
Index

A

- Abnormal fracture, 128, 129
- Acute lymphoblastic leukemia (ALL), 200
- Adequate intake (AI), 27
- Adolescence athletes
 - bone health, 265
 - definitions, 157, 158
 - EDs, 146, 147
 - epidemiology, 158–159
 - etiology, 157, 158
 - fractures, 133, 134
 - multiple fractures, 130
 - nutrition, 173, 174
 - risk factors, 159–162
 - young, 172
- Age-related bone loss, 58–60
- Alanine aminotransferase, 106
- Alcohol, 42
- Amenorrhea, 82, 85, 183, 263
- Anorexia nervosa (AN), 143, 204, 263
- Anthropometric parameters, 82
- Anti-fracture, 58, 59
- Antiresorptive agents, 151, 152
- Areal bone mineral density (aBMD), 1
 - skeleton, 2
 - stress fracture, 7
 - tobacco use, 7
- Asthma, 206
- Atypical femur fractures (AFF), 252
- Avoidant/restrictive food intake disorder (ARFID), 145

B

- Binge eating disorder (BED), 145
- Bisphosphonates (BPs) therapy, 151, 152, 201, 230, 231, 233, 250, 265, 266

- Body mass index (BMI), 4
- Bone adaptation
 - cellular level, 63
 - clinical implications, 66, 67, 69
 - lacunocanalicular network, 63
 - loading rate, 63
 - localization of cells, 16
 - mechanical loading, 64, 65
 - site-specific, 65
- Bone age Z-score, 119, 232
- Bone densitometry, 232, 245
 - bone-focused H&P, 87
 - development, 78, 82
 - family history, 87–88
 - fractures, 78
 - growth, 78, 82
 - immobilization, 87
 - physical examination, 88
 - primary care clinician, 77
 - skeletal disorders, 77, 79
 - social history, 88
- Bone formation markers
 - alkaline phosphatase, 100, 101
 - collagen propeptides, 102
 - instability of, 101
 - osteocalcin, 101
 - and resorption, 100
- Bone fragility, 111, 244, 265
- Bone healing and remodeling, 135
- Bone mass accrual, 4–7
 - cross-sectional studies, 55
 - DXA analysis, 2, 3
 - estrogen and testosterone, 1
 - factors, 2
 - longevity, 55
 - maximal rates, 2
 - mineral density, 2

- Bone mass accrual (*cont.*)
- modifiable factors
 - body composition, 4–5
 - contraception, 6
 - dietary intake, 6
 - physical activity and exercise, 5
 - substance use, 7
 - non-modifiable factors
 - genetics and ancestry, 4
 - puberty/hormonal status, 4
 - somatic maturation, 55
 - study design, 55
 - suboptimal lifestyle choices, 2
 - systemic traits, 56
- Bone mineral (hydroxyapatite)
- calcium and phosphorus homeostasis, 14
 - FGF23, 15
 - hyper/hypocalcification, 13
 - inorganic phase of, 13
 - matrix vesicles, 13
 - organic matrix (osteoid), 13
 - PTH secretion, 14
 - rickets, 14
 - vitamin D deficiency, 14
- Bone mineral apparent density (BMAD), 118
- Bone mineral content (BMC), 4, 112, 137, 219, 245
- aBMD Z-scores, 114, 118, 121
 - BMAD, 118
 - BMD, 111
 - bone size, 118
 - bone-muscle unit, 120
 - interpretation, 117
 - puberty, 117
 - spine, 119
- Bone mineral density (BMD)
- adolescents, 221, 222
 - AN, 146, 148
 - bone density, 112
 - bone map, 111
 - in children, 221, 222
 - CP, 224
 - fractures/fracture risk, 129, 147
 - hip, 146
 - L1-L4, 114
 - lumbar spine, 146
 - malnutrition, 146
 - mechanical loading, 147
 - skeletal sites, 143
 - sports-related injuries, 128
 - vertebral strength, 146
- Bone physiology, 11–18
- adolescent bone development, 20–22
 - bone mineral (hydroxyapatite) (*see* Bone mineral (hydroxyapatite))
 - canonical Wnt/ β -catenin signaling
 - osteoblastogenesis, 15–17
 - sclerostin and dickkopf 1 antagonize, 17, 18
 - components, 11
 - formation (osteogenesis), 19, 20
 - growth hormone/IGF-1 axis, 21
 - mechanical loading, 21, 22
 - organic matrix (*see* Organic matrix (osteoid))
 - osteoblasts, 15
 - osteoclasts, 18
 - osteocytes, 18
 - osteoprotegerin antagonizes RANK/RANKL signaling, 19
 - RANK/RANKL promote
 - osteoclastogenesis, 19
 - sex steroids, 20, 21
 - skeletal system, 11
- Bone remodeling, 183, 207
- Bone structure, 58
- Bone-specific alkaline phosphatase (BAP), 101
- Bone-to-bone linkages, 53
- Boron, 35, 36
- Bulimia nervosa (BN), 145
- C**
- Caffeine, 43
- Calcaneus, 171
- Calcipenic rickets, 14
- Calcium, 28, 30, 31, 33, 34, 147–149, 152, 230
- Calcium-sensing receptor (CaSR), 14, 94, 96
- Cancer
- adolescents, 199
 - bone disease, 200
 - evaluation, 200, 201
 - management, 201
 - pathophysiology, 199, 200
- Canonical Wnt-frizzled-LRP5/6 pathway, 17
- Carbonated beverages, 43
- Celiac disease, 106
- autoimmune-mediated disorder, 192
 - bone disease, 193
 - evaluation, 194
 - management, 194
 - pathophysiology, 193
- Cellular accommodation theory, 64
- Cerebral palsy (CP), 219
- BMD, 224
 - fractures, 222, 223
- Cholecalciferol, 39

- Chronic disease
 adolescent girls, 183
 impaired linear growth, 185
 lean body mass, 185
 peak bone accrual, 182
 pediatric imaging techniques, 186, 187
 physical activity, 184
 skeletal mass, 179
 systemic glucocorticoids, 179, 186
- Chronic kidney disease (CKD)
 bone disease, 197, 198
 definition, 197
 evaluation, 198
 management, 198
 pathophysiology, 197
 substantial complications, 197
- Contraception, 6
- Copper, 36
- Cortical trabecularization, 58
- Crohn disease, 194
- C-terminal cross-linked telopeptide (CTX), 102
- C-terminal ELISA (cFGF23) assays, 103
- Cystic fibrosis (CF)
 autosomal recessive diseases, 187
 bone disease, 187–189
 management, 189
- Cystic fibrosis transmembrane conductance regulator (CFTR), 187
- Cytoplasmic β -catenin, 15
- D**
- Dehydroepiandrosterone (DHEA), 150
- Delayed growth, 118
- Denosumab, 255
- Deoxyypyridinoline (DPD), 102
- Depot medroxyprogesterone acetate (DMPA), 6
- Dietary reference intakes (DRIs), 6, 27, 29, 43, 44
- Dietary sodium, 44
- 1,25-Dihydroxyvitamin D (1,25(OH)₂D), 14, 15, 93–95, 97–99, 102, 105, 106
- Distal forearm radiographs, 254
- DSM-5 diagnostic criteria, 144, 145
- Dual-energy x-ray absorptiometry (DXA), 1, 56, 57, 185, 186
 artifacts, 113
 BMC and aBMD, 115
 bone density, 111
 challenges, 121
 follow-up scans, 120, 121
 forearm, 116
 hip, 116
 interpretation, 117, 118, 120
 lateral distal femur scan, 115
 lumbar spine, 115
 morphometric analysis, 122
 radiation exposure, 112, 113
 report, 114
 software algorithms, 111
 spine scan, 114
 types, 112
 whole-body scan, 113, 114
- Duchenne muscular dystrophy (DMD)
 bone density, 226, 227
 dystrophin protein, 224
 fractures, 225, 226
 RCTs that GCS, 225
 symptoms, 224
- E**
- Eating disorders (EDs), 149–152
 adolescents, 146, 147
 anabolic agents, 150
 antiresorptive agents, 151, 152
 therapeutic agent, 149
 vitamin D, 149
 weight gain, 149
 amenorrheic, 143
 diagnostic categories, 145
 fractures in patients, 147
 impaired bone health, 147–149
- Enzyme-linked immunosorbent assays (ELISAs), 102, 103
- Epidermolysis bullosa (EB), 207
- Ergocalciferol, 39
- ER-golgi secretory pathway, 12
- Estrogen, 148, 150–152, 204
- Ethylenediaminetetraacetic acid (EDTA), 94, 96
- Exercise, 56, 61
 and body image, 88
 stress fractures, 85
 weight-bearing, 84
- F**
- Familial hypocalciuric hypercalcemia (FHH), 104
- Female athlete triad, 159, 160, 168
- Femoral neck subregion, 115, 168
- FGF/Klotho co-receptor complex, 15
- Fibula, 171
- Follicle-stimulating hormone (FSH), 201
- Food and Drug Administration (FDA), 243

- Foods
 calcium content, 32
 milk and milk substitutes, 33
 vitamin D content, 40
- Footwear, 167
- Fractures, 78, 134–136, 219, 220, 261–265
- G**
- Gastrointestinal disorders, 85
- General Practice Research Database, 127
- Glucocorticoids (GCS) therapy, 186, 219, 225, 245
- H**
- Height-for-age Z-score (HAZ), 117–119
- High-resolution peripheral quantitative computed tomography (HR-pQCT), 123, 146, 186, 193
- Hormone replacement, 204
- Human immunodeficiency virus-infected (HIV), 205, 206
- Humerus, 172
- Hydroxyapatite, 11, 13
- 25-Hydroxyvitamin D (25(OH)D), 39, 93, 97, 98, 101, 106, 131
- Hypogonadism, 182–184, 201
 bone disease, 203
 congenital syndromes, 201
 evaluation, 203, 204
 GnRH, 202
 hypogonadotropic, 201
 management, 203, 204
 pathophysiology, 202, 203
 pubertal development, 202
 sex hormone, 201
- Hypophosphatasia (HPP), 13, 14
- Hypothalamic-pituitary-gonadal (HPG) axis, 183
- Hypoxic-ischemic encephalopathy, 234
- I**
- IGF-binding proteins (IGFBP), 185
- Immobilization
 BMD, 221, 222
 clinical vignettes, 234–237
 fractures, 219, 220
- Inflammatory bowel diseases (IBD)
 bone disease, 194, 195
 evaluation, 196
 management, 196
 mucosal layer, 194
- Inorganic pyrophosphate (PPi), 13
- Institute of Medicine and the American Academy of Pediatrics, 148
- Insulin inhibits IGF-binding protein 1 (IGFBP-1), 190
- Insulin-like growth factor-1 (IGF-1) pathway, 4, 147, 185, 190
- Interleukin 6 (IL-6), 4
- The International Society of Clinical Densitometry (ISCD), 113, 191, 229, 245
- Iron, 36, 37
- J**
- Juvenile dermatomyositis, 206
- Juvenile idiopathic arthritis (JIA), 206
- K**
- The Kidney Disease: Improving Global Outcomes (KDIGO) guidelines, 198
- L**
- Laboratory assessments, bone health, 99–102
 bone formation (*see* Bone formation markers)
 bone resorption markers, 102
 calcium, 93–95
 in children, 93
 FGF-23, 102, 103
 formation/resorption, 100
 25-hydroxyvitamin D, 93, 97, 98
 hypercalcemia, 104, 105
 hyperphosphatemia, 105, 106
 hypocalcemia, 103, 104
 hypophosphatemia, 105
 low bone mass/fragility fracture, 106
 magnesium, 96
 normal serum values, 95
 1,25(OH)2D, 98–99
 phosphorus, 95, 96
 PTH (*see* Parathyroid hormone (PTH))
 vitamin D deficiency/rickets/osteomalacia, 97, 106
- Lactose intolerance, 45
- Lateral distal femur (LDF), 221
- Lean body mass (LBM), 5, 185
- Least significant change (LSC), 120
- Limb biomechanics, 167
- Lipoprotein receptor-related protein (LRP), 15
- Lumbar spine (LS), 226
- Luteinizing hormone (LH), 201

M

Macrophage colony-stimulating factor (M-CSF), 18

Magnesium, 35

Magnetic resonance imaging (MRI), 221

Manganese, 37

McCune-Albright Syndrome, 88

Mechanical loading

- animals, 59
- bone level, 65
- clinical implications, 66, 68, 69
- mechanosensory cells, 64
- osteogenic potential, 54
- PA, 55
- skeletal response, 64
- threshold-related bone adaptation, 63

Mechanoadaptation, 54

Mechanotransduction, 62

Medial malleolus, 170

Medial tibial stress syndrome (MTSS), 164

Medications, 86, 87

Menstrual dysfunction, 159, 173

Menstrual irregularity, 182–184

Mental health, 85

Metabolic equivalent (MET), 53

Metatarsals, 171

Milk/dairy allergy, 46

Monitoring time interval (MTI), 121

Multiple fractures

- abnormal, 128, 129
- adolescent, 133, 134
- BMD, 128
- epidemiological studies, 127
- factors, 128
- healing, 134–136
- lifetime fracture, 127
- low-impact fractures, 128
- in pediatric population, 129
- pubertal growth spurt, 128
- risk factors, 131
- Scandinavian study, 127
- work-Up, 129–133

Muscle-generated mechanical stimuli, 54

N

National Institute of Standards and Technology (NIST), 98

National Osteoporosis Foundation (NOF), 5

Neurofibromatosis, 88

Non-accidental trauma (NAT), 248

Non-ambulant adolescents, 232

Non-collagenous proteins (NCPs), 11, 12

Nonsteroidal anti-inflammatory drugs (NSAIDs), 136

The North American Society for Pediatric Gastroenterology, Hepatology, and Nutrition (NASPGHAN), 196

N-terminal cross-linked telopeptide (NTX), 102

Nutrient-dense foods, 174

Nutrition, adolescent bone health, 42–45, 78, 84, 85, 88, 173, 174

- acid-base balance
 - demineralization, 44
 - factor, 44
 - potassium bicarbonate, 44–45
- boron, 35–36
- calcium, 28–34
- copper, 36
- dietary components
 - alcohol, 42, 43
 - caffeine and carbonated beverages, 43
 - dietary fiber, 43, 44
 - sodium, 44
- dietary reference intakes, 27–28
- dietary supplements, 47
- iron, 36, 37
- lactose intolerance, 45
- magnesium, 35
- manganese, 37, 38
- milk/dairy allergy, 46
- phosphorus, 34
- protein, 28
- vegans, 46, 47
- vitamin A, 38, 39
- vitamin D, 39–41
- vitamin K, 42
- zinc, 38

Nutritional assessment, 84

O

Obesity, 205

Oral contraceptives (OCs), 6

Organic matrix (osteoid)

- description, 11
- non-collagenous proteins, 12, 13
- type 1 collagen, 12

Osteoblastogenesis

- cellular communication, 17
- intracellular signaling, 17

Osteoblasts, 11–14, 16–21

Osteoclasts, 11, 12, 14–16, 18, 20, 21

Osteocytes, 11, 14, 15, 17, 18, 20, 22, 62

Osteogenesis, 12

Osteoid, 11, 13, 14, 16, 17

Osteopenia, 87, 244

Osteoporosis, 54, 131, 132, 219, 220
 family history, 87
 Osteoprotegerin (OPG), 14, 17, 19, 226
 Over-suppression, 252

P

Parathyroid hormone (PTH)
 biological activity, 99
 calcium, 99
 hypercalcemia, 104
 PTHrP, 99, 100
 secretion, 99
 treatment, osteoporosis, 99
 vitamin D metabolism, 97
 Pars interarticularis, 171, 172
 Patellar stress fractures, 168
 Peak bone mass (PBM), 6, 7
 Pediatric imaging techniques, 186, 187
 Pediatric osteoporosis, 244, 245
 anti-catabolic agents, 250
 BMD, 244, 251
 in childhood, 243
 DMD/OI, 250
 DXA, 244
 family history, 245
 genetic testing, 249
 25 OHD, 249
 and osteomalacia, 249
 pharmacologic therapy, 253, 254
 primary vs. secondary, 245–248
 steroid-induced osteoporosis, 250
 treatment, 253
 Periosteal bone formation, 60
 Peripheral quantitative computed tomography (pQCT), 123, 186, 221
 Pharmacologic therapy, 244, 255
 adverse effects and monitoring, 251, 252
 indications for therapy, 249–251
 Phosphorus, 34
 Physical activity (PA), 84, 85
 adolescents, 70, 71
 age-matched controls, 60
 aging and exercise, 60
 anti-catabolic influence, 54
 benefits, 53
 bone mass, 55, 56
 bone-to-bone linkages, 53
 cardio-metabolic risk factors, 53
 cellular level, 63
 dominant-to-nondominant arm
 differences, 59
 energy expenditure, 53
 exercise, 56

lifestyles, 55
 mechanical loading, 54
 mechanotransduction process, 63
 medullary cavity, 58
 menopausal transition, 59
 osteogenic index, 68
 osteoporotic fracture, 54
 periosteal surface, 59
 peri-pubertal players, 55
 site-specific deposition, 59
 skeletal health, 53
 structural benefits, 59
 surface-specific accrual, 58
 Physical therapy interventions, 231, 232
 Phytic acid, 30
 Potassium bicarbonate, 44
 Pre- and early puberty, 55
 Primary osteoporosis, 246
 Primary ovarian insufficiency (POI), 202
 Procollagen, 12
 Provitamin A, 38
 Pubertal assessment, 233
 Puberty, 4, 78, 82, 85, 88
 Pyridinoline (PYD), 102
 Pyrophosphate (PPi), 249

Q

Quantitative computed tomography (QCT),
 123, 133

R

Radiation exposure, 112, 113
 Radioimmunoassays, 99, 102
 Receptor activator of nuclear factor kappa-B
 ligand (RANKL), 14, 17–19, 21, 226
 Recommended dietary allowance (RDA),
 27, 149
 Re-fracture, 136–139
 Relative energy deficiency in sport
 (RED-S), 203
 Rheumatologic conditions, 206, 207
 Runt-related transcription factor 2
 (Runx2), 15, 20

S

Scleroderma, 206
 Sclerostin (SOST), 17, 18
 Secondary osteoporosis, 247
 Selective serotonin reuptake inhibitors
 (SSRIs), 148–149
 Serum glutamic pyruvate transaminase, 106

- Sex hormone suppression, 182–184
Skeleton mechanoadaptation, 54
Slipped capital femoral epiphysis (SCFE), 200
Small integrin-binding ligand, N-glycosylated (SIBLING), 13
Spinal cord injury (SCI), 220, 229, 230
Spinal muscular atrophy (SMA), 227, 229
Spondylolysis, 165
Stork test, 165
Stress fracture, 159–162
 classification systems, 166
 clinical diagnosis, 162, 163
 complications and treatment, 170
 femoral neck, 168
 high-risk vs. low-risk, 163
 imaging, 165, 166
 individual sports, 160
 lower-extremity, 164
 lumbar extension, 165
 medial malleolus, 170
 metatarsals, 165
 patellar, 168
 pathognomonic radiographic finding, 164
 principles, 167, 168
 tibia, 168–170
Stress-strain index (SSI), 133
Systemic inflammation, 185
Systemic lupus erythematosus (SLE), 206
- T**
Talus, 170
Tanner staging, 83
Tarsal navicular, 171
Tartrate-resistant acid phosphatase (TRAP), 101
Tibia, 168–170
Tissue-nonspecific alkaline phosphatase (TNSALP), 13, 249
Tolerable upper intake level, 27
Transforming growth factor beta (TGF- β), 4
Tropocollagen, 12
T-scores, 244
- Turner syndrome, 202
Type 1 collagen, 12, 17
Type 1 diabetes mellitus (T1DM)
 bimodal distribution, 190
 bone disease, 190, 191
 evaluation, 191, 192
 management, 192
 pathophysiology, 190
- U**
US Food and Drug Administration (FDA), 6
- V**
van Buchem disease, 18
Vegans, 46, 47
Vertebral fracture assessment (VFA), 121, 122
Vertebral fractures (VF), 115, 121, 122, 245, 246
Vitamin A, 38, 39
Vitamin D, 39–42, 148, 149, 152, 173, 230, 233, 261–266
Vitamin K, 42
Volumetric BMD (vBMD), 118, 229
- W**
Weight-bearing physical activity, 149, 150
Whole-body vibration therapy (WBVT), 231
Wolff's law, 54
Work-up for multiple fractures, 129–133
- X**
X-linked hypophosphatemic rickets, 14
- Z**
Zinc, 38
Zoledronic acid (ZA), 251
Z-scores, 119, 133, 185, 244