1996:54—88.
188. Roy R, Edgerton VR, Ishihara A. Influence of endurance training and detraining on motoneuron and sensory neuron morphology and metabolism. In: Astrand RJS, editor. *Endurance in Sport*, Encyclopaedia of Sports Medicine. Oxford: Blackwell Scientific Publishers; 2000:136—157.
189. Roy RR, Matsumoto A, Zhong H, et al. Rat α - and γ -motoneuron soma size and succinate dehydrogenase activity are independent of neuromuscular activity level. *Muscle Nerve.* 2007;36:234—241.
190. Nakano H, Masuda K, Sasaki S, et al. Oxidative enzyme activity and soma size in motoneurons innervating the rat slow-twitch and fast-twitch muscles after chronic activity. *Brain Res Bull.* 1997;43:149—154.
191. Chalmers GR, Roy RR, Edgerton VR. Motoneuron and muscle fiber succinate dehydrogenase activity in control and overloaded plantaris. *J Appl Physiol.* 1991;71 :1589—1592.
192. Gerehman LB, Edgerton VR, Carr RW. Effects of physical training on the histochemistry and morphology of ventral motor neurons. *Exp Neurol.* 1975;49:790—801.
193. Seburn K, Coienu C, Gardiner R. Effects of altered muscle activation on oxidative enzyme activity in rat α -motoneurons. *J Appl Physiol.* 1994;77:2269—2274.
194. Munsat B, Pnehring RC, Mendell LM, et al. Fast-to-slow conversion following chronic low-frequency activation of medial gastrocnemius muscle in cats. II. Motoneuron properties. *J Neurophysiol.* 1997;77:2605—2615.
195. Roy RR, Talmadge RJ, Hodgson JA, et al. Training effects on soleus of cats spinal cord transected (T12—T13) as adults. *Muscle Nerve.* 1998;21:63—71.
196. Petruska JC, Ichiyama RM, Jindrich DL, et al. Changes in motoneuron properties and synaptic inputs related to step training after spinal cord transection in rats. *J Neurosci.* 2007;27:4460—4471.
197. Button DC, Kalmar JM, Gardiner K, et al. Does elimination of afferent input modify the changes in rat motoneuron properties that occur following chronic spinal cord transection? *J Physiol.* 2008;586:529—544.
198. Roy RR, Zhong H, Siengthai B, et al. Activity-dependent influences are greater for fibers in rat medial gastrocnemius than tibialis

199. Gharakhanlou R, Chadan S, Gardiner P. Increased activity in the form of endurance training increases calcitonin gene-related peptide content in lumbar motoneuron cell bodies and in sciatic nerve in the rat. *Neuroscience*. 1999;89:1229—1239.
200. Gonzalez M, Collins WF 3rd. Modulation of motoneuron excitability by brain-derived neurotrophic factor. *J Neurophysiol*. 1997;77:502—506.
201. Deachen MR, Judelson DA, Kracmer WJ, et al. Effects of resistance training on neuromuscular junction morphology. *Muscle Nerve*. 2000;23:1576—1581.
202. Andonian MH, Eahim MA. Endurance exercise alters the morphology of fast- and slow-twitch rat neuromuscular junctions. *Int J Sports Med*. 1988;9:218—223.
203. Deschenes MR, Maresh CM, Crivello JE, et al. The effects of exercise training of different intensities on neuromuscular junction morphology. *J Neurocytol*. 1993;22:603—615.
204. Wachhaug D, Dahl HA, Kardel K. Different effects of physical training on the morphology of motor nerve terminals in the rat extensor digitorum longus and soleus muscles. *Anat Embryol (Berl)*. 1992;486:125—128.
205. Crockett JL, Edgerton VR, Max SR, et al. The neuromuscular junction in response to endurance training. *Exp Neurol*. 1976;51:207—215.
206. Rosenheimer JL. Effects of chronic stress and exercise on age-related changes in end-plate architecture. *J Neurophysiol*. 1985;53:1582—1589.
207. Stebbins CL, Schultz E, Smith RT, et al. Effects of chronic exercise during aging on muscle and end-plate morphology in rats. *J Appl Physiol*. 1985;58:45—51.
208. Svcistrup H, Chan RY, Jasmin BJ. Chronic enhancement of neuromuscular activity increases acetylcholinesterase gene expression in skeletal muscle. *Am J Physiol*. 1995;269:C856—C862.
209. Burns AS, Jawaid S, Zhong H, et al. Paralysis elicited by spinal cord injury evokes selective disassembly of neuromuscular synapses with and without terminal sprouting in ankle flexors of the adult rat. *J Comp Neurol*. 2007;500:116—133.
210. Homonko DA, Thriault E. Calcitonin gene-related peptide is increased in hindlimb motoneurons after exercise. *Int J Sports Med*. 1997;18:503—509.
211. Sala C, Andreose JS, Eumagalli G, et al. Calcitonin gene-related peptide: possible role in formation and maintenance of neuromuscular junctions. *J Neurosci*. 1995;15:520—528.
212. Wernig A, Salvini TE, Irintchev A. Axonal sprouting and changes in fibre types after running-induced muscle damage. *J Neurocytol*. 1991;20:903—913.
213. Wuerker RB, Henneman E. Reflex regulation of primary (annulospiral) stretch receptors via gamma motoneurons in the cat. *J Neurophysiol*. 1963;26:539—550.
214. Buller AJ, Eccles JC, Eccles RM. Differentiation of fast and slow muscles in the cat hind limb. *J Physiol*. 1960;150:399—416.
215. Buller AJ, Eccles JC, Eccles RM. Interactions between motoneurons and muscles in respect of the characteristic speeds of their responses. *J Physiol*. 1960;150:417—439.
216. Kugelberg E, Edstrom L. Differential histochemical effects of muscle contractions on phosphorylase and glycogen in various types of fibres: relation to fatigue. *J Neurol Neurosurg Psychiatry*. 1968;31:415—423.
217. Edgerton VR, Simpson D, Barnard RJ, et al. Phosphorylase activity in acutely exercised muscle. *Nature*. 1970;225:866—867.
218. Burke RE, Levine DN, Zajac EE III. Mammalian motor units: physiological histochemical correlation in three types in cat gastrocnemius. *Science*. 1971;174:709—712.

Chapter 3

1. Kastelic J, Galeski A, Baer E. The multicomposite structure of tendon. *Connect Tissue Res*. 1978;6:11—23.
2. Sweigart MA, Athanasiou KA. Toward tissue engineering of the knee meniscus. *Tissue Eng*. 2001;7:111—129.
3. Jee WSS. Integrated bone tissue physiology: anatomy and physiology. In: Cowin SC, editor. *Bone Mechanics Handbook*. Boca Raton: CRC Press; 2001. p. 1—53.
4. Butler DL, Goad ES, Noyes ER, et al. Biomechanics at ligaments and tendons. *Exerc Sport Sci Rev*. 1978;6:125—181.
5. Erank CB. Ligament injuries. In: Zachazewski JE, Magee DJ, Quillen WS, editors. *Athletic Injuries and Rehabilitation*. Philadelphia: Saunders; 1996. p. 9—26.
6. Tipton CM, Matthes RD, Sandage DS. In situ measurement of junction strength and ligament elongation in rats. *J Appl Physiol*. 1974;37:758—761.
7. Akeson WH. An experimental study of joint stiffness. *Am J Orthop*. 1961;43-A:1022—1034.
8. Akeson WH, Amiel D, LaValette D. The connective-tissue response to immobility: a study at the chondroitin-4 and 6-sulfate and dermatan sulfate changes in periarthral connective tissue of central and immobilized knees of dogs. *Clin Orthop*. 1967;51:183—197.
9. Woo SL, Matthews JV, Akeson WH, et al. Connective tissue response to immobility. Correlative study at biomechanical and biochemical measurements of normal and immobilized rabbit knees. *Arthritis Rheum*. 1975;18:257—264.
10. Amiel D, Woo SL, Harwood EL, et al. The effect of immobilization on collagen turnover in connective tissue: a biochemical-biomechanical correlation. *Acta Orthop Scand*. 1982;53:325—332.
11. Klein L, Dawson MH, Heiple KG. Turnover of collagen in the adult rat after denervation. *J Bone Joint Surg Am*. 1977;59:1065—1067.
12. Laitz BJ, Zerwicke RE, Vilas AC, et al. Effects of short-term immobilization versus continuous passive motion on the biomechanical and biochemical properties of the rabbit tendon. *Clin Orthop*. 1989;265—271.
13. Matsumata F, Trudel G, Uthairat HK, et al. Mechanical effects of immobilization on the Achilles' tendon. *Arch Phys Med Rehabil*. 2003;84:662—667.

14. Elint M. Interrelationships of mucopolysaccharides and collagen in connective tissue remodelling. *J Embryol Exp Morphol.* 1982;27:481—495.
15. Cabaud HE, Chatty A, Gildengarin V, et al. Exercise effects on the strength of the rat anterior cruciate ligament. *Am J Sports Med.* 1980;8:79—86.
16. Tipton CM, James SL, Merguer W, et al. Influence of exercise on strength of medial collateral knee ligaments of dogs. *Am J Physiol.* 1970;218:894—902.
17. Binkley JM, Feat M. The effects of immobilization on the ultra-structure and mechanical properties at the medial collateral ligament of rats. *Clin Orthop.* 1986:301—308.
18. Zamora AJ, Marini JF. Tendinomyotendinous junction in an overloaded skeletal muscle of the rat. *Anat Embryol Berl.* 1988;179:89—96.
19. Curwin SL, Vailas AC, Waad J. Immature tendon adaptation to strenuous exercise. *J Appl Physiol.* 1988;65:2297—2301.
20. Michna H. Morphometric analysis of loading-induced changes in collagen-fibril populations in young tendons. *Cell Tissue Res.* 1984;236:465—470.
21. Wan SL, Ritter MA, Amiel D, et al. The biomechanical and biochemical properties of swine tendons—long term effects of exercise on the digital extensors. *Connect Tissue Res.* 1980;7:177—83.
22. Buchanan CI, Marsh RL. Effects of long-term exercise on the biomechanical properties at the Achilles tendon of guinea pig. *J Appl Physiol.* 2001;90:164—171.
23. Rasager S, Aagaard F, Dyhre-Paulsen F, et al. Load-displacement properties at the human triceps surae aponeurosis and tendon in runners and non-runners. *Scand J Med Sci Sports.* 2002;12:90—98.
24. Hansen P, Aagaard P, Kjaer M, et al. The effect of habitual running on human Achilles tendon load-deformation properties and cross sectional area. *J Appl Physiol.* 2003;95:2375—2380.
25. Cax JS, Nyc CE, Schaeter WW, et al. The degenerative effects of partial and total resection of the medial meniscus in dogs' knees. *Clin Orthop.* 1975:178—183.
26. Klein L, Heiple KG, Torzilli PA, et al. Prevention of ligament and meniscus atrophy by active joint motion in a non-weight-bearing model. *J Orthop Res.* 1989;7:80—85.
27. Djurasovic M, Aldridge JW, Grumbles R, et al. Knee joint immobilization decreases aggrecan gene expression in the meniscus. *Am J Sports Med.* 1998;26:460—466.
28. Weinberg JB, Fermor B, Guilak F. Nitric oxide synthase and cyclooxygenase interactions in cartilage and meniscus: relationships to joint physiology, arthritis, and tissue repair. *Subcell Biochem.* 2007;42:31—62.
29. Amiel D, Abel ME, Kleiner JB, et al. Synovial fluid nutrient delivery in the diarthral joint: an analysis of rabbit knee ligaments. *J Orthop Res.* 1986;4:90—95.
30. Ochi M, Randa T, Sumen Y, et al. Changes in the permeability and histologic findings of rabbit menisci after immobilization. *Clin Orthop.* 1997:305—315.
31. Mikic B, Johnson TL, Chhabra AB, et al. Differential effects of embryonic immobilization on the development of fibrocartilaginous skeletal elements. *J Rehabil Res Dev.* 2000;37:127—133.
32. Bray RC, Smith JA, Eng MR, et al. Vascular response of the meniscus to injury: effects of immobilization. *J Orthop Res.* 2001; 19:384—390.
33. Imler SM, Doshi AN, Levenston ME. Combined effects of growth factors and static mechanical compression on meniscus explant biosynthesis. *Osteoarthritis Cartilage.* 2004;12:736—744.
34. Upton ML, Chen J, Guilak F, et al. Differential effects of static and dynamic compression on meniscal cell gene expression. *J Orthop Res.* 2003;21:963—969.
35. Pedrini-Mille A, Fedrini VA, Maynard JA, et al. Response of immature chicken meniscus to strenuous exercise: biochemical studies of proteoglycan and collagen. *J Orthop Res.* 1988;6:196—204.
36. Vailas AC, Zernicke RF, Matsuda J, et al. Adaptation of rat knee meniscus to prolonged exercise. *J Appl Physiol.* 1986;60:1031—1034.
37. Mow VC, Holmes MH, Lai WM. Fluid transport and mechanical properties of articular cartilage: a review. *J Biomech.* 1984;17:377—394.
38. Egnor E. Knee joint meniscal degeneration as it relates to tissue fiber structure and mechanical resistance. *Pathol Res Pract.* 1982;173:310—324.
39. Suzuki T, Toyoda T, Suzuki H, et al. Hydrostatic pressure modulates mRNA expressions for matrix proteins in human meniscal cells. *Biorheology.* 2006;43:611—622.
40. FiBer RL, Blough FR, Dehlin JM, et al. Oscillatory fluid flow regulates glycosaminoglycan production via an intracellular calcium pathway in meniscal cells. *J Orthop Res.* 2006;24:375—384.
41. Kessler MA, Glaser C, Tittel S, et al. Recovery of the menisci and articular cartilage of runners after cessation of exercise: additional aspects of in vivo investigation based on 3-dimensional magnetic resonance imaging. *Am J Sports Med.* 2008;36:966—970.
42. Kessler MA, Glaser C, Tittel S, et al. Volume changes in the menisci and articular cartilage of runners: an in vivo investigation based on 3-D magnetic resonance imaging. *Am J Sports Med.* 2006;34:832—836.
43. Gupta T, Haut Donahue TL. Role of cell location and morphology in the mechanical environment around meniscal cells. *Acta Biomater.* 2006;2:483—492.
44. Osborn M. *A Strategy for Research in Space Biology and Medicine in the New Century.* Washington DC: National Academy Press; 1998.
45. Vico L, Collet P, Guignandon A, et al. Effects of long-term microgravity exposure on cancellous and cortical weight-bearing bones of cosmonauts. *Lancet.* 2000;355:1607—1611.
46. Vainionpaa A, Korpelainen R, Sievanen H, et al. Effect of impact exercise and its intensity on bone geometry at weight-bearing tibia and femur. *Bone.* 2007;40:604—611.
47. Woo SL, Rueti SC, Amid D, et al. The effect of prolonged physical training on the properties of long bone: a study of Wolff's Law. *J Bone Joint Surg Am.* 1981;63:780—787.

48. Haapasalo H, Rannus P, Sievanen H, et al. Long-term unilateral loading and bone mineral density and content in female squash players. *Calcif Tissue Int.* 1994;54:249—255.
49. Gunter R, Baxter-Jones AD, Mirwald RL, et al. Impact exercise increases BMC during growth: an 8-year longitudinal study. *J Bone Miner Res.* 2008;23:986—993.
50. Park H, Rim RJ, Romatsu T, et al. Effect of combined exercise training on bone, body balance, and gait ability: a randomized controlled study in community-dwelling elderly women. *J Bone Miner Metab.* 2008;26:254—259.
51. Genant HR. Current state of bone densitometry for osteoporosis. *Radiographics.* 1998;18:913—918.
52. Robling AG, Hinant FM, Burr DB, et al. Improved bone structure and strength after long-term mechanical loading is greatest if loading is separated into short bouts. *J Bone Miner Res.* 2002;17:1545—1554.
53. Drinkwater BL. C. H. McCloy Research lecture: does physical activity play a role in preventing osteoporosis? *Res Q Exer Sport.* 1994;65:197—206.
54. Beck BR, Snow CM. Bone health across the lifespan—exercising our options. *Exerc Sport Sci Rev.* 2003;31:117—122.
55. Umemura Y, Ishiko T, Yamauchi T, et al. Five jumps per day increase bone mass and breaking force in rats. *J Bone Miner Res.* 1997;12:1480—1485.
56. Turner CH, Robling AG. Designing exercise regimens to increase bone strength. *Exerc Sport Sci Rev.* 2003;31:45—50.
57. Vogt MT, Cauley JA, Ruller LH, et al. Bone mineral density and blood flow to the lower extremities: the study of osteoporotic fractures. *J Bone Miner Res.* 1997;12:283—289.
58. Burge R, Dawson-Hughes B, Solomon DH, et al. Incidence and economic burden of osteoporosis-related fractures in the United States, 2005—2025. *J Bone Miner Res.* 2007;22:465—475.
59. Greaney RB, Gerber FH, Laughlin RL, et al. Distribution and natural history of stress fractures in U.S. Marine recruits. *Radiology.* 1983;146:339—346.
60. Bennell KL, Brukner PD. Epidemiology and site specificity of stress fractures. *Clin Sports Med.* 1997;16:179—196.
61. Loucks AB. Energy availability, not body fatness, regulates reproductive function in women. *Exerc Sport Sci Rev.* 2003;31:144—148.
62. Khan KM, Liu-Ambrose T, Sran MM, et al. New criteria for female athlete triad syndrome? As osteoporosis is rare, should osteopenia be among the criteria for defining the female athlete triad syndrome? *Br J Sports Med.* 2002;36:10—13.
63. Bailey DA, Martin AD, McKay HA, et al. Calcium accretion in girls and boys during puberty: a longitudinal analysis. *J Bone Miner Res.* 2000;15:2245—2250.
64. Martin AD, Bailey DA, McKay HA, et al. Bone mineral and calcium accretion during puberty. *Am J Clin Nutr.* 1997;66:611—615.
65. Bailey DA, McKay HA, Mirwald RL, et al. A six-year longitudinal study of the relationship of physical activity to bone mineral accrual in growing children: the university of Saskatchewan bone mineral accrual study. *J Bone Miner Res.* 1999;14:1672—1679.
66. Gustavsson A, Nordstrom P, Lorcenzon R, et al. Osteocalcin gene polymorphism is related to bone density in healthy adolescent females. *Osteoporos Int.* 2000;11:847—851.
67. Morrison NA, Qi JC, Tokita A, et al. Prediction of bone density from vitamin D receptor alleles. *Nature.* 1994;367:284—287.
68. Nakamura O, Ishii T, Ando Y, et al. Potential role of vitamin D receptor gene polymorphism in determining bone phenotype in young male athletes. *J Appl Physiol.* 2002;93:1973—1979.
69. Dhamrait SS, James L, Brull DJ, et al. Cortical bone resorption during exercise is interleukin-6 genotype-dependent. *Eur J Appl Physiol.* 2003;89:21—25.
70. Specker BL. Evidence for an interaction between calcium intake and physical activity on changes in bone mineral density. *J Bone Miner Res.* 1996;11:1539—1544.
71. Zernicke RE, Salem GJ, Barnard RJ, et al. Adaptations of immature trabecular bone to exercise and augmented dietary protein. *Med Sport Sci.* 1995;27:1486—1493.
72. Atteh JO, Leeson S. Effects of dietary saturated or unsaturated fatty acids and calcium levels on performance and mineral metabolism of broiler chicks. *Foult Sci.* 1984;63:2252—2260.
73. Corwin RL, Hartman TJ, Maczuga SA, et al. Dietary saturated fat intake is inversely associated with bone density in humans: analysis of NHANES III. *J Nutr.* 2006;136:159—165.
74. Lorincz CR, Manske SL, Zernicke RE. Bone health, Part 1: nutrition. *Spats Health: A Multidisciplinary Approach.* 2009;1:253—260.
75. DeFronzo RA, Cooke CR, Andres R, et al. The effect of insulin on renal handling of sodium, potassium, calcium, and phosphate in man. *J Clin Invest.* 1975;55:845—855.
76. Lemann Jr, Lennon EJ, Piering WR, et al. Evidence that glucose ingestion inhibits net renal tubular reabsorption of calcium and magnesium in man. *J Lab Clin Med.* 1970;75:578—585.
77. Li KC, Zernicke RE, Barnard RJ, et al. Effects of a high fat-sucrose diet on cortical bone morphology and biomechanics. *Calcif Tissue Int.* 1990;47:308—313.
78. Salem GJ, Zernicke RE, Barnard RJ. Diet-related changes in mechanical properties of rat vertebrae. *Am J Physiol.* 1998;262:R318—R321.
79. Kunstel K. Calcium requirements for the athlete. *Curr Sports Med Rep.* 2005;4:203—206.
80. Lee K, Jessop H, Suswillo R, et al. Endocrinology: bone adaptation requires oestrogen receptor-alpha. *Nature.* 2003;424:389.
81. Kohrt WM, Snead DB, Slatopolsky F, et al. Additive effects of weight-bearing exercise and estrogen on bone mineral density in older women. *J Bone Miner Res.* 1995;10:1303—1311.
82. Khan K, McKay HA, Haapasalo H, et al. Does childhood and adolescence provide a unique opportunity for exercise to strengthen the skeleton? *J Sports Med.* 2000;3:150—164.
83. Petit MA, McKay HA, MacKelvie KJ, et al. A randomized school-based jumping intervention confers site and maturity-specific benefits on bone structural properties in girls: a hip structural analysis study. *J Bone Miner Res.* 2002;17:363—372.

84. MacKellvie KJ, Khan KM, McKay HA. Is there a critical period for bone response to weight-bearing exercise in children and adolescents? A systematic review. *Br J Sports Med.* 2002;36:250—257; discussion 257.
85. MacKellvie KJ, Khan KM, Petit MA, et al. A school-based exercise intervention elicits substantial bone health benefits: a 2-year randomized controlled trial in girls. *Pediatrics.* 2003;112:e447.
86. MacKellvie KJ, Petit MA, Khan KM, et al. Bone mass and structure are enhanced following a 2-year randomized controlled trial of exercise in prepubertal boys. *Bone.* 2004;34:755—764.
87. Macdonald HM, Kontulainen SA, Khan KM, et al. Is a school-based physical activity intervention effective for increasing tibial bone strength in boys and girls? *Bone Miner Res.* 2007;22:434—446.
88. Heinonen A, Sievanen H, Kannus P, et al. High-impact exercise and bones of growing girls: a 9-month controlled trial. *Osteoporos Int.* 2000;11:1010—1017.
89. MacKellvie KJ, McKay HA, Khan KM, et al. A school-based exercise intervention augments bone mineral accrual in early pubertal girls. *Pediatr.* 2001;139:50f—508.
90. Manske SL, Larincz CR, Zernicke RF. Bone health, Part 2: physical activity. *Sports Health: A Multidisciplinary Approach.* 2009;1:341—346.
91. Heaney RE Calcium, dairy products and osteoporosis. *Am J Clin Nutr.* 2000;19:83S—99S.
92. Banaiuti D, Shea B, Iovine R, et al. Exercise for preventing and treating osteoporosis in postmenopausal women. *Cochrane database of systematic reviews.* 2002;2002:C0000333.
93. Martyn-St James M, Carroll S. High-intensity resistance training and postmenopausal bone loss: a meta-analysis. *Osteoporos Int.* 2006; 17: 1225—1240.
94. Prittan SP, McLead KJ, Rabin CT. Quantifying the strain history of bone: spatial uniformity and self-similarity of low-magnitude strains. *J Biomech.* 2000;33:317—325.
95. Rabin C, Turner AS, Mallinckrodt C, et al. Mechanical strain, induced noninvasively in the high-frequency domain, is anabolic to cancellous bone, but not cortical bone. *Bone.* 2002;30:445—452.
96. Xie L, Rubin C, Judex S. Enhancement of the adolescent murine musculoskeletal system using low-level mechanical vibrations. *J Appl Physiol.* 2008;104:1056—1062.
97. Gilsanz V, Wren TA, Sanchez M, et al. Low-level, high-frequency mechanical signals enhance musculoskeletal development of young women with low BMD. *J Bone Miner Res.* 2006;21:1464—1474.
98. Rubin C, Reeker R, Callen D, et al. Prevention of postmenopausal bone loss by a low-magnitude, high-frequency mechanical stimuli: a clinical trial assessing compliance, efficacy, and safety. *J Bone Miner Res.* 2004;19:343—351.
99. Ward K, Alsap C, Caultan, et al. Low magnitude mechanical loading is osteogenic in children with disabling conditions. *J Bone Miner Res.* 2004;19:360—369.
100. Judex S, Gupta S, Rabin C. Regulation of mechanical signals in bone. *Orthod Craniofac Res.* 2009;12:94—104.
101. Grass TS, Edwards JL, McLead KJ, et al. Strain gradients correlate with sites of periosteal bone formation. *J Bone Miner Res.* 1997;12:982—988.
102. Judex S, Gross TS, Zernicke RF. Strain gradients correlate with sites of exercise-induced bone-forming surfaces in the adult skeleton. *J Bone Miner Res.* 1997;12:1737—1745.
103. Otter MW, Palmieri VR, Wu DO, et al. A comparative analysis of streaming potentials in vivo and in vitro. *J Orthop Res.* 1992; 10: 710—719.
104. Duncan RL, Turner CH. Mechanotransduction and the functional response of bone to mechanical strain. *Calcif Tissue Int.* 1995; 57:344—358.
105. Burger FH, Klein-Nulend, van der Plas A, et al. Function of osteocytes in bone—their role in mechanotransduction. *Nutr.* 1995;125:20205—20235.
106. Reilly GC, Haut TR, Yellowley CF, et al. Fluid flow induced PGF2 release by bone cells is reduced by glycealyx degradation whereas calcium signals are not. *Biorheology.* 2003;40:591—603.
107. Tatsumi S, Ishii K, Amizuka N, et al. Targeted ablation of osteocytes induces osteoporosis with defective mechanotransduction. *Cell Metab.* 2007;5:464—475.
108. Wang N, Naruse K, Stamenovic D, et al. Mechanical behavior in living cells consistent with the tensegrity model. *Proc Natl Acad Sci USA.* 2001;98:7765—7770.
109. Smalt R, Mitchell PT, Howard RL, et al. Mechanotransduction in bone cells: induction of nitric oxide and prostaglandin synthesis by fluid shear stress, but not by mechanical strain. *Adv Exp Med Biol.* 1997;433:311—314.
110. Wang Y, McNamara LM, Schaffler MB, et al. A model for the role of integrins in flow induced mechanotransduction in osteocytes. *Proc Natl Acad Sci USA.* 2007;104:15941—15946.
111. Fukada F, Yasuda I. On the piezoelectric effect of bone. *Journal of the Physical Society of Japan.* 1957;12:1158—1162.
112. Ahn AC, Gradzinsky AJ. Relevance of collagen piezoelectricity to “Wolff’s Law”: a critical review. *Med Eng Phys.* 2009.
113. Vatsa A, Breuls RG, Semeins CM, et al. Osteocyte morphology in fibula and calvaria—is there a role for mechanosensing? *Bone.* 2008;43:452—458.
114. Panik SM, Triplett JW, Pavalko FM. Osteoblasts and osteocytes respond differently to oscillatory and unidirectional fluid flow profiles. *J Biomech.* 2007;100:794—807.
115. Weinbaum S, Cowin SC, Zeng Y. A model for the excitation of osteocytes by mechanical loading-induced bone fluid shear stresses. *J Biomech.* 1994;27:339—360.
116. Anderson EJ, Knothe Tate ML. Idealization of pericellular fluid space geometry and dimension results in a profound underprediction of nanometer-scale stresses imparted by fluid drag on osteocytes. *J Biomech.* 2008;41:1736—1746.
117. Lansman JB. Endothelial mechanosensors. Going with the flow. *Nature.* 1988;331:481—482.

118. Barakat AI, Davies PF. Mechanisms of shear stress transmission and transduction in endothelial cells. *Chest*. 1998;114:585—5635.
119. McAllister TN, Du T, Frangas JA. Fluid shear stress stimulates prostaglandin and nitric oxide release in bone marrow derived preosteoblast-like cells. *Biorheum Biophys Res Commun*. 2000;270:643—648.
120. Genetos DC, Kephart CJ, Zhang Y, et al. Oscillating fluid flow activation of gap junction hemichannels induces ATP release from MLO-Y4 osteocytes. *J Cell Physiol*. 2007;212:207—214.
121. Cherian PP, Siller-Jackson AJ, Gu S, et al. Mechanical strain opens connexin 43 hemichannels in osteocytes: a novel mechanism for the release of prostaglandin. *Mol Biol Cell*. 2005;16:3100—3106.
122. Kowalchuk RM, Pallack SR. Stress-generated potentials in bone: effects of bone fluid composition and kinetics. *J Orthop Res*. 1993;11:874—883.
123. Knäuper ML, Niederer P, Knäuper U. In vivo tracer transport through the lacunocanalicular system of rat bone in an environment devoid of mechanical loading. *Bone*. 1998;22:107—117.
124. Goulet GC, Hamilton N, Cooper D, et al. Influence of vascular porosity on fluid flow and nutrient transport in loaded cortical bone. *J Biomech*. 2008;41:2169—2175.
125. Bullough PG, Munuera L, Murphy J, et al. The strength of the menisci of the knee as it relates to their fine structure. *J Bone Joint Surg Br*. 1970;52:564—567.
126. Madlesky CM, Lewis RD. Does exercise during growth have a long-term effect on bone health? *Exerc Sport Sci Rev*. 2002;30:171—176.
127. Qin TX, Rubin CT, McLeod KJ. Nonlinear dependence of loading intensity and cycle number in the maintenance of bone mass and morphology. *J Orthop Res*. 1998;16:482—489.

Chapter 4

1. Huxley AF. Muscle structure and theories of contraction. *Prog Biophys Biophys Chem*. 1957;7:255—318.
2. Clark RA, McFlaherty AS, Beckerle MC, et al. Striated muscle cytoarchitecture: an intricate web of form and function. *Ann Rev Cell Dev Biol*. 2002;18:637—706.
3. Bottinelli R. Functional heterogeneity of mammalian single muscle fibres: do myosin isoforms tell the whole story? *Pflugers Arch*. 2001;443:6—17.
4. Bottinelli R, Betto R, Schiaffino S, et al. Unloaded shortening velocity and myosin heavy chain and alkali light chain isoform composition in rat skeletal muscle fibres. *J Physiol Lond*. 1994;478:341—349.
5. Fukuda N, Crazier HL, Ishiwata S, et al. Physiological functions of the giant elastic protein titin in mammalian striated muscle. *J Physiol Sri*. 2005;58:151—159.
6. Caiozzo VJ. Plasticity of skeletal muscle phenotype: mechanical consequences. *Muscle Nerve*. 2002;26:740—768.
7. Pette D, Staron RS. Cellular and molecular diversities of mammalian skeletal muscle fibers. *Rev Physiol Biochem Pharmacol*. 1990;116:1—76.
8. Schiaffino S, Reggiani C. Myosin isoforms in mammalian skeletal muscle. *J Appl Physiol*. 1994;77:493—501.
9. Brooke MH, Kaiser KK. Muscle fiber types: how many and what kind? *Arch Neurol*. 1970;23:369—379.
10. Barnard RJ, Edgerton VR, Furukawa T, et al. Histochemical, biochemical, and contractile properties of red, white, and intermediate fibers. *Am J Physiol*. 1971;220:410—414.
11. Pette D, Staron RS. Transitions of muscle fiber phenotypic profiles. *Histochem Cell Biol*. 2001;115:359—372.
12. Saltin B, Collnick PD. Skeletal muscle adaptability: significance for metabolism and performance. In: Peachey L, ed. *Handbook of Physiology*. American Physiological Society; 1983:555—631.
13. Caiozzo VJ, Baker MJ, Huang K, et al. Single-fiber myosin heavy chain polymorphism: how many patterns and what proportions? *AJ Physiol Regul Integr Comp Physiol*. 2003;285:R570—R580.
14. Talmadge RJ, Roy RR, Edgerton VR. Persistence of hybrid fibers in rat soleus after spinal cord transection. *Anat Rec*. 1999;255:188—201.
15. Caiozzo VJ, Haddad P, Baker M, et al. MHC polymorphism in rodent plantaris muscle: effects of mechanical overload and hypo thyroidism. *AJ Cell Physiol*. 2000;278:C709—C717.
16. Talmadge RJ, Roy RR, Edgerton VR. Distribution of myosin heavy chain isoforms in non-weight-bearing rat soleus muscle fibers. *J Appl Physiol*. 1996;81:2540—2546.
17. Hall ZW, Raison F. Nuclear domains in muscle cells. *Cell*. 1989;159:771—772.
18. Peuker H, Pette D. Quantitative analyses of myosin heavy-chain mRNA and protein isoforms in single fibers reveal a pronounced fiber heterogeneity in normal rabbit muscles. *Eur J Biochem*. 1997;247:30—36.
19. Edman KAP, Reggiani C, Schiaffino S, et al. Maximum velocity of shortening related to myosin isoform composition in frog skeletal muscle fibres. *J Physiol Lond*. 1988;395:679—694.
20. Rome LC, Linstedt SL. Mechanical and metabolic design of the muscular system in vertebrates. In: Dantzler WH, ed. *Comparative Physiology*. New York (NY): Oxford University Press; 1997:1587—1651.
21. Josephson RK. Dissecting muscle power output. *J Exp Biol*. 1999;202 Pt 23:3369—75.
22. Booth FW, Baldwin KM. *Muscle Plasticity: Energy Demand and Supply Processes*. New York: Oxford University Press; 1996.
23. Hill AV. The heat of shortening and the dynamic constants of muscle. *Proc R Soc London Ser B*. 1938;126:136—95.
24. Priden J, Licher RL. Spastic muscle cells are shorter and stiffer than normal cells. *Muscle Nerve*. 2003;27:157—64.
25. Licher RL, Friden J. Spasticity causes a fundamental rearrangement of muscle-joint interaction. *Muscle Nerve*. 2002;25:265—70.
26. Hill AV. *First and Last Experiments in Muscle Mechanics*. New York (NY): Cambridge University Press; 1970.
27. Woledge RC, Curtin NA, Homsher E. *Energetic Aspects of Muscle Contraction*. New York: Academic Press; 1985.
28. Caiozzo VJ, Baker MJ, Baldwin KM. Novel transitions in myosin isoforms: separate and combined effects of thyroid hormone and mechanical unloading. *J Appl Physiol*. 1998;85:2237—48.

29. Josephson RK, Edman RAP. The consequences of fibre heterogeneity on the force-velocity relation of skeletal muscle. *Acta Physiol Scand.* 1988;132:341—52.
30. Reiser PJ, Rasper CF, Moss RL. Myosin subunits and contractile properties of single fibers from hypokinetic rat muscles. *J Appl Physiol.* 1987;63:2293—3300.
31. Bottinelli R, Schiaffino S, Reggiani C. Force-velocity relations and myosin heavy chain isoform compositions of skinned fibres from rat skeletal muscle. *J Physiol.* 1991;437:655—672.
32. Larsson L, Moss RL. Maximum velocity of shortening in relation to myosin isoform composition in single fibres from human skeletal muscles. *J Physiol.* 1993;472:595—614.
33. Edman RA, Reggiani C, Schiaffino S, et al. Maximum velocity of shortening related to myosin isoform composition in frog skeletal muscle fibres. *J Physiol.* 1988;395:679—694.
34. McDonald RS, Blaser CA, Fitts RH. Force-velocity and power characteristics of rat soleus muscle fibers after hindlimb suspension. *J Appl Physiol.* 1994;77:1609—1616.
35. Wojtyś FM, Hušton U, Schoek HJ, et al. Gender differences in muscular protection of the knee in torsion in size-matched athletes. *J Bone Joint Surg Am.* 2003;85-A:782—789.
36. Riley DA, Bain JL, Thompson JL, et al. Decreased thin filament density and length in human atrophic soleus muscle fibers after spaceflight. *J Appl Physiol.* 2000;88:567—572.
37. Schulte LM, Navarro J, Randarian SC. Regulation of sarcoplasmic reticulum calcium pump gene expression by hindlimb unweighting. *Am J Physiol.* 1993;264:C1308—C1315.
38. Tournel T, Stevens L, Granzier H, et al. Passive tension of rat skeletal soleus muscle fibers: effects of unloading conditions. *J Appl Physiol.* 2002;92:1465—1472.
39. Rome FC, Lindstedt SL. The quest for speed: muscles built for high-frequency contractions. *News Physiol Sci.* 1998;13:261—268.
40. Weibel FR, Taylor CR, Hoppeler H. The concept of symmorphosis: a testable hypothesis of structure-function relationship. *Proc Natl Acad Sci USA.* 1991;88:10357—10361.
41. Diamond J, Hammond K. The matches, achieved by natural selection, between biological capacities and their natural loads. *Experientia.* 1992;48:551—557.

Chapter 5

1. Booth FW, Baldwin KM. Exercise: regulation and integration of multiple systems. In: Rowell LB, Shepherd JT, eds. *Muscle Plasticity: Energy Demand and Supply Processes. Handbook of Physiology.* New York: Oxford University; 1996:1075—1123.
2. Timson BE. Evaluation of animal models for the study of exercise-induced muscle enlargement. *J Appl Physiol.* 1990;69: 1935—1945.
3. Crowther NB. Weightlifting in antiquity: achievement and training. In: McAuslen I, Walcott P, eds. *Greece and Rome, vol. XXIV.* Oxford, UK: Oxford University; 1977:111—120.
4. Baldwin KM, Haddad E. Plasticity in skeletal, cardiac, and smooth muscle. Invited review: effects of different activity and inactivity paradigms on myosin heavy chain gene expression in striated muscle. *J Appl Physiol.* 2001;90:345—357.
5. Schiaffino S, Reggiani C. Molecular diversity of myofibrillar proteins: gene regulation and functional significance. *Physiol Rev.* 1996;76:371—432.
6. Weiss A, Leinwand L.A. The mammalian myosin heavy chain gene family. *Annu Rev Cell Dev Biol.* 1996;12:417—439.
7. Sartorius CA, Lu BD, Acakpo-Satchivi L, et al. Myosin heavy chains IIa and IIc are functionally distinct in the mouse.
8. Barany M. ATPase activity of myosin correlated with speed of muscle shortening. *J Gen Physiol.* 1967;5:197—218.
9. Tsika GL, Wiedenman JL, Gao L, et al. Induction of r3-MHC trans gene in overloaded skeletal muscle is not eliminated by mutation of conserved elements. *Am J Physiol Cell Physiol.* 1996;271:C690—C699.
10. Tsika RW, Hauschka SD, Gao L. M-creatine kinase gene expression in mechanically overloaded skeletal muscle of transgenic mice. *Am J Physiol.* 1995;269:C665—C674.
11. Tsika RW, Herrick RE, Baldwin KM. Time course adaptation in rat skeletal muscle isomyosins during compensatory growth and regression. *J Appl Physiol.* 1987;63:211—2121.
12. Gardiner PF, Michel RN, Browman F, et al. Increased EMG of rat plantaris during locomotion following surgical removal of its synergists. *Brain Res.* 1986;380:114—121.
13. Carson JA, Wei L. Invited review: integrin signaling's potential for mediating gene expression in hypertrophying skeletal muscle. *J Appl Physiol.* 2000;88:337—343.
14. Hawke J, Garry DJ. Invited review: Myogenic satellite cells: physiology to molecular biology. *J Appl Physiol.* 2001;91:534—551.
15. Adams GR, Caiozzo V, Haddad E, et al. Cellular and molecular responses to increased skeletal muscle loading after irradiation. *Am J Physiol.* 2002;283:C1182—C1195.
16. Crabtree GR, Olson EN. Review: NEAT signaling: choreographing the social lives of cells. *Cell.* 2002;109:S67—S79.
17. Olson EN, Williams RS. Calcineurin signaling and muscle remodeling. *Cell.* 2000;101:689—692.
18. Molkenkin JO, Lu JR, Autos CL, et al. A calcineurin-dependent transcriptional pathway for cardiac hypertrophy. *Cell.* 1998;93:215—228.
19. Chin ER, Olson EN, Richardson JA, et al. A calcineurin-dependent transcriptional pathway controls skeletal muscle fiber type. *Genes Dev.* 1998;12:2499—2509.
20. Kim M-S, Fielitz J, McAnally J, et al. Protein kinase D1 stimulates MEE2 activity in skeletal muscle and enhances performance. *Mol Cell Biol.* 2008;28:3600—3609.
21. Potthoff MJ, Wu H, Arnold M, et al. Histone deacetylase degradation and MEF2 activation promote the formation of slow-twitch myofibers. *Clin Invest.* 2007;117:2459—2467.
22. Parsons S, Millay D, Wilkins B, et al. Genetic loss of calcineurin blocks mechanical overload-induced skeletal muscle fiber type switching but not hypertrophy. *J Biol Chem.* 2004;279:26192—26200.
23. Karasscva NG, Tsika G, Ji, et al. Transcription enhancer factor 1 binds multiple muscle MEE2 and AIT-rich elements during fast-to-slow

- skeletal muscle fiber type transitions. *Mol Cell Biol.* 2003;23:5143—5164.
24. Buller AJ, Eccles JC, Eccles RM. Interactions between motoneurons and muscles in respect of the characteristic speeds of their responses. *J Physiol.* 1960;150:417—439.
25. Murgia MA, Serrano AL, Calabria E, et al. Ras is involved in nerve-activity-dependent regulation of muscle genes. *Nature Cell Biol.* 2000;2:142—147.
26. Rana ZA, Gundersen K, Buonanno A. Activity-dependent repression of muscle genes by NEAT. *Proc Natl Acad Sci USA.* 2008; 105:5921—5926.
27. Calabria E, Cicilioti S, Moretti T, et al., NEAT isoforms control activity-dependent muscle fiber type specification. *Cell Biol.* 2009;106:13335—13340.
28. Goldspink G. Gene expression in muscle in response to exercise. *J Muscle Res Cell Motil.* 2003;24:121—126.
29. Glass DJ. Review: molecular mechanisms modulating muscle mass. *Trends in Mol Cell Biol.* 2003;9:344—350.
30. Peng XD, Xu PZ, Chen ML, et al. Dwarfism, impaired skin development, skeletal muscle atrophy, delayed bone development, and impaired adipogenesis in mice lacking Akt1 and Akt2. *Genes Dev.* 2003;17:1352—1365.
31. McPherron AC, Lawler AM, Lee SJ. Regulation of skeletal muscle mass in mice by a new TGF- β superfamily member. *Nature.* 1997;387:83—90.
32. Wagner K, McPherron A, et al. Loss of myostatin attenuates severity of muscular dystrophy in mdx mice. *Ann Neural.* 2002;52:832—B36.
33. Kamei Y, Miura S, Suzuki M, et al., Skeletal muscle EOXO1 (FKHR) transgenic mice have less skeletal muscle mass, down-regulated type I (slow twitch/red muscle) fiber genes, and impaired glycemic control. *J Biol Chem.* 2004;279:41114—41123.
34. Sandri M, Sandri C, Gilbert A, et al., Eoxo transcription factors induce the atrophy-related ubiquitin ligase atrogin-1 and cause skeletal muscle atrophy. *Cell.* 2004;117:399—412.
35. Bogdanovich S, Krag TO, Barton ER, et al. Functional improvement of dystrophic muscle by myostatin blockade. *Nature.* 2002;420:418—421.
36. Amthor H, Otto A, Vulin A, et al. Muscle hypertrophy driven by myostatin blockade does not require stem/precursor-cell activity. *Proc Natl Acad Sci USA.* 2009;106:7479—7484.
37. Eirulli AB, Olson EN. Modular regulation of muscle gene transcription: a mechanism for muscle cell diversity. *Trends in Genet.* 1997;13:364—369.
38. Tsika GL, Wiedenman JL, Gao L, et al. Induction of β -MHC transgene in overloaded skeletal muscle is not eliminated by mutation of conserved elements. *Am J Physiol Cell Physiol.* 1996;271:C690—C699.
39. Wiedenman JL, Tsika GL, Gao L, et al. Muscle specific and inducible expression of 293-base pair beta-myosin heavy chain promoter in transgenic mice. *Am J Physiol.* 1996;271:R688—R695.
40. Vyas DR, McCarthy JJ, Tsika GE, et al. Multiprotein complex formation at the 3' myosin heavy chain distal muscle CAT element correlates with slow muscle expression but not mechanical overload responsiveness. *J Biol Chem.* 2001;276:1173—1184.
41. Vyas DR, McCarthy JJ, Tsika RW. Nuclear protein binding at the 3'-myosin heavy chain A/I-rich element is enriched following increased skeletal muscle activity. *J Biol Chem.* 1999;274:30832—30842.
42. Isika R, Schramm C, Simmer G, et al. Overexpression of β -MHC in transgenic mouse striated muscles produces a slower skeletal muscle contractile phenotype. *J Biol Chem.* 2008;283:36154—36167.
43. Morey-Holton ER, Globus RK. Invited review: Hindlimb unloading rodent model: technical aspects. *J Appl Physiol.* 2002;92:1367—1377.
44. Riley DA, Slocum GR, Bain JEW, et al. Rat hindlimb unloading: soleus histochemistry, ultrastructure, and electromyography. *J Appl Physiol.* 1990;69:58—66.
45. Tsika R, Herrick RE, Baldwin KM. Interaction of compensatory overload and hindlimb suspension on myosin isoform expression. *J Appl Physiol.* 1987;62:2180—2186.
46. McCarthy JJ, Fox AM, Tsika GE, et al. 3MyHC transgene expression in suspended and mechanically overloaded/suspended soleus muscle of transgenic mice. *Am J Physiol Reg Integ Comp Physiol.* 1997;41:R1552—R1561.
47. Tsika RW, Herrick RE, Baldwin KM. Effect of anabolic steroids on skeletal muscle mass during hindlimb suspension. *J Appl Physiol.* 1987;63:2122—2127.
48. Tsika RW, Herrick RE, Baldwin KM. Effect of anabolic steroids on overloaded and overloaded suspended skeletal muscle. *J Appl Physiol.* 1987;63:2128—2133.
49. Suzuki N, Motohashi N, Uezumi A, et al. NO production results in suspension-induced muscle atrophy through dislocation of neuronal NOS. *Clin Invest.* 2007;117:246B—2476.
50. Price SR. Increased transcription of ubiquitin-proteasome system components: molecular responses associated with muscle atrophy. *Tnt J Biochem Cell Biol.* 2003;35:617—628.
51. Nakao R, Hirasaka K, Gato J, et al. Ubiquitin ligase Cbl-b is a negative regulator for insulin-like growth factor 1 signaling during muscle atrophy caused by unloading. *Mol Cell Biol.* 2009;29:4798—4811.
52. Pielitz J, Kim MS, Shelton JM, et al. Myosin accumulation and striated muscle myopathy result from the loss of muscle RING finger 1 and 3. *Clin Invest.* 2007;117:2486—2495.
53. Cohen S, Brault J, Gygi SP, et al. During muscle atrophy, thick, but not thin, filament components are degraded by MuRF1-dependent ubiquitylation. *J Cell Biol.* 2009;185:1083—1095.
54. McCarthy JJ, Vyas DR, Tsika GE, et al. Segregated regulatory elements direct 3-myosin heavy chain expression in response to altered muscle activity. *J Biol Chem.* 1999;274:1427—1429.
55. Ji J, Tsika GE, Rindt H, et al. Pura and Pur collaborate with Sp3 to negatively regulate β 3-myosin heavy chain gene expression during skeletal muscle inactivity. *Mol Cell Biol.* 2007;27:1531—1543.
56. Tsika G, Ji J, & Tsika R. Sp3 proteins negatively regulate β 3 myosin heavy chain gene expression during skeletal muscle inactivity. *Mol Cell Biol.* 2004;24:10777—10791.

57. Isika RW, McCarthy J, Karasveva N, et al. Divergence in species and regulatory role of β -myosin heavy chain proximal promoter muscle-CAT elements. *Am J Cell Physiol*. 2002;283:C1761—C1775.
58. Bergmann O, Bhardwaj RD, Bernard S, et al. Evidence for cardiac renewal in humans. *Srirenre*. 2009;324:9B—102.

Chapter 6

1. Edwards RH. Biochemical basis of fatigue in exercise performance: catastrophe theory of muscular fatigue. In: Knuttgen HG, ed. *Biochemistry of Exercise*. Champaign, IL: Human Kinetics; 1983:3–28.
2. National Heart, Lung and Blood Institute Workshop summary. Respiratory muscle fatigue. Report of the Respiratory Muscle Fatigue Workshop Group. *Am Rev Respir Dis*. 1990;142(2):474–480.
3. Enoka RM, Duchateau J. Muscle fatigue: what, why and how it influences muscle function. *J Physiol*. 2008;586(1):11–23.
4. Allen DG, Lamb GD, Westerblad H. Skeletal muscle fatigue: cellular mechanisms. *Physiol Rev*. 2008;88(1):287–332.
5. Fitts RH. Cellular mechanisms of muscle fatigue. *Physiol Rev*. 1994;74(1):49–94.
6. Fitts RH, Balog EM. Effect of intracellular and extracellular ion changes on E-C coupling and skeletal muscle fatigue. *Acta Physiol Scand*. 1996;156(3):169–181.
7. Allen DG, Lannergren J, Westerblad H. Muscle cell function during prolonged activity: cellular mechanisms of fatigue. *Exp Physiol*. 1995;80(4):497–527.
8. Bigland-Ritchie B. Muscle fatigue and the influence of changing neural drive. *Clin Chest Med*. 1984;5(1):21–34.
9. Enoka RM, Stuart DG. Neurobiology of muscle fatigue. *J Appl Physiol*. 1992;72(5):1631–1648.
10. Gandevia SC. Spinal and supraspinal factors in human muscle fatigue. *Physiol Rev*. 2001;81(4):1725–1789.
11. Allen DG, Kabbara AA, Westerblad H. Muscle fatigue: the role of intracellular calcium stores. *Can J Appl Physiol*. 2002;27(1):83–96.
12. Allen DG, Lee JA, Westerblad H. Intracellular calcium and tension during fatigue in isolated single muscle fibres from *Xenopus laevis*. *J Physiol*. 1989;415:433–458.
13. Allen DG, Westerblad H. Role of phosphate and calcium stores in muscle fatigue. *J Physiol*. 2001;536(pt 3):657–665.
14. Coyle EF. Carbohydrate metabolism and fatigue. In: Atlan G, Beliveau L, Bouissou P, eds. *Muscle Fatigue: Biochemical and Physiological Aspects*. Paris: Masson; 1991:153–164.
15. Gollnick PD, Korge P, Karpakka J, et al. Elongation of skeletal muscle relaxation during exercise is linked to reduced calcium uptake by the sarcoplasmic reticulum in man. *Acta Physiol Scand*. 1991;142(1):135–136.
16. Hermansen L, Osnes JB. Blood and muscle pH after maximal exercise in man. *J Appl Physiol*. 1972;32(3):304–308.
17. Karlsson J, Saltin B. Lactate, ATP, and CP in working muscles during exhaustive exercise in man. *J Appl Physiol*. 1970;29(5):596–602.
18. Edman KA, Mattiazzi AR. Effects of fatigue and altered pH on isometric force and velocity of shortening at zero load in frog muscle fibres. *J Muscle Res Cell Motil*. 1981;2(3):321–334.
19. Metzger JM, Moss RL. pH modulation of the kinetics of a Ca^{2+} sensitive cross-bridge state transition in mammalian single skeletal muscle fibres. *J Physiol*. 1990;428:751–764.
20. Geeves MA, Fedorov R, Manstein DJ. Molecular mechanism of actomyosin-based motility. *Cell Mol Life Sci*. 2005;62(13):1462–1477.
21. Hill AV. The heat of shortening and the dynamic constants of muscle. *Proceedings of the Royal Society of London Series B—Biological Sciences*. 1938;126(843):136–195.
22. Nyitrai M, Rossi R, Adamek N, et al. What limits the velocity of fast-skeletal muscle contraction in mammals? *J Mol Biol*. 2006;355(3):432–442.
23. Knuth ST, Dave H, Peters JR, et al. Low cell pH depresses peak power in rat skeletal muscle fibres at both 30 degrees C and 15 degrees C: implications for muscle fatigue. *J Physiol*. 2006;575(pt 3):887–899.
24. Jones DA, de Ruiter CJ, de Haan A. Change in contractile properties of human muscle in relationship to the loss of power and slowing of relaxation seen with fatigue. *J Physiol*. 2006;576(pt 3):913–922.
25. Round JM, Jones DA, Chapman SJ, et al. The anatomy and fibre type composition of the human adductor pollicis in relation to its contractile properties. *J Neurol Sci*. 1984;66(2–3):263–272.
26. Merton PA. Voluntary strength and fatigue. *J Physiol*. 1954;123(3):553–564.
27. Bigland-Ritchie BR, Dawson NJ, Johansson RS, et al. Reflex origin for the slowing of motoneuron firing rates in fatigue of human voluntary contractions. *J Physiol*. 1986;379:451–459.
28. Fitts RH. Mechanisms of muscular fatigue. In: Poortmans JR, ed. *Principles of Exercise Biochemistry*. Basel, Karger: Medicine Sport Science; 2004:279–300.
29. Allen DG, Lamb GD, Westerblad H. Impaired calcium release during fatigue. *J Appl Physiol*. 2008;104(1):296–305.
30. Macdonald WA, Stephenson DG. Effect of ADP on slow-twitch muscle fibres of the rat: implications for muscle fatigue. *J Physiol*. 2006;573(pt 1):187–198.
31. Lindinger MI, Sjogaard G. Potassium regulation during exercise and recovery. *Sports Med*. 1991;11(6):382–401.
32. McKenna MJ, Bangsbo J, Renaud JM. Muscle K^+ , Na^+ , and Cl^- disturbances and Na^+ - K^+ pump inactivation: implications for fatigue. *J Appl Physiol*. 2008;104(1):288–295.
33. de Paoli FV, Overgaard K, Pedersen TH, et al. Additive protective effects of the addition of lactic acid and adrenaline on excitability and force in isolated rat skeletal muscle depressed by elevated extracellular K^+ . *J Physiol*. 2007;581(pt 2):829–839.
34. McKenna MJ, Medved I, Goodman CA, et al. N-acetylcysteine attenuates the decline in muscle Na^+ , K^+ -pump activity and delays fatigue during prolonged exercise in humans. *J Physiol*. 2006;576(pt 1):279–288.
35. Nielsen JJ, Mohr M, Klarskov C, et al. Effects of high-intensity intermittent training on potassium kinetics and performance in human skeletal muscle. *J Physiol*. 2004;554(pt 3):857–870.
36. Grabowski W, Lobsiger EA, Luttgau HC. The effect of repetitive stimulation at low frequencies upon the electrical and mechanical activity of single muscle fibres. *Pflügers Arch*. 1972;334(3):222–239.
37. Gyorke S. Effects of repeated tetanic stimulation on excitation-contraction coupling in cut muscle fibres of the frog. *J Physiol*.

1993;464:699–710.

38. Ríos E, Zhou J. Control of dual isoforms of Ca²⁺ release channels in muscle. *Biol Res.* 2004;37(4):583–591.

39. Eberstein A, Sandow A. Fatigue mechanisms in muscle fibers. In: Gutmann E, Hnik P, eds. *The Effect of Use and Disuse on Neuromuscular Function.* Prague, Czech: Academic Science; 1963:515–526.

40. Westerblad H, Allen DG. Changes of myoplasmic calcium concentration during fatigue in single mouse muscle fibers. *J Gen Physiol.* 1991;98(3):615–635.

41. Fryer MW, Owen VJ, Lamb GD, et al. Effects of creatine phosphate and P(i) on Ca²⁺ movements and tension development in rat skinned skeletal muscle fibers. *J Physiol.* 1995;482(pt 1):123–140.

42. Dutka TL, Cole L, Lamb GD. Calcium phosphate precipitation in the sarcoplasmic reticulum reduces action potential-mediated Ca²⁺ release in mammalian skeletal muscle. *Am J Physiol Cell Physiol.* 2005;289(6):C1502–C1512.

43. Duke AM, Steele DS. Interdependent effects of inorganic phosphate and creatine phosphate on sarcoplasmic reticulum Ca²⁺ regulation in mechanically skinned rat skeletal muscle. *J Physiol.* 2001;531(pt 3):729–742.

44. Pofterino GS, Lamb GD, Stephenson DG. Twitch and tetanic force responses and longitudinal propagation of action potentials in skinned skeletal muscle fibers of the rat. *J Physiol.* 2000;527 (pt 1):131–137.

45. Royer L, Pouvreau S, Rios E. Evolution and modulation of intracellular calcium release during long-lasting, depleting depolarization in mouse muscle. *J Physiol.* 2008;586(pt 19):4609–4629.

46. Blazev R, Lamb GD. Low [ATP] and elevated [Mg²⁺] reduce depolarization-induced Ca²⁺ release in rat skinned skeletal muscle fibers. *J Physiol.* 1999;520(pt 1):203–215.

47. Han JW, Thieleczek R, Varsanyi M, et al. Compartmentalized ATP synthesis in skeletal muscle triads. *Biochemistry.* 1992;31(2):377–384.

48. Westerblad H, Allen DG, Bruton JD, et al. Mechanisms underlying the reduction of isometric force in skeletal muscle fatigue. *Acta Physiol Scand.* 1998;162(3):253–260.

49. Holloszy JO, Coyle EF. Adaptations of skeletal muscle to endurance exercise and their metabolic consequences. *J Appl Physiol.* 1984;56(4):831–883.

50. Macdonald WA, Stephenson DG. Effects of ADP on sarcoplasmic reticulum function in mechanically skinned skeletal muscle fibers of the rat. *J Physiol.* 2001;532(pt 2):499–508.

51. Macdonald WA, Stephenson DG. Effects of ADP on action potential-induced force responses in mechanically skinned rat fast-twitch fibers. *J Physiol.* 2004;559(2):433–447.

52. Bruton JD, Lannergren J, Westerblad H. Mechanisms underlying the slow recovery of force after fatigue: importance of intracellular calcium. *Acta Physiol Scand.* 1998;162(3):285–293.

53. Westerblad H, Bruton JD, Allen DG, et al. Functional significance of Ca²⁺ in long-lasting fatigue of skeletal muscle. *Eur J Appl Physiol.* 2000;83(2–3):166–174.

54. Balog EM. Excitation-contraction coupling and minor triadic proteins in low-frequency fatigue. *Exerc Sport Sci Rev.* 2010;38(3):135–142.

55. Ferreira LF, Reid MB. Muscle-derived ROS and thiol regulation in muscle fatigue. *J Appl Physiol.* 2008;104(3):853–860.

56. Andrade FH, Reid MB, Allen DG, et al. Effect of hydrogen peroxide and dithiothreitol on contractile function of single skeletal muscle fibers from the mouse. *J Physiol.* 1998;509(pt 2):565–575.

57. Moopanar TR, Allen DG. Reactive oxygen species reduce myofibrillar Ca²⁺ sensitivity in fatiguing mouse skeletal muscle at 37 degrees C. *J Physiol.* 2005;564(pt 1):189–199.

58. Nosek TM, Fender KY, Godt RE. It is diprotonated inorganic phosphate that depresses force in skinned skeletal muscle fibers. *Science.* 1987;236(4798):191–193.

59. Fitts RH. The cross-bridge cycle and skeletal muscle fatigue. *J Appl Physiol.* 2008;104(2):551–558.

60. Debold EP, Romatowski J, Fitts RH. The depressive effect of Pi on the force-pCa relationship in skinned single muscle fibers is temperature dependent. *Am J Physiol Cell Physiol.* 2006;290(4):C1041–C1050.

61. Cairns SP. Lactic acid and exercise performance: culprit or friend? *Sports Med.* 2006;36(4):279–291.

62. Karatzaferi C, Franks-Skiba K, Cooke R. Inhibition of shortening velocity of skinned skeletal muscle fibers in conditions that mimic fatigue. *Am J Physiol Regul Integr Comp Physiol.* 2008;294(3):R948–R955.

63. Sahlin K, Katz A, Broberg S. Tricarboxylic acid cycle intermediates in human muscle during prolonged exercise. *Am J Physiol.* 1990;259(5 pt 1):C834–C841.

64. Wagenmakers AJ, Beckers EJ, Brouns F, et al. Carbohydrate supplementation, glycogen depletion, and amino acid metabolism during exercise. *Am J Physiol.* 1991;260(6 pt 1):E883–E890.

65. Brass EP, Scarrow AM, Ruff LJ, et al. Carnitine delays rat skeletal muscle fatigue in vitro. *J Appl Physiol.* 1993;75(4):1595–1600.

66. Tupling R, Green H, Grant S, et al. Postcontractile force depression in humans is associated with an impairment in SR Ca²⁺ pump function. *Am J Physiol Regul Integr Comp Physiol.* 2000;278(1):R87–R94.

67. Fitts RH, Courtright JB, Kim DH, et al. Muscle fatigue with prolonged exercise: contractile and biochemical alterations. *Am J Physiol.* 1982;242(1):C65–C73.

68. Tonkonogi M, Harris B, Sahlin K. Mitochondrial oxidative function in human saponin-skinned muscle fibers: effects of prolonged exercise. *J Physiol.* 1998;510(pt 1):279–286.

69. Lannergren J, Westerblad H. Force decline due to fatigue and intracellular acidification in isolated fibers from mouse skeletal muscle. *J Physiol.* 1991;434:307–322.

70. Thompson LV, Balog EM, Riley DA, et al. Muscle fatigue in frog semitendinosus: alterations in contractile function. *Am J Physiol.* 1992;262(6 pt 1):C1500–C1506.

71. Metzger JM, Fitts RH. Fatigue from high- and low-frequency muscle stimulation: role of sarcolemma action potentials. *Exp Neurol.* 1986;93(2):320–333.

Chapter 7

1. Christensen NJ, Galbo H. Sympathetic nervous activity during exercise. *Annu Rev Physiol.* 1983;45:139–153.
2. Epstein S, Robinson BF, Kahler RL, et al. Effects of beta-adrenergic blockade on the cardiac response to maximal and submaximal exercise in man. *J Clin Invest.* 1965;44:1745–1753.
3. Martin CE, Shaver JA, Leon DF, et al. Autonomic mechanisms in hemodynamic responses to isometric exercise. *J Clin Invest.* 1974;54:104–115.
4. Robinson BF, Epstein SE, Beiser GD, et al. Control of heart rate by the autonomic nervous system. Studies in man on the interrelation between baroreceptor mechanisms and exercise. *Circ Res.* 1966;19:400–411.
5. Galbo H. *Hormonal and Metabolic Adaptation to Exercise*. Stuttgart, New York: Thieme-Stratton; 1983.
6. Rowell LB. *Human Circulation Regulation During Physical Stress*. New York: Oxford University; 1986.
7. Nonogaki K. New insights into sympathetic regulation of glucose and fat metabolism. *Diabetologia.* 2000;43:533–549.
8. Tipton CM. *The Autonomic Nervous System*. New York: Oxford University; 2003.
9. Robinson S, Percy M, Brueckman FR, et al. Effects of atropine on heart rate and oxygen intake in working man. *J Appl Physiol.* 1953;5:508–512.
10. Ekblom B, Goldbarg AN, Kilbom A, et al. Effects of atropine and propranolol on the oxygen transport system during exercise in man. *Scand J Clin Lab Invest.* 1972;30:35–42.
11. Wilmore JH, Ewy GA, Freund BJ, et al. Cardiorespiratory alterations consequent to endurance exercise training during chronic beta-adrenergic blockade with atenolol and propranolol. *Am J Cardiol.* 1985;55:142D–148D.
12. Joyner MJ, Freund BJ, Jilka SM, et al. Effects of beta-blockade on exercise capacity of trained and untrained men: a hemodynamic comparison. *J Appl Physiol.* 1986;60:1429–1434.
13. Freyschuss U. Elicitation of heart rate and blood pressure increase on muscle contraction. *J Appl Physiol.* 1970;28:758–761.
14. Billman GE, Dujardin JP. Dynamic changes in cardiac vagal tone as measured by time-series analysis. *Am J Physiol.* 1990;258:H896–H902.
15. O’Leary DS, Rossi NF, Churchill PC. Substantial cardiac parasympathetic activity exists during heavy dynamic exercise in dogs. *Am J Physiol.* 1997;273:H2135–H2140.
16. Brenner IK, Thomas S, Shephard RJ. Autonomic regulation of the circulation during exercise and heat exposure: inferences from heart rate variability. *Sports Med.* 1998;26:85–99.
17. Carter JB, Banister EW, Blaber AP. Effect of endurance exercise on autonomic control of heart rate. *Sports Med.* 2003;33:33–46.
18. Casadei B, Cochrane S, Johnston J, et al. Pitfalls in the interpretation of spectral analysis of the heart rate variability during exercise in humans. *Acta Physiol Scand.* 1995;153:125–131.
19. Esler M, Jennings G, Lambert G, et al. Overflow of catecholamine neurotransmitters to the circulation: source, fate, and functions. *Physiol Rev.* 1990;70:963–985.
20. Grassi G, Esler M. How to assess sympathetic activity in humans. *J Hypertens.* 1999;17:719–734.
21. Mazzeo RS. Catecholamine responses to acute and chronic exercise. *Med Sci Sports Exerc.* 1991;23:839–845.
22. Rowell LB, O’Leary DS, Kellogg DL. Integration of cardiovascular control systems in dynamic exercise. In: Rowell LB, Sheperd JT, eds. *Handbook of Physiology*. New York: Oxford University; 1996:770–838.
23. Pernow J, Lundberg JM, Kaijser L, et al. Plasma neuropeptide Y-like immunoreactivity and catecholamines during various degrees of sympathetic activation in man. *Clin Physiol.* 1986;6:561–578.
24. Tidgren B, Hjerdahl P, Theodorsson E, et al. Renal neurohormonal and vascular responses to dynamic exercise in humans. *J Appl Physiol.* 1991;70:2279–2286.
25. Seals DR, Victor RG. Regulation of muscle sympathetic nerve activity during exercise in humans. *Exerc Sport Sci Rev.* 1991;19:313–349.
26. Kjaer M. Epinephrine and some other hormonal responses to exercise in man: with special reference to physical training. *Int J Sports Med.* 1989;10:2–15.
27. Bachman ES, Dhillon H, Zhang CY, et al. betaAR signaling required for diet-induced thermogenesis and obesity resistance. *Science.* 2002;297:843–845.
28. Arai Y, Saul JP, Albrecht P, et al. Modulation of cardiac autonomic activity during and immediately after exercise. *Am J Physiol.* 1989;256:H132–H141.
29. Fagraeus L, Linnarsson D. Autonomic origin of heart rate fluctuations at the onset of muscular exercise. *J Appl Physiol.* 1976;40:679–682.
30. Yamamoto Y, Hughson RL, Peterson JC. Autonomic control of heart rate during exercise studied by heart rate variability spectral analysis. *J Appl Physiol.* 1991;71:1136–1142.
31. Kukielka M, Seals DR, Billman GE. Cardiac vagal modulation of heart rate during prolonged submaximal exercise in animals with healed myocardial infarctions: effects of training. *Am J Physiol Heart Circ Physiol.* 2006;290:H1680–H1685.
32. DiCarlo SE, Bishop VS. Onset of exercise shifts operating point of arterial baroreflex to higher pressures. *Am J Physiol.* 1992;262:H303–H307.
33. O’Hagan KP, Bell LB, Mittelstadt SW, et al. Effect of dynamic exercise on renal sympathetic nerve activity in conscious rabbits. *J Appl Physiol.* 1993;74:2099–2104.
34. Tsuchimochi H, Matsukawa K, Komine H, et al. Direct measurement of cardiac sympathetic efferent nerve activity during dynamic exercise. *Am J Physiol Heart Circ Physiol.* 2002;283:H1896–H1906.
35. Saito M, Naito M, Mano T. Different responses in skin and muscle sympathetic nerve activity to static muscle contraction. *J Appl Physiol.* 1990;69:2085–2090.
36. Callister R, Ng AV, Seals DR. Arm muscle sympathetic nerve activity during preparation for and initiation of leg-cycling exercise in humans. *J Appl Physiol.* 1994;77:1403–1410.
37. Ray CA, Rea RF, Clary MP, et al. Muscle sympathetic nerve responses to dynamic one-legged exercise: effect of body posture. *Am J Physiol.* 1993;264:H1–H7.

38. Hasking GJ, Esler MD, Jennings GL, et al. Norepinephrine spillover to plasma during steady-state supine bicycle exercise: comparison of patients with congestive heart failure and normal subjects. *Circulation*. 1988;78:516–521.
39. Esler M, Kaye D, Thompson J, et al. Effects of aging on epinephrine secretion and regional release of epinephrine from the human heart. *J Clin Endocrinol Metab*. 1995;80:435–442.
40. Bloom SR, Johnson RH, Park DM, et al. Differences in the metabolic and hormonal response to exercise between racing cyclists and untrained individuals. *J Physiol*. 1976;258:1–18.
41. Galbo H, Holst JJ, Christensen NJ. Glucagon and plasma catecholamine responses to graded and prolonged exercise in man. *J Appl Physiol*. 1975;38:70–76.
42. Lehmann M, Keul J, Huber G, et al. Plasma catecholamines in trained and untrained volunteers during graduated exercise. *Int J Sports Med*. 1981;2:143–147.
43. Leuenberger U, Sinoway L, Gubin S, et al. Effects of exercise intensity and duration on norepinephrine spillover and clearance in humans. *J Appl Physiol*. 1993;75:668–674.
44. Saito M, Tsukanaka A, Yanagihara D, et al. Muscle sympathetic nerve responses to graded leg cycling. *J Appl Physiol*. 1993;75:663–667.
45. Victor RG, Seals DR, Mark AL. Differential control of heart rate and sympathetic nerve activity during dynamic exercise: insight from intraneural recordings in humans. *J Clin Invest*. 1987;79:508–516.
46. Savard G, Strange S, Kiens B, et al. Noradrenaline spillover during exercise in active versus resting skeletal muscle in man. *Acta Physiol Scand*. 1987;131:507–515.
47. Mazzeo RS, Rajkumar C, Jennings G, et al. Norepinephrine spillover at rest and during submaximal exercise in young and old subjects. *J Appl Physiol*. 1997;82:1869–1874.
48. Ichinose M, Saito M, Fujii N, et al. Modulation of the control of muscle sympathetic nerve activity during incremental leg cycling. *J Physiol*. 2008;586:2753–2766.
49. Manhem P, Lecerof H, Hokfelt B. Plasma catecholamine levels in the coronary sinus, the left renal vein and peripheral vessels in healthy males at rest and during exercise. *Acta Physiol Scand*. 1978;104:364–369.
50. Coker RH, Krishna MG, Zinker BA, et al. Sympathetic drive to liver and nonhepatic splanchnic tissue during prolonged exercise is increased in diabetes. *Metabolism*. 1997;46:1327–1332.
51. Rowell LB. *Human Cardiovascular Control*. New York: Oxford University; 1993.
52. Davy KP, Johnson DG, Seals DR. Cardiovascular, plasma norepinephrine, and thermal adjustments to prolonged exercise in young and older healthy humans. *Clin Physiol*. 1995;15:169–181.
53. Hagberg JM, Seals DR, Yerg JE, et al. Metabolic responses to exercise in young and older athletes and sedentary men. *J Appl Physiol*. 1988;65:900–908.
54. Saito M, Sone R, Ikeda M, et al. Sympathetic outflow to the skeletal muscle in humans increases during prolonged light exercise. *J Appl Physiol*. 1997;82:1237–1243.
55. Mazzeo RS, Marshall P. Influence of plasma catecholamines on the lactate threshold during graded exercise. *J Appl Physiol*. 1989;67:1319–1322.
56. Fattor JA, Miller BF, Jacobs KA, et al. Catecholamine response is attenuated during moderate-intensity exercise in response to the “lactate clamp.” *Am J Physiol Endocrinol Metab*. 2005;288:E143–E147.
57. Joyner MJ, Thomas GD. Having it both ways? Vasoconstriction in contracting muscles. *J Physiol*. 2003;550:333.
58. Thomas GD, Segal SS. Neural control of muscle blood flow during exercise. *J Appl Physiol*. 2004;97:731–738.
59. Blomqvist CG, Lewis SF, Taylor WF, et al. Similarity of the hemodynamic responses to static and dynamic exercise of small muscle groups. *Circ Res*. 1981;48:187–192.
60. McMurray RG, Forsythe WA, Mar MH, et al. Exercise intensity-related responses of beta-endorphin and catecholamines. *Med Sci Sports Exerc*. 1987;19:570–574.
61. Galbo H, Houston ME, Christensen NJ, et al. The effect of water temperature on the hormonal response to prolonged swimming. *Acta Physiol Scand*. 1979;105:326–337.
62. Watson RD, Hamilton CA, Jones DH, et al. Sequential changes in plasma noradrenaline during bicycle exercise. *Clin Sci (Lond)*. 1980;58:37–43.
63. Anderson DE, Hickey MS. Effects of caffeine on the metabolic and catecholamine responses to exercise in 5 and 28 degrees C. *Med Sci Sports Exerc*. 1994;26:453–458.
64. Escourrou P, Johnson DG, Rowell LB. Hypoxemia increases plasma catecholamine concentrations in exercising humans. *J Appl Physiol*. 1984;57:1507–1511.
65. Esler MD, Thompson JM, Kaye DM, et al. Effects of aging on the responsiveness of the human cardiac sympathetic nerves to stressors. *Circulation*. 1995;91:351–358.
66. Seals DR, Enoka RM. Sympathetic activation is associated with increases in EMG during fatiguing exercise. *J Appl Physiol*. 1989;66:88–95.
67. Saito M, Mano T, Iwase S. Sympathetic nerve activity related to local fatigue sensation during static contraction. *J Appl Physiol*. 1989;67:980–984.
68. Matsukawa K, Mitchell JH, Wall PT, et al. The effect of static exercise on renal sympathetic nerve activity in conscious cats. *J Physiol*. 1991;434:453–467.
69. Iwamoto GA, Wappel SM, Fox GM, et al. Identification of diencephalic and brainstem cardiorespiratory areas activated during exercise. *Brain Res*. 1996;726:109–122.
70. Kaufman MP, Forster H. *Reflexes Controlling Circulatory, Ventilatory and Airway Responses to Exercise*. New York: Oxford University; 1996.
71. Waldrop T, Eldridge FL, Iwamoto GA, et al. *Central Neural Control of Respiration and Circulation During Exercise*. New York: Oxford University; 1996.

72. Williamson JW, Fadel PJ, Mitchell JH. New insights into central cardiovascular control during exercise in humans: a central command update. *Exp Physiol.* 2006;91:51–58.
73. Ichiyama RM, Waldrop TG, Iwamoto GA. Neurons in and near insular cortex are responsive to muscular contraction and have sympathetic and/or cardiac-related discharge. *Brain Res.* 2004;1008:273–277.
74. Green AL, Wang S, Purvis S, et al. Identifying cardiorespiratory neurocircuitry involved in central command during exercise in humans. *J Physiol.* 2007;578:605–612.
75. Potts JT, Waldrop TG. Discharge patterns of somatosensitive neurons in the nucleus tractus solitarius of the cat. *Neuroscience.* 2005;132:1123–1134.
76. Potts JT, Fong AY, Anguelov PI, et al. Targeted deletion of neurokinin-1 receptor expressing nucleus tractus solitarii neurons precludes somatosensory depression of arterial baroreceptor-heart rate refl ex. *Neuroscience.* 2007;145:1168–1181.
77. Elam M, Svensson TH, Thoren P. Brain monoamine metabolism is altered in rats following spontaneous, long-distance running. *Acta Physiol Scand.* 1987;130:313–316.
78. Pagliari R, Peyrin L. Norepinephrine release in the rat frontal cortex under treadmill exercise: a study with microdialysis. *J Appl Physiol.* 1995;78:2121–2130.
79. Scheurink AJ, Steffens AB, Gaykema RP. Hypothalamic adrenoceptors mediate sympathoadrenal activity in exercising rats. *Am J Physiol.* 1990;259:R470–R477.
80. Overton JM, Redding MW, Yancey SL, et al. Hypothalamic GABAergic influences on treadmill exercise responses in rats. *Brain Res Bull.* 1994;33:517–522.
81. Potts JT. Exercise and sensory integration: role of the nucleus tractus solitarius. *Ann N Y Acad Sci.* 2001;940:221–236.
82. Victor RG, Pryor SL, Secher NH, et al. Effects of partial neuromuscular blockade on sympathetic nerve responses to static exercise in humans. *Circ Res.* 1989;65:468–476.
83. Alam M, Smirk FH. Unilateral loss of a blood pressure raising, pulse accelerating, refl ex from voluntary muscle due to a lesion of the spinal cord. *Clin Sci.* 1938;3:247–252.
84. Williamson JW, McColl R, Mathews D, et al. Brain activation by central command during actual and imagined handgrip under hypnosis. *J Appl Physiol.* 2002;92:1317–1324.
85. Williamson JW, McColl R, Mathews D, et al. Hypnotic manipulation of effort sense during dynamic exercise: cardiovascular responses and brain activation. *J Appl Physiol.* 2001;90:1392–1399.
86. Vissing SF, Hjortso EM. Central motor command activates sympathetic outflow to the cutaneous circulation in humans. *J Physiol.* 1996;492 (pt 3):931–939.
87. MacLean DA, Vickery LM, Sinoway LI. Elevated interstitial adenosine concentrations do not activate the muscle refl ex. *Am J Physiol Heart Circ Physiol.* 2001;280:H546–H553.
88. Sinoway LI, Smith MB, Enders B, et al. Role of diprotonated phosphate in evoking muscle refl ex responses in cats and humans. *Am J Physiol.* 1994;267:H770–H778.
89. Alam M, Smirk FH. Observations in man upon a blood pressure raising refl ex arising from the voluntary muscles. *J Physiol (London).* 1937;89:372–383.
90. Sinoway L, Prophet S, Gorman I, et al. Muscle acidosis during static exercise is associated with calf vasoconstriction. *J Appl Physiol.* 1989;66:429–436.
91. Victor RG, Bertocci LA, Pryor SL, et al. Sympathetic nerve discharge is coupled to muscle cell pH during exercise in humans. *J Clin Invest.* 1988;82:1301–1305.
92. Pryor SL, Lewis SF, Haller RG, et al. Impairment of sympathetic activation during static exercise in patients with muscle phosphorylase deficiency (McArdle's disease). *J Clin Invest.* 1990;85:1444–1449.
93. Ansorge EJ, Shah SH, Augustyniak RA, et al. Muscle metaborefl ex control of coronary blood flow. *Am J Physiol Heart Circ Physiol.* 2002;283:H526–H532.
94. Herr MD, Imadojemu V, Kunselman AR, et al. Characteristics of the muscle mechanorefl ex during quadriceps contractions in humans. *J Appl Physiol.* 1999;86:767–772.
95. Joyner MJ. Baroreceptor function during exercise: resetting the record. *Exp Physiol.* 2006;91:27–36.
96. Raven PB, Fadel PJ, Ogoh S. Arterial barorefl ex resetting during exercise: a current perspective. *Exp Physiol.* 2006;91:37–49.
97. Melcher A, Donald DE. Maintained ability of carotid barorefl ex to regulate arterial pressure during exercise. *Am J Physiol.* 1981;241:H838–H849.
98. Ichinose M, Saito M, Kondo N, et al. Time-dependent modulation of arterial barorefl ex control of muscle sympathetic nerve activity during isometric exercise in humans. *Am J Physiol Heart Circ Physiol.* 2006;290:H1419–H1426.
99. Ogoh S, Fisher JP, Raven PB, et al. Arterial barorefl ex control of muscle sympathetic nerve activity in the transition from rest to steady-state dynamic exercise in humans. *Am J Physiol Heart Circ Physiol.* 2007;293:H2202–H2209.
100. Ogoh S, Brothers RM, Barnes Q, et al. Cardiopulmonary barorefl ex is reset during dynamic exercise. *J Appl Physiol.* 2006;100:51–59.
101. Goldsmith SR, Iber C, McArthur CD, et al. Influence of acid-base status on plasma catecholamines during exercise in normal humans. *Am J Physiol.* 1990;258:R1411–R1416.
102. Bouissou P, Defer G, Guezennec CY, et al. Metabolic and blood catecholamine responses to exercise during alkalosis. *Med Sci Sports Exerc.* 1988;20:228–232.
103. Seals DR, Suwarno NO, Dempsey JA. Influence of lung volume on sympathetic nerve discharge in normal humans. *Circ Res.* 1990;67:130–141.
104. Rodman JR, Henderson KS, Smith CA, et al. Cardiovascular effects of the respiratory muscle metaborefl exes in dogs: rest and exercise. *J Appl Physiol.* 2003;95:1159–1169.
105. Seals DR. Robin Hood for the lungs? A respiratory metaborefl ex that “steals” blood flow from locomotor muscles. *J Physiol.* 2001;537:2.

106. Sala-Mercado JA, Ichinose M, Hammond RL, et al. Muscle metaboreflex attenuates spontaneous heart rate baroreflex sensitivity during dynamic exercise. *Am J Physiol Heart Circ Physiol.* 2007;292:H2867–H2873.
107. Kim JK, Sala-Mercado JA, Rodriguez J, et al. Arterial baroreflex alters strength and mechanisms of muscle metaboreflex during dynamic exercise. *Am J Physiol Heart Circ Physiol.* 2005;288:H1374–H1380.
108. Ekblom B, Kilbom A, Soltysiak J. Physical training, bradycardia, and autonomic nervous system. *Scand J Clin Lab Invest.* 1973;32:251–256.
109. Frick MH, Elovainio RO, Somer T. The mechanism of bradycardia evoked by physical training. *Cardiologia.* 1967;51:46–54.
110. Kenney WL. Parasympathetic control of resting heart rate: relationship to aerobic power. *Med Sci Sports Exerc.* 1985;17:451–455.
111. Yamamoto K, Miyachi M, Saitoh T, et al. Effects of endurance training on resting and post-exercise cardiac autonomic control. *Med Sci Sports Exerc.* 2001;33:1496–1502.
112. Goldsmith RL, Bigger JT Jr, Steinman RC, et al. Comparison of 24-hour parasympathetic activity in endurance-trained and untrained young men. *J Am Coll Cardiol.* 1992;20:552–558.
113. Herrlich HC, Raab W, Gigege W. Influence of muscular training and of catecholamines on cardiac acetylcholine and cholinesterase. *Arch Int Pharmacodyn Ther.* 1960;129:201–215.
114. Katona PG, McLean M, Dighton DH, et al. Sympathetic and parasympathetic cardiac control in athletes and nonathletes at rest. *J Appl Physiol.* 1982;52:1652–1657.
115. Meredith IT, Friberg P, Jennings GL, et al. Exercise training lowers resting renal but not cardiac sympathetic activity in humans. *Hypertension.* 1991;18:575–582.
116. Iellamo F, Legramante JM, Pigozzi F, et al. Conversion from vagal to sympathetic predominance with strenuous training in high-performance world class athletes. *Circulation.* 2002;105:2719–2724.
117. Ng AV, Callister R, Johnson DG, et al. Endurance exercise training is associated with elevated basal sympathetic nerve activity in healthy older humans. *J Appl Physiol.* 1994;77:1366–1374.
118. Peronnet F, Cleroux J, Perrault H, et al. Plasma norepinephrine response to exercise before and after training in humans. *J Appl Physiol.* 1981;51:812–815.
119. Jennings G, Nelson L, Nestel P, et al. The effects of changes in physical activity on major cardiovascular risk factors, hemodynamics, sympathetic function, and glucose utilization in man: a controlled study of four levels of activity. *Circulation.* 1986;73:30–40.
120. Poehlman ET, Danforth E Jr. Endurance training increases metabolic rate and norepinephrine appearance rate in older individuals. *Am J Physiol.* 1991;261:E233–E239.
121. Marker JC, Cryer PE, Clutter WE. Simplified measurement of norepinephrine kinetics: application to studies of aging and exercise training. *Am J Physiol.* 1994;267:E380–E387.
122. Seals DR. Sympathetic neural adjustments to stress in physically trained and untrained humans. *Hypertension.* 1991;17:36–43.
123. Svedenhag J, Wallin BG, Sundlof G, et al. Skeletal muscle sympathetic activity at rest in trained and untrained subjects. *Acta Physiol Scand.* 1984;120:499–504.
124. Sheldahl LM, Ebert TJ, Cox B, et al. Effect of aerobic training on baroreflex regulation of cardiac and sympathetic function. *J Appl Physiol.* 1994;76:158–165.
125. Ostman-Smith I. Adaptive changes in the sympathetic nervous system and some effector organs of the rat following long term exercise or cold acclimation and the role of cardiac sympathetic nerves in the genesis of compensatory cardiac hypertrophy. *Acta Physiol Scand Suppl.* 1979;477:1–118.
126. Mazzeo RS, Grantham PA. Norepinephrine turnover in various tissues at rest and during exercise: evidence for a training effect. *Metabolism.* 1989;38:479–483.
127. DeSchryver C, DeHerdt P, Lammerant J. Effect of physical training on cardiac catecholamine concentrations. *Nature.* 1967;214:907–908.
128. Hammond HK, White FC, Brunton LL, et al. Association of decreased myocardial beta-receptors and chronotropic response to isoproterenol and exercise in pigs following chronic dynamic exercise. *Circ Res.* 1987;60:720–726.
129. Dela F, Mikines KJ, von Linstow M, et al. Heart rate and plasma catecholamines during 24 h of everyday life in trained and untrained men. *J Appl Physiol.* 1992;73:2389–2395.
130. Winder WW, Hagberg JM, Hickson RC, et al. Time course of sympathoadrenal adaptation to endurance exercise training in man. *J Appl Physiol.* 1978;45:370–374.
131. Hagberg JM, Hickson RC, McLane JA, et al. Disappearance of norepinephrine from the circulation following strenuous exercise. *J Appl Physiol.* 1979;47:1311–1314.
132. Greiwe JS, Hickner RC, Shah SD, et al. Norepinephrine response to exercise at the same relative intensity before and after endurance exercise training. *J Appl Physiol.* 1999;86:531–535.
133. Ordway GA, Charles JB, Randall DC, et al. Heart rate adaptation to exercise training in cardiac-denervated dogs. *J Appl Physiol.* 1982;52:1586–1590.
134. Wolfel EE, Hiatt WR, Brammell HL, et al. Effects of selective and nonselective beta-adrenergic blockade on mechanisms of exercise conditioning. *Circulation.* 1986;74:664–674.
135. Liang C, Tuttle RR, Hood WB Jr, et al. Conditioning effects of chronic infusions of dobutamine: comparison with exercise training. *J Clin Invest.* 1979;64:613–619.
136. Fry AC, Kraemer WJ, van Borselen F, et al. Catecholamine responses to short-term high-intensity resistance exercise overtraining. *J Appl Physiol.* 1994;77:941–946.
137. Peronnet F, Thibault G, Perrault H, et al. Sympathetic response to maximal bicycle exercise before and after leg strength training. *Eur J Appl Physiol Occup Physiol.* 1986;55:1–4.
138. Carter JR, Ray CA, Downs EM, et al. Strength training reduces arterial blood pressure but not sympathetic neural activity in young normotensive subjects. *J Appl Physiol.* 2003;94:2212–2216.
139. Ichiyama RM, Gilbert AB, Waldrop TG, et al. Changes in the exercise activation of diencephalic and brainstem cardiorespiratory areas

after training. *Brain Res.* 2002;947:225–233.

140. Christou DD, Jones PP, Seals DR. Baroreflex buffering in sedentary and endurance exercise-trained healthy men. *Hypertension.* 2003;41:1219–1222.
141. Grassi G, Seravalle G, Calhoun DA, et al. Physical training and baroreceptor control of sympathetic nerve activity in humans. *Hypertension.* 1994;23:294–301.
142. Smith SA, Querry RG, Fadel PJ, et al. Differential baroreflex control of heart rate in sedentary and aerobically fit individuals. *Med Sci Sports Exerc.* 2000;32:1419–1430.
143. Bedford TG, Tipton CM. Exercise training and the arterial baroreflex. *J Appl Physiol.* 1987;63:1926–1932.
144. Bullough RC, Gillette CA, Harris MA, et al. Interaction of acute changes in exercise energy expenditure and energy intake on resting metabolic rate. *Am J Clin Nutr.* 1995;61:473–481.
145. Clausen JP, Klausen K, Rasmussen B, et al. Central and peripheral circulatory changes after training of the arms or legs. *Am J Physiol.* 1973;225:675–682.
146. Fisher WJ, White MJ. Training-induced adaptations in the central command and peripheral reflex components of the pressor response to isometric exercise of the human triceps surae. *J Physiol.* 1999;520(Pt 2):621–628.
147. Hakkinen K, Komi PV. Electromyographic changes during strength training and detraining. *Med Sci Sports Exerc.* 1983;15:455–460.
148. Saltin B, Nazar K, Costill DL, et al. The nature of the training response: peripheral and central adaptations of one-legged exercise. *Acta Physiol Scand.* 1976;96:289–305.
149. Elsner R, Carlson L. Post exercise hyperemia in trained and untrained subjects. *J Appl Physiol.* 1962;17:436–440.
150. Sinoway L, Shenberger J, Leaman G, et al. Forearm training attenuates sympathetic responses to prolonged rhythmic forearm exercise. *J Appl Physiol.* 1996;81:1778–1784.
151. Moštoufi-Moab S, Widmaier EJ, Cornett JA, et al. Forearm training reduces the exercise pressor reflex during ischemic rhythmic handgrip. *J Appl Physiol.* 1998;84:277–283.
152. Nelson AJ, Juraska JM, Musch TI, et al. Neuroplastic adaptations to exercise: neuronal remodeling in cardiorespiratory and locomotor areas. *J Appl Physiol.* 2005;99:2312–2322.
153. Nelson AJ, Iwamoto GA. Reversibility of exercise-induced dendritic attenuation in brain cardiorespiratory and locomotor areas following exercise detraining. *J Appl Physiol.* 2006;101:1243–1251.
154. Mueller, PJ. Physical (in)activity-dependent alterations at the rostral ventrolateral medulla: influence on sympathetic nervous system regulation. *Am J Physiol Regul Integr Comp Physiol.* 2010; 298:R1468–R1474.
155. Delp MD, McAllister RM, Laughlin MH. Exercise training alters endothelium-dependent vasoreactivity of rat abdominal aorta. *J Appl Physiol.* 1993;75:1354–1363.
156. Jones PP, Shapiro LF, Keisling GA, et al. Is autonomic support of arterial blood pressure related to habitual exercise status in healthy men? *J Physiol.* 2002;540:701–706.
157. Svedenhag J, Martinsson A, Ekblom B, et al. Altered cardiovascular responsiveness to adrenoceptor agonists in endurance-trained men. *J Appl Physiol.* 1991;70:531–538.
158. Wiegman DL, Harris PD, Joshua IG, et al. Decreased vascular sensitivity to norepinephrine following exercise training. *J Appl Physiol.* 1981;51:282–287.
159. LeBlanc J, Boulay M, Dulac S, et al. Metabolic and cardiovascular responses to norepinephrine in trained and nontrained human subjects. *J Appl Physiol.* 1977;42:166–173.
160. Sylvestre-Gervais L, Nadeau A, Nguyen MH, et al. Effects of physical training on beta-adrenergic receptors in rat myocardial tissue. *Cardiovasc Res.* 1982;16:530–534.
161. Stratton JR, Cerqueira MD, Schwartz RS, et al. Differences in cardiovascular responses to isoproterenol in relation to age and exercise training in healthy men. *Circulation.* 1992;86:504–512.
162. Williams RS, Schaible TF, Bishop T, et al. Effects of endurance training on cholinergic and adrenergic receptors of rat heart. *J Mol Cell Cardiol.* 1984;16:395–403.
163. Hopkins MG, Spina RJ, Ehsani AA. Enhanced beta-adrenergic-mediated cardiovascular responses in endurance athletes. *J Appl Physiol.* 1996;80:516–521.
164. Lash JM. Exercise training enhances adrenergic constriction and dilation in the rat spinotrapezius muscle. *J Appl Physiol.* 1998;85:168–174.
165. Lehmann M, Dickhuth HH, Schmid P, et al. Plasma catecholamines, beta-adrenergic receptors, and isoproterenol sensitivity in endurance trained and non-endurance trained volunteers. *Eur J Appl Physiol Occup Physiol.* 1984;52:362–369.
166. Evans YM, Funk JN, Charles JB, et al. Endurance training in dogs increases vascular responsiveness to an alpha 1-agonist. *J Appl Physiol.* 1988;65:625–632.
167. Plourde G, Rousseau-Migneron S, Nadeau A. Effect of endurance training on beta-adrenergic system in three different skeletal muscles. *J Appl Physiol.* 1993;74:1641–1646.

Chapter 8

1. Smith JC, Ellenberger HH, Ballanyi K, et al. Pre-Bötzinger complex: a brainstem region that may generate respiratory rhythm in mammals. *Science.* 1991;254(5032):726–729.
2. St-John WM, Paton JF. Defining eupnea. *Respir Physiol Neurobiol.* 2003;139(1):97–103.
3. Orem J, Netick A. Characteristics of midbrain respiratory neurons in sleep and wakefulness in the cat. *Brain Res.* 1982;244(2):231–241.
4. Feldman JL, Mitchell GS, Nattie EE. Breathing: rhythmicity, plasticity, chemosensitivity. *Annu Rev Neurosci.* 2003;26:239–266.
5. Takakura AC, Moreira TS, Colombari E, et al. Peripheral chemoreceptor inputs to retrotrapezoid nucleus (RTN) CO₂-sensitive neurons in rats. *J Physiol.* 2006;572(pt 2):503–523.
6. Blain GM, Smith CA, Henderson KS, et al. Contribution of the carotid body chemoreceptors to eupneic ventilation in the intact, unanesthe-

tized dog. *J Appl Physiol.* 2009;106(5):1564–1573.

7. Lahiri S, DeLaney RG. Stimulus interaction in the responses of carotid body chemoreceptor single afferent fibers. *Respir Physiol.* 1975;24(3):249–266.

8. Nattie E, Li A. Central chemoreception is a complex system function that involves multiple brain stem sites. *J Appl Physiol.* 2009;106(4):1464–1466.

9. Kaufman MP, Forster HV. Reflexes controlling ventilatory and airway responses to exercise. In: Rowell L, Shephard RJ, eds. *Handbook of Physiology: Exercise*. New York: Oxford Press; 1996:381–447.

10. Rice AJ, Nakayama HC, Haverkamp HC, et al. Controlled versus assisted mechanical ventilation effects on respiratory motor output in sleeping humans. *Am J Respir Crit Care Med.* 2003;168(1):92–101.

11. Badr MS, Skatrud JB, Dempsey JA. Determinants of poststimulus potentiation in humans during NREM sleep. *J Appl Physiol.* 1992;73(5):1958–1971.

12. Phillipson EA, Duffin J, Cooper JD. Critical dependence of respiratory rhythmicity on metabolic CO₂ load. *J Appl Physiol.* 1981;50(1):45–54.

13. Dempsey JA, Vidruk EH, Mitchell GS. Pulmonary control systems in exercise: update. *Fed Proc.* 1985;44(7):2260–2270.

14. Huszczuk A, Whipp BJ, Adams TD, et al. Ventilatory control during exercise in calves with artificial hearts. *J Appl Physiol.* 1990;68(6):2604–2611.

15. Olson EB Jr, Dempsey JA. Rat as a model for humanlike ventilatory adaptation to chronic hypoxia. *J Appl Physiol.* 1978;44(5):763–769.

16. Haouzi P, Hill JM, Lewis BK, et al. Responses of group III and IV muscle afferents to distension of the peripheral vascular bed. *J Appl Physiol.* 1999;87(2):545–553.

17. Pickar JG, Hill JM, Kaufman MP. Dynamic exercise stimulates group III muscle afferents. *J Neurophysiol.* 1994;71(2):753–760.

18. Haouzi P, Chenuel B, Huszczuk A. Sensing vascular distension in skeletal muscle by slow conducting afferent fibers: neurophysiological basis and implication for respiratory control. *J Appl Physiol.* 2004;96(2):407–418.

19. Krogh A, Lindhard J. The regulation of respiration and circulation during the initial stages of muscular work. *J Physiol.* 1913;47(1–2):112–136.

20. Eldridge FL, Millhorn DE, Waldrop TG. Exercise hyperpnea and locomotion: parallel activation from the hypothalamus. *Science.* 1981;211(4484):844–846.

21. Innes JA, De Cort SC, Evans PJ, et al. Central command influences cardiorespiratory response to dynamic exercise in humans with unilateral weakness. *J Physiol.* 1992;448:551–563.

22. Thornton JM, Guz A, Murphy K, et al. Identification of higher brain centres that may encode the cardiorespiratory response to exercise in humans. *J Physiol.* 2001;533(pt 3):823–836.

23. Williamson JW, McColl R, Mathews D, et al. Brain activation by central command during actual and imagined handgrip under hypnosis. *J Appl Physiol.* 2002;92(3):1317–1324.

24. Wasserman K, Whipp BJ, Koyal SN, et al. Effect of carotid body resection on ventilatory and acid-base control during exercise. *J Appl Physiol.* 1975;39(3):354–358.

25. Busse MW, Maassen N, Konrad H. Relation between plasma K⁺ and ventilation during incremental exercise after glycogen depletion and repletion in man. *J Physiol.* 1991;443:469–476.

26. Hagberg JM, Coyle EF, Carroll JE, et al. Exercise hyperventilation in patients with McArdle's disease. *J Appl Physiol.* 1982;52(4):991–994.

27. Henson LC, Ward DS, Whipp BJ. Effect of dopamine on ventilatory response to incremental exercise in man. *Respir Physiol.* 1992;89(2):209–224.

28. Mateika JH, Duffin J. Coincidental changes in ventilation and electromyographic activity during consecutive incremental exercise tests. *Eur J Appl Physiol Occup Physiol.* 1994;68(1):54–61.

29. Amann M, Blain GM, Proctor LT, et al. Group III and IV muscle afferents contribute to ventilatory and cardiovascular response to rhythmic exercise in humans. *J Appl Physiol.* 2010;109:947–948.

30. Hanson P, Claremont A, Dempsey J, et al. Determinants and consequences of ventilatory responses to competitive endurance running. *J Appl Physiol.* 1982;52(3):615–623.

31. MacDougall JD, Reddan WG, Layton CR, et al. Effects of metabolic hyperthermia on performance during heavy prolonged exercise. *J Appl Physiol.* 1974;36(5):538–544.

32. White MD. Components and mechanisms of thermal hyperpnea. *J Appl Physiol.* 2006;101(2):655–663.

33. Waldrop TG, Mullins DC, Millhorn DE. Control of respiration by the hypothalamus and by feedback from contracting muscles in cats. *Respir Physiol.* 1986;64(3):317–328.

34. Waldrop TG, Mullins DC, Henderson MC. Effects of hypothalamic lesions on the cardiorespiratory responses to muscular contraction. *Respir Physiol.* 1986;66(2):215–224.

35. Liu Q, Kim J, Cinotte J, et al. Carotid body denervation effect on cytochrome oxidase activity in pre-Botzinger complex of developing rats. *J Appl Physiol.* 2003;94(3):1115–1121.

36. Serra A, Brozoski D, Hodges M, et al. Effects of carotid and aortic chemoreceptor denervation in newborn piglets. *J Appl Physiol.* 2002;92(3):893–900.

37. Waldrop TG, Eldridge FL, Iwamoto G. Central neural control of respiration and circulation during exercise. In: Rowell LB, Shepherd JT, eds. *Handbook of Physiology*. New York: Oxford University; 1996:333–380.

38. Somjen GG. The missing error signal: regulation beyond negative feedback. *News Physiol Sci.* 1992;7:15–19.

39. Houk JC. Control strategies in physiological systems. *Faseb J.* 1988;2(2):97–107.

40. Fredberg JJ, Inouye D, Miller B, et al. Airway smooth muscle, tidal stretches, and dynamically determined contractile states. *Am J Respir Crit Care Med.* 1997;156(6):1752–1759.

41. Johnson BD, Saupe KW, Dempsey JA. Mechanical constraints on exercise hyperpnea in endurance athletes. *J Appl Physiol.*

1992;73(3):874–886.

42. Johnson BD, Weisman IM, Zeballos RJ, et al. Emerging concepts in the evaluation of ventilatory limitation during exercise: the exercise tidal flow-volume loop. *Chest*. 1999;116(2):488–503.
43. Guenette JA, Dominelli PB, Reeve SS, et al. Effect of thoracic gas compression and bronchodilation on the assessment of expiratory flow limitation during exercise in healthy humans. *Respir Physiol Neurobiol*. 2010;170(3):279–286.
44. Olafsson S, Hyatt RE. Ventilatory mechanics and expiratory flow limitation during exercise in normal subjects. *J Clin Invest*. 1969;48(3):564–573.
45. Koulouris NG, Dimopoulou I, Valta P, et al. Detection of expiratory flow limitation during exercise in COPD patients. *J Appl Physiol*. 1997;82(3):723–731.
46. Aliverti A, Cala SJ, Duranti R, et al. Human respiratory muscle actions and control during exercise. *J Appl Physiol*. 1997;83(4):1256–1269.
47. Aaron EA, Seow KC, Johnson BD, et al. Oxygen cost of exercise hyperpnea: implications for performance. *J Appl Physiol*. 1992;72(5):1818–1825.
48. Seals DR. The autonomic nervous system. In: Farrell PA, Joyner MJ, Caiozzo VJ, eds. *ACSM's Advanced Exercise Physiology* (2nd ed.). Baltimore: Lippincott Williams & Wilkins; 2011.
49. Manohar M. Blood flow to the respiratory and limb muscles and to abdominal organs during maximal exertion in ponies. *J Physiol*. 1986;377:25–35.
50. Harms CA, Wetter TJ, McClaran SR, et al. Effects of respiratory muscle work on cardiac output and its distribution during maximal exercise. *J Appl Physiol*. 1998;85(2):609–618.
51. Guenette JA, Vogiatzis I, Zakynthinos S, et al. Human respiratory muscle blood flow measured by near-infrared spectroscopy and indocyanine green. *J Appl Physiol*. 2008;104(4):1202–1210.
52. Aubier M, Farkas G, De Troyer A, et al. Detection of diaphragmatic fatigue in man by phrenic stimulation. *J Appl Physiol*. 1981;50(3):538–544.
53. Kyroussis D, Mills GH, Polkey MI, et al. Abdominal muscle fatigue after maximal ventilation in humans. *J Appl Physiol*. 1996;81(4):1477–1483.
54. Johnson BD, Babcock MA, Suman OE, et al. Exercise-induced diaphragmatic fatigue in healthy humans. *J Physiol*. 1993;460:385–405.
55. Taylor BJ, How SC, Romer LM. Exercise-induced abdominal muscle fatigue in healthy humans. *J Appl Physiol*. 2006;100(5):1554–1562.
56. Babcock MA, Johnson BD, Pegelow DF, et al. Hypoxic effects on exercise-induced diaphragmatic fatigue in normal healthy humans. *J Appl Physiol*. 1995;78(1):82–92.
57. Bellemare F, Grassino A. Effect of pressure and timing of contraction on human diaphragm fatigue. *J Appl Physiol*. 1982;53(5):1190–1195.
58. Babcock MA, Pegelow DF, McClaran SR, et al. Contribution of diaphragmatic power output to exercise-induced diaphragm fatigue. *J Appl Physiol*. 1995;78(5):1710–1719.
59. Morton DP, Callister R. Characteristics and etiology of exercise-related transient abdominal pain. *Med Sci Sports Exerc*. 2000;32(2):432–438.
60. McClaran SR, Wetter TJ, Pegelow DF, et al. Role of expiratory flow limitation in determining lung volumes and ventilation during exercise. *J Appl Physiol*. 1999;86(4):1357–1366.
61. Hill JM. Discharge of group IV phrenic afferent fibers increases during diaphragmatic fatigue. *Brain Res*. 2000;856(1–2):240–244.
62. Jammes Y, Balzamo E. Changes in afferent and efferent phrenic activities with electrically induced diaphragmatic fatigue. *J Appl Physiol*. 1992;73(3):894–902.
63. Ainsworth DM, Smith CA, Henderson KS, et al. Breathing during exercise in dogs—passive or active? *J Appl Physiol*. 1996;81(2):586–595.
64. Morin D, Viala D. Coordinations of locomotor and respiratory rhythms in vitro are critically dependent on hindlimb sensory inputs. *J Neurosci*. 2002;22(11):4756–4765.
65. Chen Z, Eldridge FL, Wagner PG. Respiratory-associated rhythmic firing of midbrain neurones in cats: relation to level of respiratory drive. *J Physiol*. 1991;437:305–325.
66. Jensen D, O'Farrill D, O'Donnell DE. Effects of pregnancy, obesity and aging on the intensity of perceived breathlessness during exercise in healthy humans. *Respir Physiol Neurobiol*. 2009;167(1):87–100.
67. Coates G, O'Brodovich H, Jefferies AL, et al. Effects of exercise on lung lymph flow in sheep and goats during normoxia and hypoxia. *J Clin Invest*. 1984;74(1):133–141.
68. West JB. Invited review: pulmonary capillary stress failure. *J Appl Physiol*. 2000;89(6):2483–2489;discussion 97.
69. Hopkins SR, Sheel AW, McKenzie DC. Point: pulmonary edema does/does not occur in human athletes performing heavy sea-level exercise. *J Appl Physiol*. 2010;109:1270–1272.
70. Hopkins SR, Schoene RB, Henderson WR, et al. Intense exercise impairs the integrity of the pulmonary blood-gas barrier in elite athletes. *Am J Respir Crit Care Med*. 1997;155(3):1090–1094.
71. Wagner PD, Gale GE, Moon RE, et al. Pulmonary gas exchange in humans exercising at sea level and simulated altitude. *J Appl Physiol*. 1986;61(1):260–270.
72. Sinclair SE, McKinney S, Glenny RW, et al. Exercise alters fractal dimension and spatial correlation of pulmonary blood flow in the horse. *J Appl Physiol*. 2000;88(6):2269–2278.
73. Allemann Y, Hutter D, Lipp E, et al. Patent foramen ovale and high-altitude pulmonary edema. *JAMA*. 2006;296(24):2954–2958.
74. Stickland MK, Welsh RC, Haykowsky MJ, et al. Intra-pulmonary shunt and pulmonary gas exchange during exercise in humans. *J Physiol*. 2004;561(pt 1):321–329.
75. Lovering AT, Haverkamp HC, Romer LM, et al. Transpulmonary passage of ^{99m}Tc macroaggregated albumin in healthy humans at rest and during maximal exercise. *J Appl Physiol*. 2009;106(6):1986–1992.

76. Eldridge MW, Dempsey JA, Haverkamp HC, et al. Exercise induced intrapulmonary arteriovenous shunting in healthy humans. *J Appl Physiol.* 2004;97(3):797–805.
77. Lovering AT, Eldridge MW, Stickland MK. Counterpoint: exercise-induced intrapulmonary shunting is real. *J Appl Physiol.* 2009;107(3):994–997.
78. Hopkins SR, Olfert IM, Wagner PD. Point: exercise-induced intrapulmonary shunting is imaginary. *J Appl Physiol.* 2009;107(3):993–994.
79. Lloyd TC Jr. Respiratory system compliance as seen from the cardiac fossa. *J Appl Physiol.* 1982;53(1):57–62.
80. Willeput R, Rondeux C, De Troyer A. Breathing affects venous return from legs in humans. *J Appl Physiol.* 1984;57(4):971–976.
81. Moreno AH, Katz AI, Gold LD. An integrated approach to the study of the venous system with steps toward a detailed model of the dynamics of venous return to the right heart. *IEEE Trans Biomed Eng.* 1969;16(4):308–324.
82. Takata M, Wise RA, Robotham JL. Effects of abdominal pressure on venous return: abdominal vascular zone conditions. *J Appl Physiol.* 1990;69(6):1961–1972.
83. Miller JD, Pegelow DF, Jacques AJ, et al. Skeletal muscle pump versus respiratory muscle pump: modulation of venous return from the locomotor limb in humans. *J Physiol.* 2005;563(pt 3):925–943.
84. Wexler L, Bergel DH, Gabe IT, et al. Velocity of blood flow in normal human venae cavae. *Circ Res.* 1968;23(3):349–359.
85. Miller JD, Smith CA, Hemauer SJ, et al. The effects of inspiratory intrathoracic pressure production on the cardiovascular response to submaximal exercise in health and chronic heart failure. *Am J Physiol Heart Circ Physiol.* 2007;292(1):H580–H592.
86. Miller JD, Hemauer SJ, Smith CA, et al. Expiratory threshold loading impairs cardiovascular function in health and chronic heart failure during submaximal exercise. *J Appl Physiol.* 2006;101(1):213–227.
87. Stark-Leyva KN, Beck KC, Johnson BD. Influence of expiratory loading and hyperinflation on cardiac output during exercise. *J Appl Physiol.* 2004;96(5):1920–1927.
88. Miller JD, Pegelow DF, Jacques AJ, et al. Effects of augmented respiratory muscle pressure production on locomotor limb venous return during calf contraction exercise. *J Appl Physiol.* 2005;99(5):1802–1815.
89. Belenkie I, Smith ER, Tyberg JV. Ventricular interaction: from bench to bedside. *Ann Med.* 2001;33(4):236–241.
90. Scharf SM, Pinsky MR, Magder S, et al. *Respiratory-Circulatory Interactions in Health and Disease*. New York: Marcel Dekker; 2001.
91. St Croix CM, Satoh M, Morgan BJ, et al. Role of respiratory motor output in within-breath modulation of muscle sympathetic nerve activity in humans. *Circ Res.* 1999;85(5):457–469.
92. Eckberg DL, Kifle YT, Roberts VL. Phase relationship between normal human respiration and baroreflex responsiveness. *J Physiol.* 1980;304:489–502.
93. Taha BH, Simon PM, Dempsey JA, et al. Respiratory sinus arrhythmia in humans: an obligatory role for vagal feedback from the lungs. *J Appl Physiol.* 1995;78(2):638–645.
94. Potts JT, Paton JF, Mitchell JH, et al. Contraction-sensitive skeletal muscle afferents inhibit arterial baroreceptor signalling in the nucleus of the solitary tract: role of intrinsic GABA interneurons. *Neuroscience.* 2003;119(1):201–214.
95. Hajduczuk G, Hade JS, Mark AL, et al. Central command increases sympathetic nerve activity during spontaneous locomotion in cats. *Circ Res.* 1991;69(1):66–75.
96. Hussain SN, Chatillon A, Comtois A, et al. Chemical activation of thin-fiber phrenic afferents. 2. Cardiovascular responses. *J Appl Physiol.* 1991;70(1):77–86.
97. Rodman JR, Henderson KS, Smith CA, et al. Cardiovascular effects of the respiratory muscle metaboreflexes in dogs: rest and exercise. *J Appl Physiol.* 2003;95(3):1159–1169.
98. St Croix CM, Morgan BJ, Wetter TJ, et al. Fatiguing inspiratory muscle work causes reflex sympathetic activation in humans. *J Physiol.* 2000;529(pt 2):493–504.
99. Sheel AW, Derchak PA, Morgan BJ, et al. Fatiguing inspiratory muscle work causes reflex reduction in resting leg blood flow in humans. *J Physiol.* 2001;537:277–289.
100. Derchak PA, Sheel AW, Morgan BJ, et al. Effects of expiratory muscle work on muscle sympathetic nerve activity. *J Appl Physiol.* 2002;92(4):1539–1552.
101. Stickland MK, Morgan BJ, Dempsey JA. Carotid chemoreceptor modulation of sympathetic vasoconstrictor outflow during exercise in healthy humans. *J Physiol.* 2008;586(6):1743–1754.
102. Stickland MK, Miller JD, Smith CA, et al. Carotid chemoreceptor modulation of regional blood flow distribution during exercise in health and chronic heart failure. *Circ Res.* 2007;100(9):1371–1378.
103. Rowell LB, O’Leary DS. Reflex control of the circulation during exercise: chemoreflexes and mechanoreflexes. *J Appl Physiol.* 1990;69(2):407–418.
104. Harms CA, Babcock MA, McClaran SR, et al. Respiratory muscle work compromises leg blood flow during maximal exercise. *J Appl Physiol.* 1997;82(5):1573–1583.
105. Aaker A, Laughlin MH. Diaphragm arterioles are less responsive to alpha(1)-adrenergic constriction than gastrocnemius arterioles. *J Appl Physiol.* 2002;92(5):1808–1816.
106. Cooper DM, Kaplan MR, Baumgarten L, et al. Coupling of ventilation and CO₂ production during exercise in children. *Pediatr Res.* 1987;21(6):568–572.
107. Mead J. Dysanapsis in normal lungs assessed by the relationship between maximal flow, static recoil, and vital capacity. *Am Rev Respir Dis.* 1980;121(2):339–342.
108. Gaultier C, Perret L, Boule M, et al. Occlusion pressure and breathing pattern in healthy children. *Respir Physiol.* 1981;46(1):71–80.
109. Rowland TW, Cunningham LN. Development of ventilatory responses to exercise in normal white children: a longitudinal study. *Chest.* 1997;111(2):327–332.
110. Nourry C, Deruelle F, Fabre C, et al. Evidence of ventilatory constraints in healthy exercising prepubescent children. *Pediatr Pulmonol.* 2006;41(2):133–140.
111. Cook CD, Mead J, Orzalesi MM. Static volume-pressure characteristics of the respiratory system during maximal efforts. *J Appl Physiol.*

1964;19:1016–1022.

112. Koechlin C, Matecki S, Jaber S, et al. Changes in respiratory muscle endurance during puberty. *Pediatr Pulmonol.* 2005;40(3):197–204.
113. Janssens JP. Aging of the respiratory system: impact on pulmonary function tests and adaptation to exertion. *Clin Chest Med.* 2005;26(3):469–484, vi–vii.
114. Johnson BD, Reddan WG, Seow KC, et al. Mechanical constraints on exercise hyperpnea in a fit aging population. *Am Rev Respir Dis.* 1991;143(5 Pt 1):968–977.
115. Prefaut C, Anselme F, Caillaud C, et al. Exercise-induced hypoxemia in older athletes. *J Appl Physiol.* 1994;76(1):120–126.
116. Thurlbeck WM. Postnatal human lung growth. *Thorax.* 1982;37(8):564–571.
117. Hopkins SR, Harms CA. Gender and pulmonary gas exchange during exercise. *Exerc Sport Sci Rev.* 2004;32(2):50–56.
118. Martin TR, Cañile RG, Fredberg JJ, et al. Airway size is related to sex but not lung size in normal adults. *J Appl Physiol.* 1987;63(5):2042–2047.
119. McClaran SR, Harms CA, Pegelow DF, et al. Smaller lungs in women affect exercise hyperpnea. *J Appl Physiol.* 1998;84(6):1872–1881.
120. Guenette JA, Witt JD, McKenzie DC, et al. Respiratory mechanics during exercise in endurance-trained men and women. *J Physiol.* 2007;581(pt 3):1309–1322.
121. Guenette JA, Romer LM, Querido JS, et al. Sex differences in exercise-induced diaphragmatic fatigue in endurance-trained athletes. *J Appl Physiol.* 2010;109(1):35–46.
122. Hicks AL, Kent-Braun J, Ditor DS. Sex differences in human skeletal muscle fatigue. *Exerc Sport Sci Rev.* 2001;29(3):109–112.
123. Moore RL. The cardiovascular system: cardiac function. In: Farrell PA, Joyner MJ, Caiozzo VJ, eds. *ACSM's Advanced Exercise Physiology*. 2nd ed. Baltimore: Lippincott Williams & Wilkins; 2011.
124. Caiozzo VJ. The muscular system: structural and functional plasticity. In: Farrell PA, Joyner MJ, Caiozzo VJ, eds. *ACSM's Advanced Exercise Physiology* (2nd ed.). Baltimore: Lippincott Williams & Wilkins; 2011.
125. Weibel ER, Taylor CR, Hoppeler H. Variations in function and design: testing symmorphosis in the respiratory system. *Respir Physiol.* 1992;87(3):325–348.
126. Johnson LR, Rush JW, Turk JR, et al. Short-term exercise training increases ACh-induced relaxation and eNOS protein in porcine pulmonary arteries. *J Appl Physiol.* 2001;90(3):1102–1110.
127. Clanton TL, Dixon GF, Drake J, et al. Effects of swim training on lung volumes and inspiratory muscle conditioning. *J Appl Physiol.* 1987;62(1):39–46.
128. Leith DE, Bradley M. Ventilatory muscle strength and endurance training. *J Appl Physiol.* 1976;41(4):508–516.
129. Scichilone N, Morici G, Marchese R, et al. Reduced airway responsiveness in nonelite runners. *Med Sci Sports Exerc.* 2005;37(12):2019–2025.
130. Scichilone N, Morici G, Zangla D, et al. Effects of exercise training on airway responsiveness and airway cells in healthy subjects. *J Appl Physiol.* 2010;109(2):288–294.
131. Bonsignore MR, La Grutta S, Cibella F, et al. Effects of exercise training and montelukast in children with mild asthma. *Med Sci Sports Exerc.* 2008;40(3):405–412.
132. Mendes FA, Almeida FM, Cukier A, et al. Effects of aerobic training on airway inflammation in asthmatic patients. *Med Sci Sports Exerc.* 2011;43:197–203.
133. Scichilone N, Togias A. The role of lung inflammation in airway hyperresponsiveness and in asthma. *Curr Allergy Asthma Rep.* 2004;4(2):166–174.
134. Hewitt M, Estell K, Davis IC, et al. Repeated bouts of moderate-intensity aerobic exercise reduce airway reactivity in a murine asthma model. *Am J Respir Cell Mol Biol.* 2010;42(2):243–249.
135. Nourry C, Deruelle F, Fabre C, et al. Exercise flow-volume loops in prepubescent aerobically trained children. *J Appl Physiol.* 2005;99(5):1912–1921.
136. Courteix D, Obert P, Lecoq AM, et al. Effect of intensive swimming training on lung volumes, airway resistance and on the maximal expiratory flow-volume relationship in prepubertal girls. *Eur J Appl Physiol Occup Physiol.* 1997;76(3):264–269.
137. Nourry C, Deruelle F, Guinhouya C, et al. High-intensity intermittent running training improves pulmonary function and alters exercise breathing pattern in children. *Eur J Appl Physiol.* 2005;94(4):415–423.
138. Hagberg JM, Yerg JE 2nd, Seals DR. Pulmonary function in young and older athletes and untrained men. *J Appl Physiol.* 1988;65(1):101–105.
139. McClaran SR, Babcock MA, Pegelow DF, et al. Longitudinal effects of aging on lung function at rest and exercise in healthy active fit elderly adults. *J Appl Physiol.* 1995;78(5):1957–1968.
140. Seals DR, Walker AE, Pierce GL, et al. Habitual exercise and vascular ageing. *J Physiol.* 2009;587(pt 23):5541–5549.
141. Dempsey JA, Reddan WG, Birnbaum ML, et al. Effects of acute through life-long hypoxic exposure on exercise pulmonary gas exchange. *Respir Physiol.* 1971;13(1):62–89.
142. Massaro D, Massaro GD, Baras A, et al. Calorie-related rapid onset of alveolar loss, regeneration, and changes in mouse lung gene expression. *Am J Physiol Lung Cell Mol Physiol.* 2004;286(5):L896–L906.
143. Hsia CC, Fryder-Doffey F, Stalder-Nayarro V, et al. Structural changes underlying compensatory increase of diffusing capacity after left pneumonectomy in adult dogs. *J Clin Invest.* 1993;92(2):758–764.
144. Karjalainen EM, Laitinen A, Sue-Chu M, et al. Evidence of airway inflammation and remodeling in ski athletes with and without bronchial hyperresponsiveness to methacholine. *Am J Respir Crit Care Med.* 2000;161(6):2086–2091.
145. Powers S, Shanley R. Exercise-induced changes in diaphragmatic bioenergetic and antioxidant capacity. *Exerc Sport Sci Rev.* 2002;30(2):69–74.
146. Vincent HK, Shanely RA, Stewart DJ, et al. Adaptation of upper airway muscles to chronic endurance exercise. *Am J Respir Crit Care Med.* 2002;166(3):287–293.
147. Ramirez-Sarmiento A, Orozco-Levi M, Guell R, et al. Inspiratory muscle training in patients with chronic obstructive pulmonary disease:

- structural adaptation and physiologic outcomes. *Am J Respir Crit Care Med.* 2002;166(11):1491–1497.
148. Levine S, Nguyen T, Shrager J, et al. Diaphragm adaptations elicited by severe chronic obstructive pulmonary disease: lessons for sports science. *Exerc Sport Sci Rev.* 2001;29(2):71–75.
149. Babcock MA, Pegelow DF, Johnson BD, et al. Aerobic fitness effects on exercise-induced low-frequency diaphragm fatigue. *J Appl Physiol.* 1996;81(5):2156–2164.
150. Zhan WZ, Sieck GC. Adaptations of diaphragm and medial gastrocnemius muscles to inactivity. *J Appl Physiol.* 1992;72(4):1445–1453.
151. Levine S, Nguyen T, Taylor N, et al. Rapid disuse atrophy of diaphragm fibers in mechanically ventilated humans. *N Engl J Med.* 2008;358(13):1327–1335.
152. Farkas GA, Roussos C. Adaptability of the hamster diaphragm to exercise and/or emphysema. *J Appl Physiol.* 1982;53(5):1263–1272.
153. Farkas GA, Roussos C. Diaphragm in emphysematous hamsters: sarcomere adaptability. *J Appl Physiol.* 1983;54(6):1635–1640.
154. Arnold JS, Thomas AJ, Kelsen SG. Length-tension relationship of abdominal expiratory muscles: effect of emphysema. *J Appl Physiol.* 1987;62(2):739–745.
155. Shrager JB, Kim DK, Hashmi YJ, et al. Sarcomeres are added in series to emphysematous rat diaphragm after lung volume reduction surgery. *Chest.* 2002;121(1):210–215.
156. Shrager JB, Kim DK, Hashmi YJ, et al. Lung volume reduction surgery restores the normal diaphragmatic length-tension relationship in emphysematous rats. *J Thorac Cardiovasc Surg.* 2001;121(2):217–224.
157. Saltin B, Calbet JA. Point: in health and in a normoxic environment, VO₂ max is limited primarily by cardiac output and locomotor muscle blood flow. *J Appl Physiol.* 2006;100(2):744–745.
158. Wagner PD. Counterpoint: in health and in normoxic environment VO₂max is limited primarily by cardiac output and locomotor muscle blood flow. *J Appl Physiol.* 2006;100(2):745–747; discussion 7–8.
159. Bayly WM, Hodgson DR, Schulz DA, et al. Exercise-induced hypercapnia in the horse. *J Appl Physiol.* 1989;67(5):1958–1966.
160. Dempsey JA, Hanson PG, Henderson KS. Exercise-induced arterial hypoxaemia in healthy human subjects at sea level. *J Physiol.* 1984;355:161–175.
161. Gore CJ, Little SC, Hahn AG, et al. Reduced performance of male and female athletes at 580 m altitude. *Eur J Appl Physiol Occup Physiol.* 1997;75(2):136–143.
162. Lawler J, Powers SK, Thompson D. Linear relationship between VO₂max and VO₂max decrement during exposure to acute hypoxia. *J Appl Physiol.* 1988;64(4):1486–1492.
163. Romer LM, Haverkamp HC, Lovering AT, et al. Effect of exercise-induced arterial hypoxemia on quadriceps muscle fatigue in healthy humans. *Am J Physiol Regul Integr Comp Physiol.* 2006;290(2):R365–R375.
164. Amann M, Eldridge MW, Lovering AT, et al. Arterial oxygenation influences central motor output and exercise performance via effects on peripheral locomotor muscle fatigue. *J Physiol.* 2006;575:937–952.
165. Amann M, Calbet JA. Convective oxygen transport and fatigue. *J Appl Physiol.* 2008;104(3):861–870.
166. Harms CA, Wetter TJ, St. Croix CM, et al. Effects of respiratory muscle work on exercise performance. *J Appl Physiol.* 2000;89(1):131–138.
167. Mador MJ, Acevedo FA. Effect of respiratory muscle fatigue on subsequent exercise performance. *J Appl Physiol.* 1991;70:2059–2065.
168. Taylor BJ, Romer LM. Effect of expiratory muscle fatigue on exercise tolerance and locomotor muscle fatigue in healthy humans. *J Appl Physiol.* 2008;104(5):1442–1451.
169. Romer LM, Polkey MI. Exercise-induced respiratory muscle fatigue: implications for performance. *J Appl Physiol.* 2008;104(3):879–888.
170. Romer LM, Lovering AT, Haverkamp HC, et al. Effect of inspiratory muscle work on peripheral fatigue of locomotor muscles in healthy humans. *J Physiol.* 2006;571(pt 2):425–439.
171. Amann M, Pegelow DF, Jacques AJ, et al. Inspiratory muscle work in acute hypoxia influences locomotor muscle fatigue and exercise performance of healthy humans. *Am J Physiol Regul Integr Comp Physiol.* 2007;293(5):R2036–R2045.
172. Nielsen HB, Bredmose PP, Stromstad M, et al. Bicarbonate attenuates arterial desaturation during maximal exercise in humans. *J Appl Physiol.* 2002;93(2):724–731.
173. Wetter TJ, Xiang Z, Sonetti DA, et al. Role of lung inflammatory mediators as a cause of exercise-induced arterial hypoxemia in young athletes. *J Appl Physiol.* 2002;93(1):116–126.
174. Prefaut C, Anselme-Poujol F, Caillaud C. Inhibition of histamine release by nedocromil sodium reduces exercise-induced hypoxemia in master athletes. *Med Sci Sports Exerc.* 1997;29(1):10–16.
175. Haverkamp HC, Dempsey JA, Pegelow DF, et al. Treatment of airway inflammation improves exercise pulmonary gas exchange and performance in asthmatic subjects. *J Allergy Clin Immunol.* 2007;120(1):39–47.
176. McConnell AK, Romer LM. Respiratory muscle training in healthy humans: resolving the controversy. *Int J Sports Med.* 2004;25(4):284–293.
177. Johnson MA, Sharpe GR, Brown PI. Inspiratory muscle training improves cycling time-trial performance and anaerobic work capacity but not critical power. *Eur J Appl Physiol.* 2007;101(6):761–770.
178. McConnell AK, Sharpe GR. The effect of inspiratory muscle training upon maximum lactate steady-state and blood lactate concentration. *Eur J Appl Physiol.* 2005;94(3):277–284.
179. Romer LM, McConnell AK, Jones DA. Inspiratory muscle fatigue in trained cyclists: effects of inspiratory muscle training. *Med Sci Sports Exerc.* 2002;34(5):785–792.
180. Verges S, Lenherr O, Haner AC, et al. Increased fatigue resistance of respiratory muscles during exercise after respiratory muscle endurance training. *Am J Physiol Regul Integr Comp Physiol.* 2007;292(3):R1246–R1253.
181. McConnell AK, Lomax M. The influence of inspiratory muscle work history and specific inspiratory muscle training upon human limb muscle fatigue. *J Physiol.* 2006;577(pt 1):445–457.
182. Witt JD, Guenette JA, Rupert JL, et al. Inspiratory muscle training attenuates the human respiratory muscle metaboreflex. *J Physiol.*

2007;584(pt 3):1019–1028.

183. McConnell AK, Romer LM. Dyspnoea in health and obstructive pulmonary disease: the role of respiratory muscle function and training. *Sports Med.* 2004;34(2):117–132.

Chapter 9

- .1 Mitchell JH, Schmidt RF. Cardiovascular reflex control by afferent fibers from skeletal muscle receptors. In: *Handbook of Physiology*. Bethesda, MD: American Physiological Society; 1983:623–658.
- .2 Rowell LB, O’Leary DS, Kellogg DL. *Integration of Cardiovascular Control Systems in Dynamic Exercise*. New York: Oxford Press; 1996:770–838.
- .3 White S, Patrick T, Higgins CB, et al. Effects of altering ventricular rate on blood flow distribution in conscious dogs. *Am J Physiol.* 1971;221:1402–1407.
- .4 Manders WT, Vatner SF. Effects of sodium pentobarbital anesthesia on left ventricular function and distribution of cardiac output in dogs, with particular reference to the mechanism for tachycardia. *Circ Res.* 1976;39:512–517.
- .5 Vatner SF, Smith NT. Effects of halothane on left ventricular function and distribution of regional blood flow in dogs and primates. *Circ Res.* 1974;34:155–167.
- .6 Vatner SF, Braunwald E. Cardiovascular control mechanisms in the conscious state. *N Engl J Med.* 1975;293(19):970–976.
- .7 Sagawa K, Maughan L, Suga H, et al. *Cardiac Contraction and the Pressure–Volume Relationship*. New York: Oxford University Press Inc.; 1988.
- .8 Cheng CP, Igarashi Y, Little WC. Mechanism of augmented rate of left ventricular filling during exercise. *Circ Res.* 1992;70:9–19.
- .9 Sala-Mercado JA, Hammond RL, Kim JK, et al. Heart failure attenuates muscle metaboreflex control of ventricular contractility during dynamic exercise. *Am J Physiol Heart Circ Physiol.* 2006;292(5):H2159–H2166.
- .10 Sheriff DD, Nelson CD, Sundermann RK. Does autonomic blockade reveal a potent contribution of nitric oxide to locomotion-induced vasodilation? *Am J Physiol Heart Circ Physiol.* 2000;279:H726–H732.
- .11 Sheriff DD, Van BR. Flow-generating capability of the isolated skeletal muscle pump. *Am J Physiol.* 1998;274:H1502–H1508.
- .12 Victor RG, Pryor SL, Secher NH, et al. Effects of partial neuromuscular blockade on sympathetic nerve responses to static exercise in humans. *Circ Res.* 1989;65:468–476.
- .13 Victor RG, Secher NH, Lyson T, et al. Central command increases muscle sympathetic nerve activity during intense intermittent isometric exercise in humans. *Circ Res.* 1995;76:127–131.
- .14 Hayes SG, Kaufman MP. MLR stimulation and exercise pressor reflex activate different renal sympathetic fibers in decerebrate cats. *J Appl Physiol.* 2002;92:1628–1634.
- .15 McIlveen SA, Hayes, SG, Kaufman MP. Both central command and exercise pressor reflex reset carotid sinus baroreflex. *Am J Physiol.* 2001; 280:H1454–H1463.
- .16 Matsukawa K, Mitchell JH, Wall PT, et al. The effect of static exercise on renal sympathetic nerve activity in conscious cats. *J Physiol.* 1991;434:453–467.
- .17 Vatner SF, Rutherford JD, Ochs HR. Baroreflex and vagal mechanisms modulating left ventricular contractile responses to sympathomimetic amines in conscious dogs. *Circ Res.* 1979;44:195–207.
- .18 Blukoo-Allotey JA, Vincent NH, Ellis S. Interactions of acetylcholine and epinephrine on contractility, glycogen and phosphorylase activity of isolated mammalian hearts. *J Pharmacol Exp Ther.* 1969;170:27–36.
- .19 Jacobowitz DAV, Cooper THE, Barner HB. Histochemical and chemical studies of the localization of adrenergic and cholinergic nerves in normal and denervated cat hearts. *Circ Res.* 1967;20:289–298.
- .20 Xenopoulos NP, Applegate RJ. The effect of vagal stimulation on left ventricular systolic and diastolic performance. *Am J Physiol Heart Circ Physiol.* 1994;266:H2167–H2173.
- .21 Matsuura W, Sugimachi M, Kawada T, et al. Vagal stimulation decreases left ventricular contractility mainly through negative chronotropic effect. *Am J Physiol Heart Circ Physiol.* 1997;273:H534–H539.
- .22 Bristow JD, Brown EB Jr, Cunningham DJC, et al. Effect of bicycling on the baroreflex regulation of pulse interval. *Circ Res.* 1971;28:582–592.
- .23 Bevegard BS, Shepherd JT. Circulatory effects of stimulating the carotid arterial stretch receptors in man at rest and during exercise. *J Clin Invest.* 1966;45:132–142.
- .24 Melcher A, Donald DE. Maintained ability of carotid baroreflex to regulate arterial pressure during exercise. *Am J Physiol.* 1981;241:H838–H849.
- .25 Potts JT, Shi XR, Raven PB. Carotid baroreflex responsiveness during dynamic exercise in humans. *Am J Physiol.* 1993;265:H1928–H1938.
- .26 Ogoh S, Fadel PJ, Nissen P, et al. Baroreflex-mediated changes in cardiac output and vascular conductance in response to alterations in carotid sinus pressure during exercise in humans. *J Physiol (Lond).* 2003;550:317–324.
- .27 O’Leary DS, Seamans DP. Effect of exercise on autonomic mechanisms of baroreflex control of heart rate. *J Appl Physiol.* 1993;75:2251–2257.
- .28 Potts JT, Li J. Interaction between carotid baroreflex and exercise pressor reflex depends on baroreceptor afferent input. *Am J Physiol.* 1998;274:H1841–H1847.
- .29 Ogoh S, Fadel PJ, Monteiro F, et al. Haemodynamic changes during neck pressure and suction in seated and supine positions. *J Physiol (Lond).* 2002;540(Pt 2):707–716.
- .30 Sala-Mercado JA, Ichinose M, Hammond RL, et al. Muscle metaboreflex attenuates spontaneous heart rate baroreflex sensitivity during dynamic exercise. *Am J Physiol Heart Circ Physiol.* 2007;292(6):H2867–H2873.
- .31 O’Leary DS, Seamans DP. Effect of exercise on autonomic mechanisms of baroreflex control of heart rate. *J Appl Physiol.* 1993;75:2251–2257.

- .23 Vatner SF, Higgins CB, Franklin D, et al. Extent of carotid sinus regulation of the myocardial contractile state in conscious dogs. *J Clin Invest.* 1972;51(4):995–1008.
- .33 Shimizu T, Bishop VS. Mechanism of reflex control of cardiac contractility by carotid sinus baroreceptors. *Am J Physiol Heart Circ Physiol.* 1980;239:H65–H72.
- .43 Young MA, Hintze TH, Vatner SF. Correlation between cardiac performance and plasma catecholamine levels in conscious dog. *Am J Physiol Heart Circ Physiol.* 1985;248:H82–H88.
- .53 Hammond RL, Augustyniak RA, Rossi NF, et al. Alteration of humoral and peripheral vascular responses during graded exercise in heart failure. *J Appl Physiol.* 2001;90:55–61.
- .63 Sala-Mercado JA, Hammond RL, Kim JK, et al. Muscle metaboreflex control of ventricular contractility during dynamic exercise. *Am J Physiol Heart Circ Physiol.* 2006;290:H751–H757.
- .73 Bennett TD, Wyss CR, Scher AM. Changes in vascular capacity in awake dogs in response to carotid sinus occlusion and administration of catecholamines. *Circ Res.* 1984;55:440–453.
- .83 Remensnyder JP, Mitchell JH, Sarnoff SJ. Functional sympatholysis during muscular activity. Observations on influence of carotid sinus on oxygen uptake. *Circ Res.* 1962;11:370–380.
- .93 O’Leary DS. Regional vascular resistance vs. conductance: which index for baroreflex responses? *Am J Physiol.* 1991;260:H632–H637.
- .04 Collins HL, Augustyniak RA, Ansoerge EJ, et al. Carotid baroreflex pressor responses at rest and during exercise: cardiac output vs. regional vasoconstriction. *Am J Physiol Heart Circ Physiol.* 2001;280:H642–H648.
- .14 Remensnyder JP, Mitchell JH, Sarnoff SJ. Functional sympatholysis during muscular activity. Observations on influence of carotid sinus on oxygen uptake. *Circ Res.* 1962;11:370–380.
- .24 O’Leary DS. Regional vascular resistance vs. conductance: which index for baroreflex responses? *Am J Physiol.* 1991;260:H632–H637.
- .34 Collins HL, Augustyniak RA, Ansoerge EJ, et al. Carotid baroreflex pressor responses at rest and during exercise: cardiac output vs. regional vasoconstriction. *Am J Physiol Heart Circ Physiol.* 2001;280:H642–H648.
- .44 Alam M, Smirk FH. Observations in man upon a blood pressure raising reflex arising from the voluntary muscles. *J Physiol.* 1937;89:372–383.
- .54 Sheriff DD, O’Leary DS, Scher AM, et al. Baroreflex attenuates pressor response to graded muscle ischemia in exercising dogs. *Am J Physiol.* 190;258:H305–H310.
- .64 Sheriff DD, Augustyniak RA, O’Leary DS. Muscle chemoreflex-induced increases in right atrial pressure. *Am J Physiol.* 1998;275:H767–H775.
- .74 O’Leary DS, Sheriff DD. Is the muscle metaboreflex important in control of blood flow to ischemic active skeletal muscle in dogs? *Am J Physiol.* 1995;268:H980–H986.
- .84 Augustyniak RA, Collins HL, Ansoerge EJ, et al. Severe exercise alters the strength and mechanisms of the muscle metaboreflex. *Am J Physiol Heart Circ Physiol.* 2001;280:H1645–H1652.
- .94 Hammond RL, Augustyniak RA, Rossi NF, et al. Heart failure alters the strength and mechanisms of the muscle metaboreflex. *Am J Physiol.* 2000;278:H818–H828.
- .05 Crisafulli A, Salis E, Tocco F, et al. Impaired central hemodynamic response and exaggerated vasoconstriction during muscle metaboreflex activation in heart failure patients. *Am J Physiol Heart Circ Physiol.* 2007;292:H2988–H2996.
- .15 Wallin BG, Victor RG, Mark AL. Sympathetic outflow to resting muscles during static handgrip and postcontraction muscle ischemia. *Am J Physiol.* 1989;256:H105–H110.
- .25 Wyss CR, Ardell JL, Scher AM, et al. Cardiovascular responses to graded reductions in hindlimb perfusion in exercising dogs. *Am J Physiol.* 1983;245:H481–H486.
- .35 Sheriff DD, Wyss CR, Rowell LB, et al. Does inadequate oxygen delivery trigger pressor response to muscle hypoperfusion during exercise? *Am J Physiol.* 1987;253:H1199–H1207.
- .45 O’Hagan KP, Casey SP, Clifford PS. Muscle chemoreflex increases renal sympathetic nerve activity. *J Appl Physiol.* 1997;82:1818–1825.
- .55 O’Leary DS. Autonomic mechanisms of muscle metaboreflex control of heart rate. *J Appl Physiol.* 1993;74:1748–1754.
- .65 Fisher JP, Seifert T, Hartwich D, et al. Autonomic control of heart rate by metabolically sensitive skeletal muscle afferents in humans. *J Physiol.* 2010;588:1117–1127.
- .75 Crisafulli A, Salis E, Pittau G, et al. Modulation of cardiac contractility by muscle metaboreflex following efforts of different intensities in humans. *Am J Physiol Heart Circ Physiol.* 2006;291(6):H3035–H3042.
- .85 Kaufman MP, Rybicki KJ, Waldrop TG, et al. Effect of ischemia on responses of group III and IV afferents to contraction. *J Appl Physiol.* 1984;57:644–650.
- .95 Hayes SG, Kaufman MP. Gadolinium attenuates exercise pressor reflex in cats. *Am J Physiol Heart Circ Physiol.* 2001;280:H2153–H2161.
- .06 Potts JT, Mitchell JH. Rapid resetting of carotid baroreceptor reflex by afferent input from skeletal muscle receptors. *Am J Physiol Heart Circ Physiol.* 1998;44:H2000–H2008.
- .16 Kim JK, Sala-Mercado JA, Rodriguez J, et al. The arterial baroreflex alters the strength and mechanisms of the muscle metaboreflex pressor response during dynamic exercise. *Am J Physiol Heart Circ Physiol.* 2005;288:H1374–H1380.
- .26 Kim JK, Sala-Mercado JA, Hammond RL, et al. Attenuated arterial baroreflex buffering of muscle metaboreflex in heart failure. *Am J Physiol Heart Circ Physiol.* 2005;289:H2416–H2423.
- .36 Blair SN. Physical inactivity: the biggest public health problem of the 21st century. *Br J Sports Med.* 2009;43:1–2.
- .46 Blair SN, Morris JN. Healthy hearts—and the universal benefits of being physically active: physical activity and health. *Ann Epidemiol.* 2009;19:253–256.
- .56 Sui X, LaMonte MJ, Laditka JN, et al. Cardiorespiratory fitness and adiposity as mortality predictors in older adults. *JAMA.* 2007;298:2507–2516.
- .66 Raven PB, Pawelczyk JA. Chronic endurance exercise training: a condition of inadequate blood pressure regulation and reduced tolerance to

LBNP. *Med Sci Sports Exerc.* 1993;25:713–721.

- .76 Watenpaugh DE, Hargens AR. The cardiovascular system in microgravity. In: Fregly MJ, Blatteis CM, eds. *Handbook of Physiology*. New York: Oxford University Press; 1996:631–674.
- .86 Pavy-Le TA, Heer M, Narici MV, et al. From space to Earth: advances in human physiology from 20 years of bed rest studies (1986–2006). *Eur J Appl Physiol.* 2007;101:143–194.
- .96 Booth FW, Lees SJ. Physically active subjects should be the control group. *Med Sci Sports Exerc.* 2006;38:405–406.
- .07 Hamilton MT, Hamilton DG, Zderic TW. Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exerc Sport Sci Rev.* 2004;32:161–166.
- .17 Hamilton MT, Hamilton DG, Zderic TW. Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes.* 2007;56:2655–2667.
- .27 Bertagnolli M, Schenkel PC, Campos C, et al. Exercise training reduces sympathetic modulation on cardiovascular system and cardiac oxidative stress in spontaneously hypertensive rats. *Am J Hypertens.* 2008;21:1188–1193.
- .37 Tipton CM, Matthes RD, Marcus KD, et al. Influences of exercise intensity, age, and medication on resting systolic blood pressure of SHR populations. *J Appl Physiol.* 1983;55:1305–1310.
- .47 Kenney MJ, Seals DR. Postexercise hypotension: key features, mechanisms, and clinical significance. *Hypertension.* 1993;22:653–664.
- .57 Roveda F, Middlekauff HR, Rondon MU, et al. The effects of exercise training on sympathetic neural activation in advanced heart failure: a randomized controlled trial. *J Am Coll Cardiol.* 2003;42:854–860.
- .67 Zucker IH. Novel mechanisms of sympathetic regulation in chronic heart failure. *Hypertension.* 2006;48:1005–1011.
- .77 Veras-Silva AS, Mattos KC, Gava NS, et al. Low-intensity exercise training decreases cardiac output and hypertension in spontaneously hypertensive rats. *Am J Physiol.* 1997;273:H2627–H2631.
- .87 Dicarulo SE, Bishop VS. Exercise training attenuates baroreflex regulation of nerve activity in rabbits. *Am J Physiol.* 1988;255:H974–H979.
- .97 Negrao CE, Irigoyen MC, Moreira ED, et al. Effect of exercise training on RSNA, baroreflex control, and blood pressure responsiveness. *Am J Physiol.* 1993;265:R365–R370.
- .08 Lees SJ, Booth FW. Sedentary death syndrome. *Can J Appl Physiol.* 2004;29:447–460.
- .18 Mueller PJ. Exercise training and sympathetic nervous system activity: evidence for physical activity dependent neural plasticity. *Clin Exp Pharmacol Physiol.* 2007;34:377–384.
- .28 Schlaich MP, Lambert E, Kaye DM, et al. Sympathetic augmentation in hypertension: role of nerve firing, norepinephrine reuptake, and Angiotensin neuromodulation. *Hypertension.* 2004;43:169–175.
- .38 Straznicky NE, Lambert EA, Lambert GW, et al. Effects of dietary weight loss on sympathetic activity and cardiac risk factors associated with the metabolic syndrome. *J Clin Endocrinol Metab.* 2005;90:5998–6005.
- .48 Julius S, Valentini M. Consequences of the increased autonomic nervous drive in hypertension, heart failure and diabetes. *Blood Press Suppl.* 1998;3:5–13.
- .58 Esler M, Rumantir M, Kaye D, et al. Sympathetic nerve biology in essential hypertension. *Clin Exp Pharmacol Physiol.* 2001;28:986–989.
- .68 Benedict CR, Shelton B, Johnstone DE, et al. Prognostic significance of plasma norepinephrine in patients with asymptomatic left ventricular dysfunction. SOLVD Investigators. *Circulation.* 1996;94:690–697.
- .78 Zoccali C, Mallamaci F, Parlongo S, et al. Plasma norepinephrine predicts survival and incident cardiovascular events in patients with end-stage renal disease. *Circulation.* 2002;105:1354–1359.
- .88 Dicarulo SE, Bishop VS. Exercise training attenuates baroreflex regulation of nerve activity in rabbits. *Am J Physiol.* 1988;255:H974–H979.

Chapter 10

1. Rowell LB. *Human Cardiovascular Control*. New York: Oxford University Press; 1993:162–479.
2. Saltin B, Blomqvist G, Mitchell JH, et al. Response to exercise after bed rest and after training: a longitudinal study of adaptive changes in oxygen transport and body composition. *Circulation.* 1968;38:1–78.
3. Saltin B, Rowell LB. Functional adaptations to physical activity and inactivity. *Fed Proc.* 1980;39:1506–1513.
4. Moore R, Korzick D. Cellular adaptations of the myocardium to chronic exercise. *Prog Cardiovasc Dis.* 1995;37(6):371–396.
5. Katz AM. *Physiology of the Heart*. 2nd ed. New York: Raven Press; 1992:687.
6. Demir SS, Clark JW, Giles WR. Parasympathetic modulation of sinoatrial node pacemaker activity in rabbit heart: a unifying model. *Am J Physiol.* 1999;276(45):H2221–H2244.
7. Lipsius SL, Huser J, Blatter LA. Intracellular Ca²⁺ release sparks atrial pacemaker activity. *News Physiol Sci.* 2001;16:101–106.
8. Trautwein W. Cellular pacemakers. In: Carpenter D, ed. *I. Mechanisms and Pacemaker Generation*. New York: Wiley; 1981:127–160.
9. Hammond HK, White FC, Brunton LL, et al. Association of decreased myocardial β -receptors and chronotropic response to isoproterenol and exercise in pigs following chronic dynamic exercise. *Circ Res.* 1987;60(5):720–726.
10. Hammond HK, Ransas LA, Insel PA. Noncoordinate regulation of cardiac G protein and β -adrenergic receptors by a physiological stimulus, chronic dynamic exercise. *J Clin Invest.* 1988;82:2168–2171.
11. Schaefer ME, Allert JA, Adams HR, et al. Adrenergic responsiveness and intrinsic sinoatrial automaticity of exercise-trained rats. *Med Sci Sports Exerc.* 1992;24(8):887–894.
12. Brown DA, Chicco AJ, Jew KN, et al. Cardioprotection afforded by chronic exercise is mediated by the sarcolemmal, and not the mitochondrial, isoform of the KATP channel in the rat. *J Physiol.* 2005;569:913–924.
13. Poliner LR, Dehmer GJ, Lewis SE, et al. Left ventricular performance in normal subjects: a comparison of the responses to exercise in the upright and supine positions. *Circulation.* 1980;62:528–534.
14. Bers DM. *Excitation-Contraction Coupling and Cardiac Contractile Force*. 2nd ed. Dordrecht, The Netherlands: Kluwer Academic Publishers; 2001:427.

15. Korzick DH. Regulation of cardiac excitation-contraction coupling: a cellular update. *Adv Physiol Educ.* 2003;27:192–200.
16. Marks AR. Cardiac intracellular calcium release channels: role in heart failure. *Circ Res.* 2000;87:8–11.
17. Bers DM. Cardiac excitation-contraction coupling. *Nature.* 2002;415:198–205.
18. Gordon AM, Huxley AF, Julian FJ. The variation in isometric tension with sarcomere length in vertebrate muscle fibres. *J Physiol.* 1966;184:170–192.
19. Allen DG, Jewell BR, Murray JW. The contribution of activation processes to the length tension relation in cardiac muscle. *Nature.* 1974;248:606–607.
20. Solaro RJ, Wise RM, Shiner JS, et al. Calcium requirement for cardiac myofibrillar activation. *Circ Res.* 1974;34:525–530.
21. Hibberd MG, Jewell BR. Calcium- and length-dependent force production in rat ventricular muscle. *J Physiol.* 1982;329:527–540.
22. Kentish JC, ter Keurs HE, Ricciardi L, et al. Comparison between the sarcomere length-force relations of intact and skinned trabeculae from rat right ventricle. *Circ Res.* 1986;58:755–768.
23. Fabiato A. Calcium release in skinned cardiac cells: variations with species, tissues, and development. *Fed Proc.* 1982;41:2238–2244.
24. Allen DG, Kurihara S. The effects of muscle length on intracellular calcium transients in mammalian cardiac muscle. *J Physiol.* 1982;327:79–94.
25. Woodworth RS. Maximal contraction, “staircase” contraction, refractory period, and compensatory pause of the heart. *Am J Physiol.* 1902;8:213–249.
26. Bowditch HP. Über die eigenthümlichkeiten der reizbarkeit, welche die muskelfasern des herzens zeigen. *Ber Sachs Ges Wiss.* 1871;23:652–689.
27. Yatani A, Codina J, Imoto Y, et al. A G protein directly regulates mammalian cardiac calcium channels. *Science.* 1987;238:1288–1292.
28. Fabiato A. Stimulated calcium current can both cause calcium loading in and trigger calcium release from the sarcoplasmic reticulum of a skinned canine Purkinje cell. *J Gen Physiol.* 1985;85:291–320.
29. Unitt JF, McCormack JG, Reid D, et al. Direct evidence for a role of intramitochondrial Ca²⁺ in the regulation of oxidative phosphorylation in the stimulated rat heart. Studies using ³¹P n.m.r. and ruthenium red. *Biochem J.* 1989;262(1):293–301.
30. David H, Meyer R, Marx I, et al. Morphometric characterization of left ventricular myocardial cells of male rats during postnatal development. *J Mol Cell Cardiol.* 1979;11(7):631–638.
31. Schaper J, Meiser E, Stammler G. Ultrastructural morphometric analysis of myocardium from dogs, rats, hamsters, mice, and from human hearts. *Circ Res.* 1985;56(3):377–391.
32. Clark BJ III, Acker MA, McCully K, et al. In vivo ³¹P-NMR spectroscopy of chronically stimulated canine skeletal muscle. *Am J Physiol.* 1988;254(2 pt 1):C258–C266.
33. Wollenberger A. Relation between work and labile phosphate content in the isolated dog heart. *Circ Res.* 1957; 5(2):175–178.
34. Balaban RS. Domestication of the cardiac mitochondrion for energy conversion. *J Mol Cell Cardiol.* 2009;46:832–841.
35. Ringer S. A further contribution regarding the influence of the different constituents of the blood on the contraction of the heart. *J Physiol.* 1883;4(1):29–42.3.
36. Territo PR, Mootha VK, French SA, et al. Ca²⁺ activation of heart mitochondrial oxidative phosphorylation: role of the F₀/F₁-ATPase. *Am J Physiol Cell Physiol.* 2000;278(2):C423–C435.
37. Schaible TF, Scheuer J. Cardiac adaptations to chronic exercise. *Prog Cardiovasc Dis.* 1985;27(5):297–324.
38. Scheuer J, Tipton CM. Cardiovascular adaptations to physical training. *Annu Rev Physiol.* 1977;39:221–251.
39. Moore RL, Palmer BM. Exercise training and cellular adaptations of normal and diseased hearts. *Exerc Sport Sci Rev.* 1999;27:285–315.
40. Lakatta EG. Cardiovascular regulatory mechanisms in advanced age. *Physiol Rev.* 1993;73(2):413–467.
41. Baldwin KM, Cooke DA, Cheadle WG. Time course adaptations in cardiac and skeletal muscle to different running programs. *J Appl Physiol.* 1977;42(2):267–272.
42. Laughlin MH, Hale CC, Novela L, et al. Biochemical characterization of exercise-trained porcine myocardium. *J Appl Physiol.* 1991;71(1):229–235.
43. Liu J, Yeo HC, Overvik-Douki E, et al. Chronically and acutely exercised rats: biomarkers of oxidative stress and endogenous antioxidants. *J Appl Physiol.* 2000;89(1):21–28.
44. Starnes JW, Taylor RP, Park Y. Exercise improves postischemic function in aging hearts. *Am J Physiol Heart Circ Physiol.* 2003;285(1):H347–H351.
45. Brown DA, Jew KN, Sparagna GC, et al. Exercise training preserves coronary flow and reduces infarct size after ischemiareperfusion in rat heart. *J Appl Physiol.* 2003;95(6):2510–2518.
46. Diffie GM, Seversen EA, Titus MM. Exercise training increases the Ca²⁺ sensitivity of tension in rat cardiac myocytes. *J Appl Physiol.* 2001;91:309–315.
47. Diffie GM, Nagle DF. Exercise training alters the length dependence of contractile properties in rat myocardium. *J Appl Physiol.* 2003;94:1137–1144.
48. Natali AJ, Wilson LA, Peckham M, et al. Different regional effects of voluntary exercise on the mechanical and electrical properties of rat ventricular myocytes. *J Physiol.* 2002;541:863–875.
49. Laughlin MH, Oltman CL, Bowles DK. Exercise training-induced adaptations in the coronary circulation. *Med Sci Sports Exerc.* 1998;30:352–360.
50. Laughlin MH, et al. Adaptation of coronary circulation to exercise training. In: Fletcher GF, ed. *Cardiovascular Response to Exercise*. Mount Kisco, NY: Futura Publishing Company, Inc; 1994:175–205.
51. Bowles DK, Woodman CR, Laughlin MH. Coronary smooth muscle and endothelial adaptations to exercise training. *Exerc Sport Sci Rev.* 2000;28:57–62.
52. Laughlin MH, Overholser KA, Bhatte MJ. Exercise training increases coronary transport reserve in miniature swine. *J Appl Physiol.* 1989;67(3):1140–1149.
53. Laughlin MH, Tomanek RJ. Myocardial capillarization and maximal capillary diffusion capacity in exercise-trained dogs. *J Appl Physiol.*

1987;63(4):1481–1486.

54. Laughlin MH, McAllister RM. Exercise training-induced coronary vascular adaptation. *J Appl Physiol.* 1992;73(6):2209–2225.

55. Laughlin MH, Rubin LJ, Rush JW, et al. Short-term training enhances endothelium-dependent dilation of coronary arteries, not arterioles. *J Appl Physiol.* 2003;94:234–244.

56. Morris JN, Everitt MG, Pollard R, et al. Vigorous exercise in leisure-time: protection against coronary heart disease. *Lancet.* 1980;2(8206):1207–1210.

57. Bowles DK, Farrar RP, Starnes JW. Exercise training improves cardiac function after ischemia in the isolated, working rat heart. *Am J Physiol.* 1992;263:H804–H809.

58. Brown DA, Moore RL. Perspectives in innate and acquired cardioprotection: cardioprotection acquired through exercise. *J Appl Physiol.* 2007;103(5):1894–1899.

59. Hamilton KL, Quindry JC, French JP, et al. MnSOD antisense treatment and exercise-induced protection against arrhythmias. *Free Radic Biol Med.* 2004;37(9):1360–1368.

Chapter 11

1. Andersen P, Saltin B. Maximal perfusion of skeletal muscle in man. *J Physiol.* 1985;366:233–249.

2. Laughlin MH, Korthius RJ, Duncker DJ, et al. Control of blood flow to cardiac and skeletal muscle during exercise. In: Rowell LB, Shepherd JT, eds. *Handbook of Physiology, Section 12: Exercise: Regulation and Integration of Multiple Systems*. New York: Oxford University; 1996:705–769.

3. Rowell LB, O’Leary DS, Kellog DLJ. Integration of cardiovascular control systems in dynamic exercise. In: Rowell LB, Shepherd JT, eds. *Handbook of Physiology, Section 12: Exercise: Regulation and Integration of Multiple Systems*. New York: Oxford University; 1996:770–838.

4. Christensen KL, Mulvany MJ. Location of resistance arteries. *J Vasc Res.* 2001;38:1–12.

5. Delashaw JB, Duling BR. A study of the functional elements regulating capillary perfusion in striated muscle. *Microvasc Res.* 1988;36:162–171.

6. Rhodin JA. The ultrastructure of mammalian arterioles and precapillary sphincters. *J Ultrastruct Res.* 1967;18:181–223.

7. Greensmith JE, Duling BR. Morphology of the constricted arteriolar wall: physiological implications. *Am J Physiol.* 1984;247:H687–H698

8. Marshall JM. The venous vessel within skeletal muscle. *NIPS.* 1991;6:11–15.

9. Bloch EH, Iberall AS. Toward a concept of the functional unit of mammalian skeletal muscle. *Am J Physiol.* 1982;242:R411–R420.

10. Fuglevand AJ, Segal SS. Simulation of motor unit recruitment and microvascular unit perfusion: spatial considerations. *J Appl Physiol.* 1997;83:1223–1234.

11. Klitzman B, Damon DN, Gorczynski RJ, et al. Augmented tissue oxygen supply during striated muscle contraction in the hamster: relative contributions of capillary recruitment, functional dilation and reduced tissue PO₂. *Circ Res.* 1982;51:711–721

12. Sarelius IH. Cell flow path influences transit time through striated muscle capillaries. *Am J Physiol.* 1986;250:H899–H907.

13. Krogh A. The number and distribution of capillaries in muscles with calculations of the oxygen pressure head necessary for supplying the tissue. *J Physiol.* 1918;52:409–415.

14. Saltin BG, Gollnick PD. Skeletal muscle adaptability: significance for metabolism and performance. In: Peachey LD, eds. *Handbook of Physiology, Section 10: Skeletal Muscle*. Bethesda, MD: American Physiological Society; 1983:555–631.

15. Weibel ER. Scaling of structural and functional variables in the respiratory system. *Annu Rev Physiol.* 1987;49:147–159.

16. Duling BR, Desjardins C. Capillary hematocrit: what does it mean? *NIPS.* 1987;2:66–69.

17. Tsai AG, Johnson PC, Intaglietta M. Oxygen gradients in the microcirculation. *Physiol Rev.* 2003;83:933–963.

18. Ellsworth ML, Ellis CG, Goldman D, et al. Erythrocytes: oxygen sensors and modulators of vascular tone. *Physiology.* 2009; 24:107–116.

19. Lund N, Jorfeldt L, Lewis DH. Skeletal muscle oxygen pressure fields in healthy human volunteers: a study of the normal state and the effects of different arterial oxygen pressures. *Acta Anaesth Scand.* 1980;24:272–278.

20. Bearden SE, Moffatt RJ. VO₂ and heart rate kinetics in cycling: transitions from an elevated baseline. *J Appl Physiol.* 2001;90:2081–2087.

21. Van Teeffelen JW, Segal SS. Effect of motor unit recruitment on functional vasodilatation in hamster retractor muscle. *J Physiol.* 2000;524:267–278.

22. Jackson WF. Potassium channels in the peripheral microcirculation. *Microcirculation.* 2005;12:113–127.

23. Ledoux J, Werner ME, Brayden JE, et al. Calcium-activated potassium channels and the regulation of vascular tone. *Physiology.* 2006;21:69–78.

24. Davis MJ, Hill MA, Kuo L. Local control of microvascular perfusion. In: Tuma RF, Duran WN, Ley K, eds. *Handbook of Physiology, Microcirculation: Regulation of Microvascular Blood Flow*. 2nd ed. Amsterdam: Elsevier; 2008:161–284.

25. Davies PF. Flow-mediated endothelial mechanotransduction. *Physiol Rev.* 1995;75:519–560.

26. Clifford PS. Skeletal muscle vasodilatation at the onset of exercise. *J Physiol.* 2007;583:825–833.

27. Schaper W, Scholz D. Factors regulating arteriogenesis. *Arterioscler Thromb Vasc Biol.* 2003;23:1143–1151.

28. Haas TL. Molecular control of capillary growth in skeletal muscle. *Can J Appl Physiol.* 2002;27:491–515.

29. Haddy FJ, Scott JB. Metabolic factors in peripheral circulatory regulation. *Fed Proc.* 1975;34:2006–2011.

30. Gonzalez-Alonso J, Olsen DB, Saltin B. Erythrocyte and the regulation of human skeletal muscle blood flow and oxygen delivery: role of circulating ATP. *Circ Res.* 2002;91:1046–1055.

31. Hester RL, Hammer LW. Venular-arteriolar communication in the regulation of blood flow. *Am J Physiol.* 2002;282:R1280–R1285.

32. Bagher P, Segal SS. Regulation of blood flow in the microcirculation: role of conducted vasodilation. *Acta Physiol.* 2011;201:1–13.

33. Segal SS, Jacobs TL. Role for endothelial cell conduction in ascending vasodilatation and exercise hyperaemia in hamster skeletal muscle. *J Physiol.* 2001;536:937–946.

34. Milkau M, Khler R, de Wit C. Crucial importance of the endothelial K channel SK3 and connexin40 in arteriolar dilations during skeletal muscle contraction. *FASEB J.* 2010;24:3572–3579.

35. Thomas GD, Segal SS. Neural control of muscle blood flow during exercise. *J Appl Physiol.* 2004;97:731–738.
36. VanTeeffelen JW, Segal SS. Interaction between sympathetic nerve activation and muscle fibre contraction in resistance vessels of hamster retractor muscle. *J Physiol.* 2003;550:563–574.
37. Moore AW, Bearden SE, Segal SS. Regional activation of rapid onset vasodilatation in mouse skeletal muscle: regulation through α -adrenoceptors. *J Physiol.* 2010;588:3321–3331.
38. Anrep GV, von Saalfeld E. The blood flow through the skeletal muscle in relation to its contraction. *J Physiol.* 1935;85:375–399.
39. Hocking DC, Titus PA, Sumagin R, et al. Extracellular matrix fibronectin mechanically couples skeletal muscle contraction with local vasodilation. *Circ Res.* 2008;102:372–379.
40. Olson KR, Whitfield NL. Hydrogen sulfide and oxygen sensing in the cardiovascular system. *Antioxid Redox Signal.* 2010;12:1219–1234.

Chapter 12

1. Gisolfi CV. The gastrointestinal system. In: Tipton CM, ed. *Exercise Physiology: People and Ideas*. New York: Oxford University; 2003:475–495.
2. Van De Graaff KM. *Human Anatomy*. 6th ed. Boston: McGraw-Hill; 2002.
3. Davenport HW. *Physiology of the Digestive Tract*. Chicago: Year Book; 1982.
4. Rowell LB. *Human Circulation: Regulation During Physical Stress*. New York: Oxford University; 1986.
5. Gisolfi CV, Summers RW, Schedl HP. Intestinal absorption of fluids during rest and exercise. In: Gisolfi CV, Lamb DR, eds. *Perspectives in Exercise Science and Sports Medicine, 3: Fluid Homeostasis During Exercise*. Indianapolis: Benchmark; 1990:129–180.
6. Lambert GP. Role of gastrointestinal permeability in exertional heatstroke. *Exer Sport Sci Rev.* 2004;32(4):185–190.
7. Lucas W, Schroy PC. Reversible ischemic colitis in a high endurance athlete. *Am J Gastroenterology.* 1998;93:2231–2234.
8. Beckers EJ, Rehrer NJ, Brouns F, et al. Determination of total gastric volume, gastric secretion and residual meal using the double sampling technique of George. *Gut.* 1988;29(12):1725–1729.
9. George JD. New clinical method for measuring the rate of gastric emptying: the double sampling test meal. *Gut.* 1968;9:237–242.
10. Leiper JB. Gastric emptying and intestinal absorption of fluids, carbohydrates, and electrolytes. In: Maughan RJ, Murray R, eds. *Sports Drinks: Basic Science and Practical Aspects*. Boca Raton: CRC Press; 2001:89–128.
11. Lambert GP, Chang RT, Xia T, et al. Absorption from different intestinal segments during exercise. *J Appl Physiol.* 1997;83(1):204–212.
12. Ryan AJ, Lambert GP, Shi X, et al. Effect of hypohydration on gastric emptying and intestinal absorption during exercise. *J Appl Physiol.* 1998;84(5):1581–1588.
13. Mitchell JB, Voss KW. The influence of volume on gastric emptying and fluid balance during prolonged exercise. *Med Sci Sports Exerc.* 1991;23(3):314–319.
14. Lambert GP, Chang RT, Joensen D, et al. Simultaneous determination of gastric emptying and intestinal absorption during cycle exercise in humans. *Int J Sports Med.* 1996;17(1):48–55.
15. Costill DL. Gastric emptying of fluids during exercise. In: Gisolfi CV, Lamb DR, eds. *Perspectives in Exercise Science and Sports Medicine, 3: Fluid Homeostasis During Exercise*. Indianapolis: Benchmark Press; 1990:97–127.
16. Murray R. The effects of consuming carbohydrate-electrolyte beverages on gastric emptying and fluid absorption during and following exercise. *Sports Med.* 1987;4:322–351.
17. Murray R, Eddy DE, Bartoli WP, et al. Gastric emptying of water and isocaloric carbohydrate solutions consumed at rest. *Med Sci Sports Exerc.* 1994;26(6):725–732.
18. Višň GE, Maughan RJ. Gastric emptying of ingested solutions in man: effect of beverage glucose concentrations. *Med Sci Sports Exerc.* 1994;26:1269–1273.
19. Owen MD, Kregel KC, Wall PT, et al. Effects of ingesting carbohydrate beverages during exercise in the heat. *Med Sci Sports Exerc.* 1986;18(5):568–575.
20. Zachwieja JJ, Costill DL, Beard GC, et al. The effects of a carbonated carbohydrate drink on gastric emptying, gastrointestinal distress, and exercise performance. *Int J Sport Nutr.* 1992;2:239–250.
21. Rogers J, Summers RW, Lambert GP. Gastric emptying and intestinal absorption of a low-carbohydrate sport drink during exercise. *Int J Sport Nutr Exerc Metab.* 2005;15:220–235.
22. Gisolfi CV, Lambert GP, Summers RW. Intestinal fluid absorption during exercise: role of sport drink osmolality and $[Na^+]$. *Med Sci Sports Exerc.* 2001;33(6):907–915.
23. Gisolfi CV, Summers RW, Lambert GP, et al. Effect of beverage osmolality on intestinal fluid absorption during exercise. *J Appl Physiol.* 1998;85(5):1941–1948.
24. Houmard JA, Egan PC, Johns RA, et al. Gastric emptying during 1 h of cycling and running at 75% VO_2 max. *Med Sci Sports Exerc.* 1991;23(3):320–325.
25. Leiper JB, Prentice AS, Wrightson C, et al. Gastric emptying of a carbohydrate-electrolyte drink during a soccer match. *Med Sci Sports Exerc.* 2001;33(11):1932–1938.
26. Rehrer NJ, Beckers E, Brouns F, et al. Exercise and training effects on gastric emptying of carbohydrate beverages. *Med Sci Sports Exerc.* 1989;21(5):540–549.
27. Brouns F, Saris WHM, Rehrer NJ. Abdominal complaints and gastrointestinal function during long-lasting exercise. *Int J Sports Med.* 1987;8:175–189.
28. Rehrer NJ. Fluid and electrolyte balance in ultra-endurance sport. *Sports Med.* 2001;31(10):701–715.
29. Lambert GP, Lang JA, Bull AJ, et al. Fluid tolerance while running: effect of repeated trials. *Int J Sports Med.* 2008;29:878–882.
30. Neuffer PD, Young AJ, Sawka MN. Gastric emptying during exercise: effects of heat stress and hypohydration. *Eur J Appl Physiol.* 1989;58:433–439.
31. Rehrer NJ, Beckers EJ, Brouns F, et al. Effects of dehydration on gastric emptying and gastrointestinal distress while running. *Med Sci*

Sports Exerc. 1990;22(6):790–795.

32. Cooper H, Levitan R, Fordtran JS, et al. A method for studying absorption of water and solute from the human small intestine. *Gastroenterology*. 1966;50:1–7.

33. Thomson ABR, Keelan M, Thiesen A, et al. Small bowel review: normal physiology part 1. *Dig Dis Sci*. 2001;46:2567–2587.

34. Kellett GL. The facilitated component of intestinal glucose absorption. *J Physiol*. 2001;531.3:585–595.

35. Stevens BR. Vertebrate intestine apical membrane mechanisms of organic nutrient transport. *Am J Physiol*. 1992(263):R458–R463.

36. Ugolev A, Zaripov B, Iezuitova N, et al. A revision of current data and views on membrane hydrolysis and transport in the mammalian small intestine based on comparison of techniques of chronic and acute experiments: experimental re-investigation and critical review. *Comp Biochem Physiol A Comp Physiol*. 1986;85A:593–612.

37. Madara JL, Pappenheimer JR. Structural basis for physiological regulation of paracellular pathways in intestinal epithelia. *J Memb Biol*. 1987;100:149–164.

38. Fordtran JS, Saltin B. Gastric emptying and intestinal absorption during prolonged severe exercise. *J Appl Physiol*. 1967;23(3):331–335.

39. Lang JA, Gisolfi CV, Lambert GP. Effect of exercise intensity on active and passive glucose absorption. *Int J Sport Nutr Exerc Metab*. 2006;16:485–493.

40. Lambert GP, Mason B, Broussard L, et al. Intestinal absorption and permeability during exercise with aspirin: effects of glutamine in replacement beverages. *FASEB J*. 1998;12(4):A370.

41. Hegarty JE, Fairclough PD, Clark ML, et al. Jejunal water and electrolyte secretion induced by L-arginine in man. *Gut*. 1981;22:108–113.

42. Fordtran JS. Stimulation of active and passive sodium absorption by sugars in the human jejunum. *J Clin Invest*. 1975;55:728–737.

43. Gisolfi CV, Summers RD, Schedl HP, et al. Effect of sodium concentration in a carbohydrate-electrolyte solution on intestinal absorption. *Med Sci Sports Exerc*. 1995;27(10):1414–1420.

44. Gisolfi CV, Spranger KJ, Summers RW, et al. Effects of cycle exercise on intestinal absorption in humans. *J Appl Physiol*. 1991;71(6):2518–2527.

45. Loo DDF, Zeuthen T, Chandy G, et al. Cotransport of water by the Na⁺/glucose cotransporter. *Proc Natl Acad Sci*. November 1996;93:13367–13370.

46. Krofchick D, Huntley SA, Silverman M. Transition states of the high-affinity rabbit Na⁺/glucose cotransporter SGLT1 as determined from measurement and analysis of voltage dependent charge movements. *Am J Physiol Cell Physiol*. 2004;287:C46–C54.

47. Lambert GP, Lanspa S, Welch R, et al. Combined effects of glucose and fructose on fluid absorption from hypertonic carbohydrate-electrolyte beverages. *J Exerc Physiol*. 2008;11(2):46–55.

48. Shi X, Summers RW, Schedl HP, et al. Effects of carbohydrate type and concentration and solution osmolality on water absorption. *Med Sci Sports Exerc*. 1995;27(12):1607–1615.

49. Leiper JB, Maughan RJ. Comparison of absorption rates from two hypotonic and two isotonic rehydration solutions in the intact human jejunum. *Clin Sci*. 1988;75(suppl 19):22P.

50. Leiper JB, Maughan RJ. The effect of luminal tonicity on water absorption from a segment of the intact human jejunum. *J Physiol*. 1986;378:95P.

51. Gisolfi CV, Summers RW, Schedl HP, et al. Human intestinal water absorption: direct vs. indirect measurements. *Am J Physiol*. 1990;258:G216–G222.

52. Leiper JB, Maughan RJ. Absorption of water and electrolytes from hypotonic, isotonic, and hypertonic solutions. *J Physiol*. 1986;373:90P.

53. Shi X, Summers RW, Schedl HP, et al. Effects of solution osmolality on absorption of select fluid replacement solutions in human duodeno-jejunum. *J Appl Physiol*. 1994;77(3):1178–1184.

54. Rolston DD, Mathan VI. Jejunal and ileal glucose-stimulated water and sodium absorption in tropical enteropathy: implications for oral rehydration therapy. *Digestion*. 1990;46:55–60.

55. Beaumont DM, Cobdett L, Sheldon WL, et al. Passive and active carbohydrate absorption by the aging gut. *Age Ageing*. 1987;16:294–300.

56. Keeling WF, Martin BJ. Gastrointestinal transit during mild exercise. *J Appl Physiol*. 1987;63(3):978–981.

57. Keeling WF, Harris A, Martin BJ. Orocecal transit during mild exercise in women. *J Appl Physiol*. 1990;68(4):1350–1353.

58. van Nieuwenhoven MA, Brouns F, Brummer RJ. The effect of physical exercise on parameters of gastrointestinal function. *Neurogastroenterol Motil*. 1999;11(6):431–439.

59. Soffer EE, Summers RW, Gisolfi C. Effect of exercise on intestinal motility and transit in trained athletes. *Am J Physiol: Gastrointest Liver Physiol*. 1991;260(23):G698–G702.

60. Feldman M, Nixon JV. Effect of exercise on postprandial gastric secretion and emptying in humans. *J Appl Physiol: Respirat Environ Exercise Physiol*. 1982;53(4):851–854.

61. Cheskin LJ, Crowell MD, Kamal B, et al. The effects of acute exercise on colonic motility. *J Gastrointest Motil*. 1992;4:173–177.

62. Rao SSC, Beaty J, Chamberlain M, et al. Effects of acute graded exercise on human colonic motility. *Am J Physiol*. 1999;276:G1221–G1226.

63. Harris A, Lindeman AK, Martin BJ. Rapid orocecal transit in chronically active persons with high energy intake. *J Appl Physiol*. 1991;70(4):1550–1553.

64. De Schryver AM, Keulemans YC, Peters HP, et al. Effects of regular physical activity on defecation pattern in middle aged-patients complaining of chronic constipation. *Scand J Gastroenterol*. 2005;40(4):422–429.

65. Markiewicz K, Cholewa M, Grski L, et al. Effect of physical exercise on gastric basal secretion in healthy men. *Acta Hepatogastroenterol (Stuttg)*. 1977;24(5):377–380.

66. Minato K. Effect of endurance training on pancreatic enzyme activity in rats. *Eur J Appl Physiol*. 1997;76:491–494.

67. Zsinka AJ, Frenkl R. Exocrine function of the pancreas in regularly swimming rats. *Acta Physiol Hung*. 1983;62(2):123–129.

68. Baumgart D, Dignass A. Intestinal barrier function. *Curr Opin Clin Nutr Metab Care*. 2002;5:685–694.

69. Nagler-Anderson C. Man the barrier! Strategic defences in the intestinal mucosa. *Nature Rev*. 2001;1:59–67.

70. Lambert GP. Stress-induced gastrointestinal barrier dysfunction and its inflammatory effects. *J Anim Sci.* 2009;87:E101–E108.
71. Lambert GP, Murray R, Eddy D, et al. Intestinal permeability following the 1998 Ironman triathlon. *Med Sci Sports Exerc.* 1999;31(5):S318.
72. Pals KL, Chang RT, Ryan AJ, et al. Effect of running intensity on intestinal permeability. *J Appl Physiol.* 1997;82(2):571–576.
73. Lambert GP, Boylan MW, Laventure JP, et al. Effect of aspirin and ibuprofen on GI permeability during exercise. *Int J Sports Med.* 2007;28(9):722–726.
74. Halvorsen FA, Ritland S. Gastrointestinal problems related to endurance event training. *Sports Med.* 1992;14(3):157–163 .
75. Keefe EB, Lowe DK, Goss JR, et al. Gastrointestinal symptoms of marathon runners. *West J Med.* 1984;141:481–484 .
76. Moses FM, Brewer TG, Peura DA. Running-associated proximal hemorrhagic colitis. *Ann Int Med.* 1988;108(3):385–386.
77. Oektedalen O, Lunde OC, Opstad PK, et al. Changes in the gastrointestinal mucosa after long distance running. *Scand J Gastroenterol.* 1992;27:270–274.
78. Lambert GP. Intestinal barrier dysfunction, endotoxemia, and gastrointestinal symptoms: the “canary in the coal mine” during exercise-heat stress? In: Marino F, ed. *Thermoregulation and Human Performance: Physiological and Biological Aspects* . New York: Karger; 2008:61–73.
79. Lambert GP, Broussard LJ, Mason BL, et al. Gastrointestinal permeability during exercise: effects of aspirin and energy- containing beverages. *J Appl Physiol.* 2001;90:2075–2080.
80. Lambert GP, Lang JA, Bull AJ, et al. Fluid restriction increases GI permeability during running. *Int J Sports Med.* 2008;29(3):194–198.