

Women and Exercise

Live Interactive Webinar

Presented By: Sara Ziegele, PT, DPT, OCS

Contact: sara@bepreemptive.com

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Course Overview

· “Women and Exercise” is a live (real-time) interactive webinar for rehabilitation professionals that examines female specific considerations for exercise and rehabilitation during adolescence, pregnancy and postpartum, and menopause. This course includes a review of current literature relating to women’s health at key points in the lifespan, clinical implications, and rehabilitation considerations for women.

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Course Rationale

· The purpose of this course is to provide participants with contemporary information on women and exercise with comparative analysis of physiological processes and clinical presentations to understand rehabilitation considerations and maximize outcomes based on current research

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Goals & Objectives

Upon completion of this course, participants will be able to:

1. List and identify the physiological markers of female adolescence.
2. Recognize normal and abnormal variations in physical performance during female adolescence.
3. Identify the relationship between activity, growth, and menstruation.
4. Recognize the physiological changes associated with pregnancy.
5. Define the current exercise recommendations for women during pregnancy.
6. Distinguish the presentation and pathogenesis of musculoskeletal disorders that are common in the pregnant population.
7. Detail the rehabilitation considerations for postpartum women as they return to exercise.
8. List the diagnostic criteria that define menopause in women.
9. Compare and contrast muscle strengthening before and after menopause.
10. Identify the risk factors for and exercise implication of osteoporosis.

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Disclaimer

- Application of concepts presented in this webinar is at the discretion of the individual participant in accordance with federal, state, and professional regulations
- No conflict of interest exists for the presenter or provider of this course

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Course Schedule: 3 Hr Live Webinar

Topic	Time
Physiological markers of female adolescence	0:00-0:10
Adolescence and strength	0:11-0:15
Adolescence and motor control	0:16-0:25
Adolescence and cardiovascular output	0:26-0:30
Amenorrhea	0:31-0:35
Female athletic triad and REDS	0:36-0:50
Interactive Discussion of Clinical Applications	0:51-1:00
Physiological changes associated with pregnancy	1:01-1:10
Exercise and rehabilitation recommendations during pregnancy	1:11-1:25
Common musculoskeletal disorders during pregnancy	1:26-1:40
Postpartum considerations	1:41-1:50
Interactive Discussion of Clinical Applications	1:51-2:00
Defining menopause	2:01-2:10
Muscle strengthening after menopause	2:11-2:20
Osteoporosis definition and risk factors	2:21-2:35
Osteoporosis management	2:36-2:50
Interactive Discussion of Clinical Applications	2:51-3:00

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Course Post-Test

- Slides with “Consider This” icon in bottom right corner will be helpful in completing the post-test



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Adolescence

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Physiological Markers of Adolescence

- Female puberty
 - Period of rapid physical change
 - Endocrine and somatic development
 - Results in reproductive maturity
 - Begins between age 8-11 y/o
 - Takes 4-5 years to complete
- Development of regulatory competence, decision making, and mental health
- Emotional, cognitive, and social development

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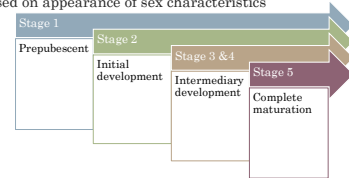
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Physiological Markers of Adolescence

- Tanner Stages
 - Based on appearance of sex characteristics

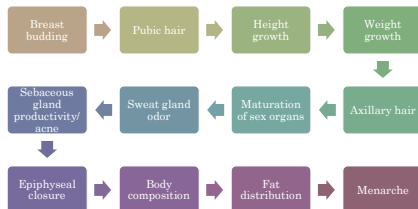


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Physiological Markers of Adolescence



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Physiological Markers of Adolescence

- Estrogen
 - Estradiol is the primary estrogen released from gonads and peripheral tissue
 - Effects
 - Breast development
 - Female typical fat distributions
 - Long bone fusion during growth spurts
 - Stimulates ovulation and menstruation
 - Levels are 4-9x higher in late adolescence than childhood

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Physiological Markers of Adolescence

- Menstruation does not typically begin until weight is 95-100 pounds
 - Role of socioeconomic status on nutrition and weight
- Body fat percentage has role in triggering onset
 - Lean, athletic girls may begin later

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Variations in Physical Performance

- ACSM activity guidelines: Adolescent transition
 - Girl's physical activity tends to decrease significantly compared to boys
 - Disparity persists into adulthood
 - May need additional support and encouragement to remain active
 - Free play
 - Sports
 - Structured programs: lifting weights, resistance bands, body weight

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Variations in Physical Performance

- Cardiovascular output
 - Absolute maximal oxygen uptake (mL/min)
 - Increases linearly with age from 7 years through 13-14 y/o in untrained girls, then declines slightly
 - Aerobic power responds positively to training
 - Absolute and relative maximal oxygen uptakes improve with training at all ages
 - Difference between trained and untrained girls is greatest during adolescence
 - Increase in adipose tissue following sexual maturation of girls likely contributes to the sex difference in aerobic power per unit of body weight

	How trained girls compare to trained boys	How untrained girls compare to untrained boys
Absolute O2 uptake	24% ↓	56% ↓
Relative O2 uptake	18% ↓	32% ↓

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Variations in Physical Performance

Consider This

- Strength
 - Muscular strength improves linearly with age from early childhood until ~15 y/o in girls
 - No clear adolescent spurt
 - Then strength improves more slowly
 - More pronounced hamstring-to-quadriceps strength imbalance
 - Knee extension strength relative to body mass steadily increases throughout maturation
 - Knee flexor strength relative to body mass remains about the same
 - Hip abduction strength relative to body mass may have significant regression in the transition to puberty

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Variations in Physical Performance

- Strength
 - Strength impacts athletic performance in adolescence
 - Strong girls have significantly faster sprint times than average girls
 - Influence of training
 - ~30% gain is typically observed after short-term (8-20 weeks) youth resistance training programs
 - Absolute strength gains
 - Adults > young adolescents > children

Image: royalty free photo Respixel <https://www.getpixel.com/image/3952286/young-gymnast-winner-holding-many-medals>
 Somerfield, L. M., Harrison, C. B., Whitman, C. S., & Hauduc, P. S. (2022). Relationship between strength, athletic performance, and movement skill in adolescent girls. *Journal of Strength and Conditioning Research*, 36(3), 674-679.

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Variations in Physical Performance

- Motor control
 - Average performances of motor tasks (dash, standing long jump, jump and reach, distance throw) improve linearly from childhood through 13-14 y/o
 - Followed by a plateau for some tasks and a decline in others
 - Later maturation is often associated with better motor performance in girls (opposite is often true in boys)

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Variations in Physical Performance

- Motor control
 - Prior to maturation male and female athletes have similar knee forces and motions during landing
 - Following the onset of pubertal growth spurt, female athletes change the way that they land on a jump
 - More valgus loading mechanism
 - Increased quadriceps activity
 - Reduced hamstring activity
 - Reduced hip flexion moment and angle
 - Reduced knee extension moment

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 Holden, S., Doherty, C., Boham, C., & Dabkurt, E. (2019). Sex differences in sagittal plane control emerge during adolescent growth: a prospective investigation. *Knee Surgery, Sports Traumatology, Arthroscopy*, 27(2), 419-426.

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Variations in Physical Performance

- Female non-contact ACL injury
 - 4-6x more likely to suffer an ACL tear than activity matched males
 - Multi-factorial: hormonal, anatomical, biomechanical and neuromuscular factors
 - Biomechanical risk factors for ACL tear
 - Landing with a more extended knee
 - Increased abduction knee angle at initial contact (IC)
 - Increased knee abduction angles and moments
 - Reduced pre-activation of hamstrings

Image: Martin Rutsch, [Wikimedia Commons](https://commons.wikimedia.org/wiki/File:2020-01-19_S&L_jumping_at_the_2020_Winter_Youth_Olympics_%E2%80%99_Women%27s_Individual_%E2%80%99_Final_Round_Martin_Rutsch_004.jpg), CC BY-SA 4.0 https://commons.wikimedia.org/wiki/File:2020-01-19_S&L_jumping_at_the_2020_Winter_Youth_Olympics_%E2%80%99_Women%27s_Individual_%E2%80%99_Final_Round_Martin_Rutsch_004.jpg

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Variations in Physical Performance

- Female non-contact ACL injury
 - Role of the menstrual cycle
 - Increased joint laxity during the ovulatory phase
 - ACL tears more common during the pre-ovulatory phase of menstrual cycle
 - Oral contraceptives decrease the laxity of the ACL

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 Mireles, J., Ferré, A., Dominguez-Balmaseda, D., González-de-la-Pena, A., Santin-Arocas, J., & García-Pérez-de-Socillo, G. (2022). The Influence of the Menstrual Cycle and Oral Contraceptives on Knee Laxity or Anterior Cruciate Ligament Injury Risk: A Systematic Review. *Applied Sciences*, 12(24), 12827.

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Variations in Physical Performance

- Female non-contact ACL injury
 - Prevention
 - ACL injury prevention programs are effective at reducing non-contact injuries
 - Reduced risk by 64%
 - Multi-faceted exercise program
 - Include at least three different exercise types (plyometrics, strengthening)
 - Beginning in preseason and continuing throughout the season
 - Feedback or emphasis on technique
 - Address high risk movements of specific sport
 - Incorporating a prevention program within a warm-up may improve adherence

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 Matto, A. T., Ghali, B., Linton, V., Zhang, A., & Pike, I. (2022). Prevention of non-contact anterior cruciate ligament injuries among youth female athletes: An umbrella review. *International Journal of Environmental Research and Public Health*, 19(8), 4548.

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Variations in Physical Performance

- Concussion in female adolescent athletes
 - Female athletes experience a higher incidence of concussion
 - Hypotheses
 - More likely to report concussion symptoms than males
 - Anatomic
 - Hormonal
 - Demyelination sex differences
 - Female participants had significantly higher severity index
 - No effect of sex was observed on recovery

Image: Microsoft stock photo
 Hannah, T. C., Li, A. Y., Sjpera, Z., Kuhn, L., Dai, J., McAuley, F., ... & Chowdhri, T. (2021). Sex-related differences in the incidence, severity, and recovery of concussion in adolescent middle athletes between 2009 and 2019. *The American Journal of Sports Medicine*, 49(7), 1929-1937.

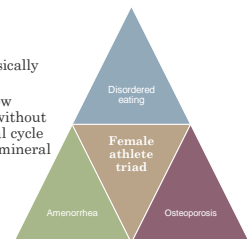
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Activity, Growth & Menstruation

- Female athlete triad
 - First described in 1990's
 - Frequently observed in physically active girls and women
 - Later revised to consist of low energy availability with or without disordered eating, menstrual cycle disturbances, and low bone mineral density



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Activity, Growth & Menstruation

- Menstrual dysfunction

Primary amenorrhea	<ul style="list-style-type: none"> Absence of menarche by 15 y/o
Secondary amenorrhea	<ul style="list-style-type: none"> Cessation of regular menses for 3 mo or cessation of irregular menses for 6 mo
Oligomenorrhea	<ul style="list-style-type: none"> Irregular menstrual cycles >35 days apart, in adolescents may be extended to include cycles longer than 45 days until 2-3 years after menarche

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Activity, Growth & Menstruation

- Causes of menstrual dysfunction
 - Functional hypothalamic amenorrhea (FHA)
 - Absence of menstruation that results from low weight, excessive exercise, and/or stress
 - Diagnosis of exclusion
 - Accounts for ~25-35% of all secondary amenorrhea and 3% of primary amenorrhea
 - Minimum fat storage for menarche: 17%
 - Minimum fat storage for regular menses: 22%
 - Higher incidence in sports with emphasis on lean body composition: runners, dancers, gymnasts, figure skaters

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Activity, Growth & Menstruation

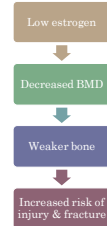
- Bone mineral density
 - 25% of bone mass accrues during the two years surrounding menarche
 - 90% of peak bone mass attained by 18 years of age
 - Estrogen has important role in bone mineral density and bone formation
 - Hypoestrogenemia can have a negative impact on musculoskeletal health
 - Estrogen mediates the continuous process of osteoblastic and osteoclastic activity
 - Requirements for optimal bone health
 - Adequate nutrition: overall energy availability, vitamin D, and calcium
 - Moderate physical activity with weight-bearing exercise

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Activity, Growth & Menstruation

- Bone mineral density
 - Athletes who self-report amenorrhea or oligomenorrhea have greater risk of musculoskeletal injury
 - Depending on the duration of the triad, bone mineral density may never return to normal age appropriate values



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Activity, Growth & Menstruation

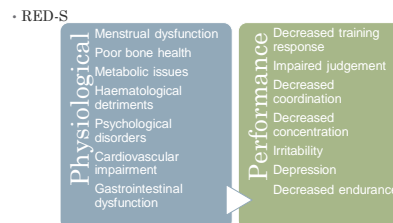
- From the female athlete triad to relative energy deficiency in sport (RED-S)
 - First described by the International Olympic Committee in 2014
 - Describes potential health and performance consequences of inadequate energy for sport
 - Low energy availability can lead to other physiological and performance decrements

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Activity, Growth & Menstruation



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Activity, Growth & Menstruation

- RED-S
 - Populations at highest risk are still not well educated about the condition
 - Knowledge, confidence, and educational impact scores regarding Triad or RED-S
 - Lowest in female cross-country athletes
 - Highest in ATs
- Support the call for education to improve the prevention and treatment

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 Lodge, M. T., Ackmann, K. E., & Galsky, J. (2022). Knowledge of the Female Athlete Triad and Relative Energy Deficiency in Sport Among Female Cross-Country Athletes and Support Staff. *Journal of Athletic Training*, 57(4), 385-392.

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Activity, Growth & Menstruation

- Long term effects of the triad or RED-S
 - Risk for long term sequelae even with management and treatment
 - Alterations to adrenal, thyroid, and gonadal axes could have detrimental health consequences on future pregnancy
 - Cardiovascular effects
 - Endothelial dysfunction can be seen and may be a marker for future cardiovascular risk

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Early Sport Specialization

- High volumes and intensities of practice and competition
- Specialization at younger ages
- Strong adult-driven emphasis from parents, coaches, and youth sports leagues
- Prevalence seems to be greater than 20 years ago



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Early Sport Specialization

- Potential for increasing the risk of injury and burnout in young athletes
- American Academy of Pediatrics (AAP), American Medical Society for Sports Medicine (AMSSM), and American Orthopedic Society for Sports Medicine (AOSSM)
 - Discourage specializing in a single sport before adolescent
- Young athletes who exceed 2:1 ratio of weekly hours of organized sports to free play may be more likely to have an injury and a serious overuse injury

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Early Sport Specialization

- Females more likely to participate in individual sports than males
- Individual sports have higher rates of early sports specialization
- Individual sports have higher rates of overuse injury than team sports
- Highly specialized young female athletes who participate in individual technical sports are more likely to develop more overuse and serious overuse injuries than their male counterparts

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Early Sport Specialization

SORT Level A	SORT Level B	SORT Level 3
<ul style="list-style-type: none"> • Preseason and/or in-season conditioning and fitness program that also focuses on injury prevention 	<ul style="list-style-type: none"> • Do not specialize in a single sport until middle or late adolescence • The total hours of organized sports per week should be <2x the number of hours playing sports just for fun • The total hours of organized sports per week should be ≤ a child's age in years • The total hours of organized athletic activity (sports + gym) should be less than 16 hrs/week 	<ul style="list-style-type: none"> • ≥1 day off per week from practices, sports-specific training/conditioning, and competitions for organized sports • Compete in one sport during a season at a time. Avoid >5 days per week of participation in practices + competition • Take 2-3 months off from competing in sports throughout the year • Take ≥1 month off from competing in a sport after a season ends

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Case Example

- 18 y/o woman
- Senior in high school, varsity soccer player
- Non-contact R ACL tear during game
- Underwent ACL reconstruction with allograft
- Completed full course of post-op rehab
- Returned to sport including recreational soccer during college

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Case Example, cont'd

- 5 years after the R ACL reconstruction, at age 23 y/o she suffered ACL rupture of the L ACL
- Non-contact injury during rec soccer game
- Underwent reconstruction of the L ACL with hamstring autograft
- Completed full course of post-op rehabilitation and returned to sport

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Case Example, cont'd

- 3 years after the L ACL reconstruction, at age 26 y/o she suffered a repeat rupture of the L ACL
- Non-contact injury during cardio exercise class, shuttle run sprints
- Underwent L ACL revision reconstruction using patellar tendon autograft
- Completed full course of post-op rehabilitation, returned to low-risk exercise
- Family hx: mother with known ACL deficiency, older sister with ACL tear/reconstruction



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Pregnancy & Postpartum

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Physiological Changes in Pregnancy

- **Weight gain**
 - 20% weight gain may increase force on a joint by as much as 100%
- **Increased mechanical strain on low back, SI joint, pelvis**
 - Increased lumbar lordosis
 - Increased anterior tilt of pelvis
 - SI joint ligaments become more lax

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Consider This

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Physiological Changes in Pregnancy

- **Ligamentous laxity**
 - Related to production of hormones relaxin and estrogen
 - Relaxin is associated with remodeling of collagen fibers
 - Values increase until the 12th week, then decline until 17th week
 - Values remain at 50% of peak
 - Pubic symphysis widening begins at week 10-12

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Physiological Changes in Pregnancy

- Hemodynamic changes
 - Create circulatory reserve
 - Sustain the pregnant woman and fetus at rest and during exercise
- Soft tissue edema in 80% of women
- Cardiovascular adaptations

Increase ↑	Decrease ↓
<ul style="list-style-type: none"> • Blood volume • Heart rate • Stroke volume • Cardiac output 	<ul style="list-style-type: none"> • Systemic vascular resistance

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Physiological Changes in Pregnancy

- Pulmonary
 - Increased minute volume by 50%, due to increased tidal volume

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Exercise Recommendations in Pregnancy

- Should pregnant women be exercising??

- Physical inactivity and excessive weight gain are independent risk factors for maternal obesity and related pregnancy complications
 - Including gestational diabetes mellitus



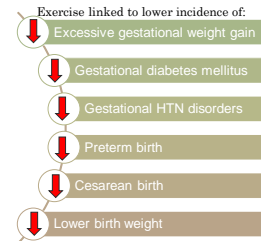
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Exercise Recommendations in Pregnancy

- Benefits of exercise in pregnancy
 - Higher incidence of vaginal birth



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Exercise Recommendations in Pregnancy

- Impact of exercise on the fetus
 - Minimum to moderate increases in fetal heart rate
 - 10-30 beats per minute increase from baseline during or after exercise
 - Minimal to no difference in baby birth weight
 - Women who continue vigorous exercise into third trimester may have 200-400g smaller baby, although no increased risk of fetal growth restriction

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Exercise Recommendations in Pregnancy

- Pre-exercise screening
 - General health status
 - Prior miscarriage
 - Pregnancy complications

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Exercise Recommendations in Pregnancy

Absolute Contraindications	Relative Contraindications
<ul style="list-style-type: none"> Hemodynamically significant heart disease Restrictive lung disease Incompetent cervix Multiple gestation at risk of premature labor Persistent 2nd/3rd trimester bleeding Placenta previa after 26 weeks Premature labor Ruptured membranes Preeclampsia or pregnancy-induced hypertension Severe anemia 	<ul style="list-style-type: none"> Anemia Unevaluated maternal cardiac rhythm Chronic bronchitis Poorly controlled type 1 DM Extreme morbid obesity BMI <12 History of extremely sedentary lifestyle Intrauterine growth restriction Poorly controlled HTN Orthopedic limitations Poorly controlled seizure disorders Poorly controlled hyperthyroidism Heavy smoker

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Exercise Recommendations in Pregnancy

- Pre-exercise screening
- Status of current pregnancy

Marked fatigue	Vaginal bleeding	Unexplained faintness/dizzy
Unexplained abdominal pain	Sudden swelling of ankles, hands, or face	Headaches
Swelling, pain, or redness in one calf	Absence of fetal movement after 6 th month	Failure to gain weight after 5 th month

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Exercise Recommendations in Pregnancy

- Pre-exercise screening
- Current activity habits
 - Regular fitness/recreational activity
 - Occupational activity
 - Heavy lifting
 - Frequent walking/stair climbing
 - Prolonged standing
 - Prolonged sitting
 - Smoking
 - Alcohol consumption

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Exercise Recommendations in Pregnancy



- Exercise prescription parameters
 - Progressive
 - At least 20-30 min per day
 - Most or all days a week
 - Moderate intensity (RPE 13-14 using 20-point scale - moderate)
 - Rating of perceived exertion is most appropriate method of assessing intensity
 - High intensity is safe for those already conditioned (jogging, aerobics)

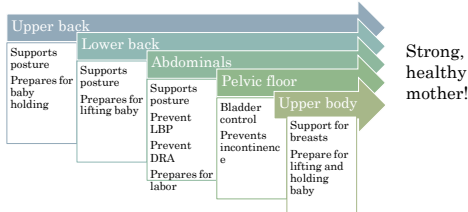
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Exercise Recommendations in Pregnancy

- Muscle group recommendations for strength



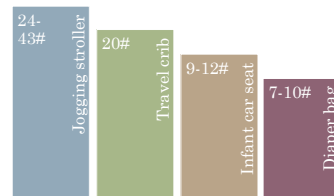
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Exercise Recommendations in Pregnancy

- Baby gear by weight



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Special Considerations

- **Temperature**
 - Regulation is highly dependent on hydration and environmental conditions
 - Stay well hydrated
 - Wear loose-fitting clothing
 - Avoid high heat and humidity to protect against heat stress
 - Exposure to heat from hot tubs, saunas, or fever has been associated with an increased risk of neural tube defects
 - Exercise does not increase core body temperature into the range of concern

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Special Considerations

- **Nutrition**
 - High-intensity or prolonged exercise in excess of 45 minutes can lead to hypoglycemia
 - Ensure adequate caloric intake before exercise
 - Or limit the intensity/length of the session
 - Baseline energy need increase due to pregnancy: 300-400 kcal

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Special Considerations

- **Position**
 - Maintaining a supine position after 20 weeks may result in decreased venous return and uterine blood flow
 - Due to aortocaval compression from the uterus
 - Leads to orthostatic hypotension
 - Modify exercise to quadruped, side lying, sitting, standing

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Special Considerations

- **Occupational lifting**
 - There are reference guides to help determine appropriate lifting restrictions in pregnancy
 - Frequency of lifting (more than once every 5 minutes, more than 3x per minute)
 - Hours per day spent lifting (less than 1 continuous hour, 1 or more hours per day)
 - Start and end height of lift
 - Distance away from body
 - Gestational phase (before 20 weeks, after 20 weeks)

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Special Considerations

- Warning signs to discontinue exercise

Vaginal bleeding	Abdominal pain	Regular painful contractions	Amniotic fluid leakage
Dyspnea before exertion	Dizziness	Headache	Chest pain
Muscle weakness affecting balance	Calf pain or swelling		

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Musculoskeletal Disorders in Pregnancy

- **Low Back Pain**
 - >60% of pregnant women experience back pain
 - Patient education
 - Breaks to elevate legs: reduce edema and relieve hyper-lordosis
 - Sleeping: pillow between knees
 - Lifting modification: teaching older kids to be independent
 - Aerobic exercise: walking, aquatics
 - Abdominal or lumbar binder
 - Acupuncture?

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Musculoskeletal Disorders in Pregnancy

- Low Back Pain, cont'd
 - Strengthening of the abdominal and back muscles
 - Example exercises for lumbopelvic mobility and stabilization in pregnancy
 - Cat cow/bird dogs
 - Standing lateral/fwd reach
 - Lower trunk rotation stretch
 - Piriformis stretch in sitting
 - Pelvic tilt in sitting and standing
 - Clamshells

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Musculoskeletal Disorders in Pregnancy

- Pelvic pain
 - Clinical practice guidelines:
 - “Conflicting evidence was found for interventions including the use of support belts, and exercise. The evidence for manual therapy can best be described as weak/emergent at this time.”
 - Example exercises in pregnancy:
 - Isometrics: Hip adductors and abductors

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Musculoskeletal Disorders in Pregnancy

- Hip pain

Transient osteoporosis	Osteonecrosis of the femoral head
<ul style="list-style-type: none"> • Treatment <ul style="list-style-type: none"> • Protected WB, medications are controversial • Typically self limited and without long term sequelae • Complications <ul style="list-style-type: none"> • Fracture requiring surgical intervention 	<ul style="list-style-type: none"> • Theory for pathogenesis <ul style="list-style-type: none"> • Increased adrenocortical activity, female sex hormones, weight, interosseous pressure • Treatment <ul style="list-style-type: none"> • Restricted WB to limit progression • Definitive treatment initiated post delivery
<p>Weightbearing hip pain, antalgia Usually in third trimester Diagnosed with radiographs/MRI</p>	

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Musculoskeletal Disorders in Pregnancy

- Falls/balance dysfunction
 - Postural stability unchanged in first trimester
 - Postural balance significantly decreased in second and third trimester, as well as postpartum (6-8 weeks)
 - 25-27% of pregnant women fall
 - Higher fall rate in sedentary women than physical exercise
 - Modifications to activities

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Hivain, L. & Rugele, D. (2022). Risk factors for accidental falls during pregnancy—a systematic literature review. *The Journal of Maternal-Fetal & Neonatal Medicine*, 35(25), 7015-7024.

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Musculoskeletal Disorders in Pregnancy

- Carpal tunnel syndrome
 - Incidence in pregnant women varies from 2-70%
 - Contributing factors
 - Hormonal fluctuations
 - Fluid accumulation
 - Nerve hypersensitivity
 - Glucose level fluctuations
 - Typically resolves without treatment following delivery or breastfeeding
 - Alternate options
 - Wrist splinting in the night
 - Steroid injection

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Musculoskeletal Disorders in Pregnancy

- Modalities with precautions
 - Heating pads
 - Thermal ultrasound
 - Dry needling
 - Diathermy
 - Whirlpool/hot tub
 - Lumbar/cervical traction
 - Electrical stimulation
 - Blood flow restriction

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Postpartum

- Abdominal muscle recovery
 - Structural changes (DRA, mm lengthening) and functional deficits persisted at 6 months postpartum
 - Partial recovery of DRA happens after childbirth but is incomplete even after 1 year
- Postpartum women showed poorer trunk strength than nulliparous women at 6 months
 - 12 (40%) of the 30 postpartum women given a grade of 3/5 or less
- Postpartum women (up to 6 months) had greater fatigability of the lumbopelvic stabilizing muscles and lower physical function than nulligravid women

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Postpartum

- Joint laxity
 - Peripheral joint laxity does not return to normal range within 6 weeks
- Cardiovascular expectations
 - VO2 max: if athlete continues moderate intensity exercise during gestation, she can expect VO2 max to return to pre-pregnancy levels after delivery
- Perineal lacerations
- Cesarean section
 - Scar management
 - Longer timeline for abdominal muscle recovery?
 - Some pilot study research has been done in Journal of Women's Health Physical Therapy, but more is needed

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Postpartum

- Return to exercise progression
 - Treat as return to sport after acute injury (Jill Thein-Nissenbaum)
 - Begin with specific lumbar stabilization with attention to loss of form
 - Strengthening program once lumbar stabilization with extremity movement is achieved
 - <70% of 1 rep max for 10-25 reps, 2-4 sets (30-60 sec rest)
 - 2-3 days per week
 - Cardiovascular exercise once lumbar stabilization with extremity movement is achieved

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Postpartum

- Biking
 - Stationary bike requires some core stabilization, but not as much as is needed for swimming
 - Recumbent bike may be sooner due to comfort and decreased core stabilization demands
 - With cesarean section will need to wait until she can use her abdominal muscles to help stabilize, typically 3-4 weeks postpartum
 - Alternate between sitting/standing to increase tolerance for bike seat

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Postpartum

- Swimming
 - As early as 1-2 weeks postpartum
 - If not experiencing any blood loss, otherwise would need to wait until cleared for tampon use (typically after week 6)
 - If cesarean section will need to have incision cleared for submersion in pool
 - Start with buoy and frequently vary strokes to reduce risk of overuse injury

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Postpartum

- Running
 - Higher level of core demands
 - Begin with walking program
 - Vaginal delivery 1 week post partum
 - Cesarean 4 weeks post partum
 - Begin walk-jog intervals after 2-3 weeks of walking only
 - Jogging stroller
 - Minimal changes in exertion with 25 and 50# load
 - Similar mechanics to solo running

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Postpartum

- Pelvic floor tips for the non-pelvic floor PT
 - Pelvic floor is part of your core
 - Draw in pelvic floor (Kegel squeeze) during abdominal stabilization
 - Inability to maintain a pelvic floor contraction → incontinence
 - Avoid holding breath
 - Increases intra abdominal pressure and can cause incontinence
 - Progress from supine to functional positions
 - Indications for pelvic floor evaluation:
 - Unable to perform isolated pf contraction
 - Exercise is severely limited by urinary incontinence
 - Pelvic pain/pressure during activity

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Postpartum

- Diastasis recti abdominis
 - Pain presentation: upper, middle or lower low back
 - Depends on where abdominal support is lacking
 - Difficulty and weakness with rotation against resistance
 - Recent studies challenge the conventional mindset of closing the gap
 - TRa pulls on the sheaths of the recti muscles and then the linea alba
 - Allows forces to cross midline
 - Pulls it wider BUT it also reduces the distortion
 - ↓ Midline doming or sagging
 - Abdomen appears flatter
 - “The goal is not to reduce the gap after all – it is to widen it, load it, and hold the abdominal contents in!”

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Lee, D. (2017). Diastasis Rectus Abdominis: A Clinical Guide for Those who are Split Down in the Middle. Learn with Diane Lee.

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Postpartum

- Special considerations
 - Weight loss/change: body image sensitivity
 - Breastfeeding: clothing, positioning, caloric demands
 - Postpartum depression: found in 10-20% of new mothers
 - Repetitive lifting
 - Appointment density

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Case Example

- 38 y/o woman presents with c/c of intermittent sharp, stabbing pubic symphysis pain after running
- Currently 4 weeks post partum, second vaginal delivery
 - Children are 21 months apart, had pelvic floor PT after first delivery for prolapse
 - Breast feeding
- Ran during both pregnancies until after 30 weeks, keeping an average mileage of 20 mi/week
- Pain began during third trimester, improved post-partum, then returned after she started running again
- Returned to running at 2 weeks post-partum with a 10-12 mile run
 - Added speed work and longer distance a week later
 - Plans to run the Boston Marathon in 4 weeks

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Case Example, cont'd

- Objective
 - Walking gait: without antalgia or compensatory patterns
 - ROM: ER WFL B, hip flex 90 deg B
 - Strength: lower abdominals able to independently activate in hooklying and with LE march, fatigue in 10 sec
 - Special test
 - Palpation: pubic symphysis level superior rami, moderate TTP, no diastasis, no increased warmth
 - Adductors with increased mm tension
 - FABER: neg B
 - SLS: no increase in sx B

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Case Example, cont'd

- Treatment
 - HEP
 - Stretch: knee fallout, pigeon, quad, HS
 - Strengthening: abdominal draw in + Kegel + double leg lift/hold, bridge, clamshells
 - Stability: trial SI bolt, gait modification (increase step rate to decrease pubic symphysis shearing)
 - Manual therapy for adductors and DN
 - Progressions: lateral planks, reverse clams, isometric hip ADD, standing pallof press, lateral band walks
 - Training program stratagizing: rehab and running to not overload



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Menopause

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Diagnostic Criteria for Menopause

- The end of a woman's fertile life
 - Loss of ovarian follicular function
- 12 months have passed since last period
- Occurs in the late 40s to early 50s
 - Premature <40 y/o
 - Early 40-45 y/o
 - Average age in US is 51 y/o
- Takes place over several years (5–8 years)

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Diagnostic Criteria for Menopause

- Perimenopause
 - The ill-defined period of time leading up to menopause
- Begins with the first onset of menstrual irregularity
 - Early transition: cycles are mostly regular
 - Late transition: more irregular, amenorrhea lasts at least 60 days
- Ends at 12 months of amenorrhea

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Diagnostic Criteria for Menopause

- Factors influencing age of menopause
 - Associations with later age at natural menopause
 - Longer life expectancy
 - Higher bone mineral density and lower risk of fracture
 - Reduced all-cause mortality, CVD, and cardiovascular death
 - Greater breast (among obese) and ovarian cancer risk

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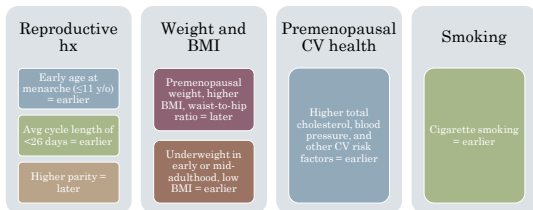
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Diagnostic Criteria for Menopause

- Factors influencing age of menopause, cont'd



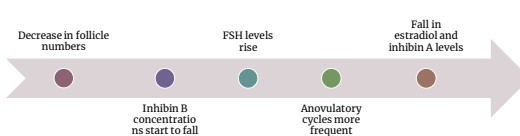
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Diagnostic Criteria for Menopause

- Hormonal changes



- Testosterone decreases between 20-45 y/o and then does not change significantly with menopause transition

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Signs and Symptoms of Menopause

• Signs and symptoms

Vasomotor symptoms	Psychological symptoms	Cognitive symptoms	Atrophic effects
<ul style="list-style-type: none"> • Hot flashes • Palpitations 	<ul style="list-style-type: none"> • Mood changes • Depression • Irritability • Anxiety • Sleep disturbances 	<ul style="list-style-type: none"> • Memory problems • Concentration 	<ul style="list-style-type: none"> • Atrophic vaginitis • Bladder irritability

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Signs and Symptoms of Menopause

- Signs and symptoms – more on vasomotor
- Most common
- ~80% of midlife women experience
- Factors
 - Hormonal
 - Obesity before menopause
 - Cigarette smoking
 - Higher levels of anxiety and depression
 - Lower level of education
- Inconsistent data on association
 - Physical activity
 - Diet
 - Alcohol consumption

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Signs and Symptoms of Menopause

• Signs and symptoms

• ...there are MORE!

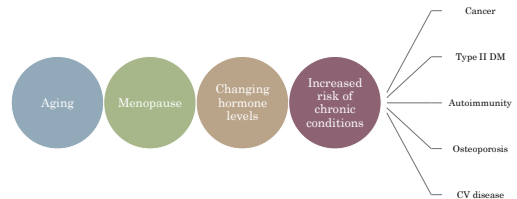
Night sweats	Headaches	Fatigue
Decreased libido	Severe itchiness	Back and muscle pains

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Signs and Symptoms of Menopause



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Signs and Symptoms of Menopause

• Signs and symptoms

- Hormone replacement therapy
 - Use of synthetic hormones (estrogen + progestin, or estrogen alone in cases of hysterectomy)
 - Most effective treatment for symptoms
- Treatment risks
 - Increased risk of breast cancer
 - Estrogen alone did not have this risk (however it did show an increased risk of stroke)
 - Increased risk of heart disease?

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Signs and Symptoms of Menopause

• Signs and symptoms

• Alternative therapies

Currently recommended	<ul style="list-style-type: none"> • Physical activity • Exercise
Studied but not able to recommend	<ul style="list-style-type: none"> • Phytoestrogens • Black cohosh • Red clover • Dong quai • Evening primrose oil • Ginseng • Wild yam • Maca

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Menopause, Exercise, & Mental Health

- Connection between physical activity and mental well-being during menopause
 - May help maintain positive mental well-being
 - May counteract the potentially negative influence of menopause on depressive symptoms
- Mechanisms
 - Positive social interaction
 - Improving resources to alleviate symptoms
- Which comes first, less menopausal symptoms or more physical activity?

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 Bondariv, D., Spits, S., Fink, T., Kujala, U. M., Auke, P., Laaksonen, E. K., ... & Kokko, K. (2020). The role of physical activity in the link between menopausal status and mental well-being. *Menopause (New York, N.Y.)*, 27(4), 398.

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Menopause, Exercise, & Mental Health

- Study of 16-week exercise program vs education for psychological well-being
 - 111 women divided into two groups
 - **Exercise group**
 - 60-min concurrent (aerobic + resistance) exercise training
 - 3 days/wk for 16 weeks
 - **Counseling group**
 - Attended conferences on healthy lifestyle (including diet and physical activity topics)

Image: Microsoft stock photo
 Aparicio, V. A., For-Abamany, M., Marin-Jimenez, N., Coll-Risco, I., & Aranda, P. (2021). A 16-week concurrent exercise program improves emotional well-being and emotional distress in middle-aged women: the FLAMENCO project randomized controlled trial. *Menopause*, 28(7), 764-771.

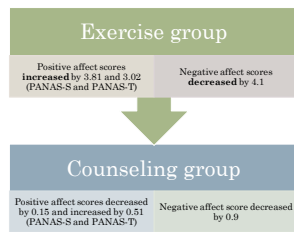
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Menopause, Exercise, & Mental Health

- Study, cont'd
- Outcome measures
 - Positive and Negative Affect Schedule (PANAS)
 - Higher scores reflect greater affective emotional health (positive affect subscale)
 - Higher scores reflect greater emotional distress (negative affect subscale)



Aparicio, V. A., For-Abamany, M., Marin-Jimenez, N., Coll-Risco, I., & Aranda, P. (2021). A 16-week concurrent exercise program improves emotional well-being and emotional distress in middle-aged women: the FLAMENCO project randomized controlled trial. *Menopause*, 28(7), 764-771.

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Menopause and Body Composition

- Age is responsible for increase in obesity
- Menopause is associated with increased truncal obesity and visceral adiposity
 - Waist circumference, waist-to-hip ratio
 - Simultaneous loss of lean body mass
- Ethnic differences
 - Menopausal transition
 - Black and white women have similar weight and visceral fat gains
 - Japanese women do not show the visceral fat gain
 - After menopause
 - White women continue to gain visceral fat, black women do not
 - Japanese women show increase in central adiposity

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 Ogoke, A. A., Abusuhaim, M., & Korje, J. C. (2023). Obesity and Menopause. *Best Practice & Research Clinical Obstetrics & Gynaecology*, 102348.

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Menopause and Body Composition

- Physiologic and metabolic changes associated with menopause are a direct effect of estrogen deficiency
 - Lipid metabolism
 - Energy consumption
 - Insulin resistance
 - Body fat composition (gynecoid → android body shape)
 - Increased abdominal and visceral fat accumulation
 - Associated with increased CVS and metabolic risks
- FSH may also be implicated
 - Stimulates fat distribution
 - Contributes to a pro-inflammatory milieu

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 Ogoke, A. A., Abusuhaim, M., & Korje, J. C. (2023). Obesity and Menopause. *Best Practice & Research Clinical Obstetrics & Gynaecology*, 102348.

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Menopause and Body Composition

- Increased cardiometabolic risk and mortality in postmenopausal women
 - Abdominal fat appears to be critical factor in development of insulin resistance and type 2 diabetes
 - Often accompanied by abnormal lipid profile
 - Postmenopausal women with obesity have a 4-fold increased risk of CVS mortality
 - Metabolic alterations occur in women with obesity AND normal weight
 - Lower BMI threshold for menopausal health screening?
 - Other measures: waist circumference, waist-to-hip ratio, body shape index, lipid accumulation product

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Menopause and Body Composition

- Effect of estrogen deficiency on energy intake and expenditure
 - Estrogen shown to have an inhibitory effect on appetite
 - Postmenopausal depletion is thought to centrally control energy intake
- Increased cancer risk
 - Obesity is a known risk factor for several malignancies
 - Hormone-associated endometrial and breast cancers
 - Both have an increased prevalence in postmenopausal women
 - Risk of postmenopausal breast cancer increases by 11% for every 5 kg gained as an adult

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Menopause and Body Composition

- Role of exercise in weight management
 - Dieting alone is an effective approach to initially lose weight
 - The resulting reduction in muscle mass can lower the metabolic rate and reduce energy expenditure
 - Physical activity can increase energy utilizing tissue
 - Facilitates the maintenance of weight loss

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Muscle Strengthening in Menopause

Consider This

- Importance of strength in older age
 - Decreased strength is a determinant of impaired functional capacity
 - Increased fall risk
 - Increased mobility disability
 - Osteoporotic fracture

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Muscle Strengthening in Menopause

- Muscle strength begins to decline during perimenopause
 - Thought to be partly estrogen dependent
 - Modifiable factors
 - Inactivity
 - Decreased protein intake
- Exercises have been shown to improve postmenopausal muscle performance
 - Hormone replacement therapy may augment the effects

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Muscle Strengthening in Menopause

- ACSM strengthening guidelines for older adults (>65)
 - Muscle-strengthening exercises should be performed to the point at which it would be difficult to do another repetition
 - To enhance muscle strength
 - 1 set of 8-12 repetitions of each exercise
 - 2 or 3 sets may be more effective
 - Progressive over time
 - Weight
 - Number of sets or repetitions
 - Number of days per week of exercise

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Menopause and Tendinopathy

- Lower limb tendinopathy prevalence increases in post-menopausal women
 - Pre-menopause
 - Women have a lower risk than men of developing lower limb tendinopathies
 - After menopause
 - Risk of tendon rupture and tendon pathology is similar in women and men
- Estradiol plays a role in maintaining homeostasis of female connective tissue

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Menopause and Tendinopathy

- Thought that higher levels of estrogen may protect tendon from injury
- Gender
 - Estrogen receptors have been identified in tendon tissue
- Body composition
 - Body shape is linked to levels of circulating sex hormones
 - Tendon pathology more prevalent in android than gynoid shapes

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Menopause and Cardiovascular Disease

- CVD is the leading cause of death in women
- Menopausal transition is a time of accelerating CVD risk
- Critical window for implementing early intervention strategies
- Only 7.2% of women in perimenopause meet physical activity guidelines
- <20% consistently maintain a healthy eating diet

Image: Microsoft stock illustrations
El Khoudiry, S. R., Aggarwal, B., Beckie, T. M., Hods, H. N., Johnson, A. E., Langer, R. D., ... & American Heart Association Prevention Science Committee of the Council on Epidemiology and Prevention and Council on Cardiovascular and Stroke Nursing. (2022). Menopausal transition and cardiovascular disease risk: Implications for timing of early prevention: a scientific statement from the American Heart Association. *Circulation*, 145(25), e506-e532.

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Menopause and Cardiovascular Disease

- Menopausal factors associated with increased CVD risk

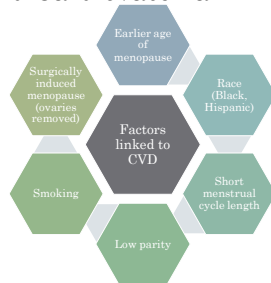


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Menopause and Cardiovascular Disease

- Paracardial fat volumes are higher after menopause
 - Potential influence of estradiol or hormone therapy
- Increased lipids (LDL-C and apolipoprotein B), metabolic syndrome risk, and vascular remodeling
 - Driven by perimenopause > aging,
 - Increased blood pressure, insulin, and glucose more influenced by aging
- Reversal in the associations of HDL-C with CVD risk during perimenopause
 - Higher HDL-C levels may not consistently reflect good CV health in midlife women

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Menopause and Cardiovascular Disease

- Preventative measures
 - Hormone therapy
 - Effects vary by age or time since menopause when therapy begins
 - Beneficial effects on CVD outcomes and all-cause mortality when initiated <60 y/o or <10 years since menopause
 - Null or harmful effects when initiated at older ages or after greater time since menopause
 - Smoking cessation
 - Weight loss
 - Dietary changes
 - Physical activity
 - Optimization of total cholesterol, fasting blood glucose, and blood pressure

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Menopause and Osteoporosis

- Incidence
 - ~10 million Americans >50 y/o
 - Additional 34 million at risk
 - 1.5 million fragility fractures each year

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Menopause and Osteoporosis

- Definition
 - Bone mineral density ≥ 2.5 standard deviations below the average for young healthy women
 - Estrogen deficiency after menopause accelerates the age-related loss of bone
 - Measured at the hip and spine using dual energy x-ray absorptiometry (DEXA)
 - Bone turnover biomarker detection can be used to monitor treatment and assess fracture risk

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Menopause and Osteoporosis

- DEXA
 - Takes about 10-30 min
 - Low-dose x-rays with two distinct energy peaks sent through bones being examined
 - One peak is absorbed mainly by soft tissue
 - Other peak is absorbed mainly by bone
 - Soft tissue amount can be subtracted from the total and what remains is the bone mineral density
 - Software calculates score

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Menopause and Osteoporosis

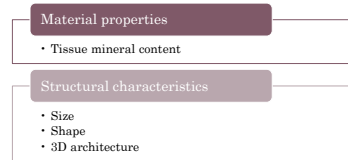
- DEXA
 - **T score**
 - Bone mineral density compared to young adults of the same gender in peak health
- | | |
|-----------------|--------------|
| -1 and above | normal score |
| -1 through -2.5 | osteopenia |
| below -2.5 | osteoporosis |
- **Z score**
 - Often used in younger people who are still growing
 - Bone mineral density compared to people in your age group of the same size and gender
 - > 2 standard deviations above or below average may indicate a need for further tests

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Menopause and Osteoporosis

- Bone strength: it's more than just bone mineral density
- Fragility fractures are independently associated with both low bone mass and reduced bone size



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Menopause and Osteoporosis

- Risk factors

Modifiable	Non-modifiable
<ul style="list-style-type: none"> · Weight · Smoking · Alcohol consumption · Physical inactivity · Dietary calcium deficiency · Long-term glucocorticoid use 	<ul style="list-style-type: none"> · Gender · Age · Race · Genetic characteristics · Premature menopause · Loss of ovarian function before menopause

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Menopause and Osteoporosis

- Symptoms
 - Decreased body height
 - Dowager's hump/kyphosis
 - Bone fracture
 - Respiratory impairment

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Menopause and Osteoporosis

- Treatment
 - Pharmacological
 - Inhibition of bone resorption (most common)
 - Bisphosphonates (Alendronate, Risedronate, Ibandronate, Zoledronic)
 - Denosumab
 - Bone formation

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Menopause and Osteoporosis

- Treatment
 - Non-pharmacological
 - Calcium
 - Vitamin D
 - Control coffee intake
 - Smoking cessation
 - Limit alcohol consumption
 - Balance training
 - Exercise
 - Education

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Menopause and Osteoporosis

- Exercise considerations
 - Bone Health & Osteoporosis Foundation recommendations
 - High or low impact weight-bearing
 - Jumping, jogging and aerobics as high impact exercise
 - Walking and step aerobics as lower impact exercises
 - Muscle strengthening exercises
 - Lifting weights
 - Elastic exercise bands
 - Exercises including resistance against gravity

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Menopause and Osteoporosis

- Exercise considerations
 - High intensity and weight bearing exercise enhance bone formation while also limiting bone resorption
 - Exercise modality matters
 - Walking has marginal or no effects on the prevention of osteoporosis
 - Swimming generally is associated with little or no effect on BMD

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Papadopoulou, S. K., Papadimitriou, K., Voulgariou, G., Georgaki, E., Tsolidou, E., Zantiidou, O., & Papanthou, D. (2021). Exercise and nutrition impact on osteoporosis and Sarcopenia—The incidence of Osteosarcopenia: A narrative review. *Nutrients*, 13(12), 4499.

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Menopause and Osteoporosis

- Exercise considerations
 - Activities to avoid
 - High fall risk (slippery surfaces, step aerobics)
 - Repeated or resisted trunk flexion (sit-ups, toe touches)

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Consider This

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Socioeconomic Influence on Menopause

- Women seek information and support from various sources (often not evidence based)
- Socioeconomic privilege influences access to care and information
 - Poor are more often under-treated
- Perception of this phase can be positive or negative
 - Loss of reproductive years, femininity, youthfulness, beauty
 - Celebration of seniority in community

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Health Magazine - Note paper - Dis - Sort of skipping the design of this women627
O'Reilly, K., McDermid, F., McInnes, S., & Peters, K. (2022). An exploration of women's knowledge and experience of perimenopause and menopause: An integrative literature review. *Journal of Clinical Nursing*.

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Case Example

- 65 y/o woman
- Presents to clinic with 3-week hx of R lateral hip and leg pain
- Began after initiating new exercise routine
 - Non-impact resistance training guided by personal trainer
- No acute MOI, rather soreness post-exercise that “resolved everywhere else but the hip”
- Provoking factors: walking, stairs
 - Pain 8/10 at worst, 3/10 current
- Medical hx: glute med/min repair for complete tear on the contralateral side 3 years prior

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Case Example, cont'd

- Objective
- **Posture:** no significant deviations
- **Gait:** ambulates without antalgia, no Trendelenberg or compensated Trendelenberg
- **ROM**
 - Hip: flex, IR, ER symmetrical and WFL B
 - Knee: lacking full ext L
- **Strength**
 - Hip ABD: able to perform independent AROM anti-gravity through full range, mild pain reported
 - SLS: able to perform B without deviation
 - DL squat: mild weight shift towards LLE
 - **Palpation:** no atrophy notable through R hip/glutes, pain just proximal to gr trochanter, taut band in posterolateral glutes

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Case Example, cont'd

- Signs and sx consistent with gluteal tendinopathy
- Initial treatment
 - HEP: glute isometrics (standing at wall and on the floor), self release using dryer ball for TrP
 - Manual therapy: IASTM to ITB, STM to lateral glutes
 - Review of gym program
- Follow up
 - Visit 2: significant reduction in pain from baseline
 - Postural education on neutral hip to reduce shearing (standing clamshell, fwd step-up)
 - Visit 3: returned to more activities without return of sx (d/c from care)
 - Progression of strengthening (clamshells, bridge progression, lateral plank)

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Conclusion

- Women have unique physiologic considerations for exercise across the lifespan. By widening our understanding of these distinctive characteristics, we can better educate our patients, improve female health, and provide more effective care.

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Q1

Which of the following statements is true regarding female adolescent muscle strength according to literature presented?

- A. Knee flexor strength increases relative to body mass
- B. Knee extensor strength increases relative to body mass
- C. Hip abductor strength increases relative to body mass
- D. Hamstring-to-quad strength ratio increases

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Q2

Which of the following is defined as the absence of menarche by 15 years old?

- A. Primary amenorrhea
- B. Secondary amenorrhea
- C. Oligomenorrhea
- D. None of the above

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Q3

Which of the following performance variables have been associated with low energy availability?

- A. Decreased training response, decreased endurance performance, and depression
- B. Irritability, depression, and insomnia
- C. Insomnia, mania, and improved reaction times
- D. Increased coordination, improved concentration, and increased endurance

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Q4

Which of the following is an anatomical change commonly associated with pregnancy?

- A. Increased posterior pelvic tilt
- B. Increased genu valgus
- C. Increased lumbar lordosis
- D. Increased pes cavus

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Q5

Which of the following is the most appropriate method for monitoring exercise intensity in the pregnant population?

- A. Heart rate
- B. Subjective rating of perceived exertion
- C. Body temperature
- D. VO₂ max

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Q6

Which of the following is a potential risk of positioning a pregnant woman supine after 20 weeks gestation?

- A. Decreased venous return
- B. Decreased uterine blood flow
- C. Orthostatic hypotension
- D. All the above

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Q7

How long postpartum does the current literature suggest there are structural, strength, and endurance consequences for the abdominal muscles?

- A. 2 weeks
- B. 6 weeks
- C. 12 weeks
- D. >6 months

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Q8

Which of the following has been associated with postmenopausal reduction in muscle strength and impaired functional capacity?

- A. Increased risk of falls
- B. Increased fasting glucose
- C. Decreased fracture risk
- D. Decreased reaction times

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Q9

According to the World Health Organization criteria, osteoporosis is defined as a bone mineral density that lies at least how many standard deviations below the average value for young healthy women?

- A.1
- B.1.5
- C.2
- D.2.5

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Q10

Which of the following exercise conditions should be avoided in women with osteoporosis?

- A. Isometric hip exercises
- B. Balance training
- C. Repeated or resisted trunk flexion
- D. Weight bearing exercises

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References

Ackerman K. E., Holman, B., Cooper K. M., Flynn, E. F., Bruhaug, G., Terforte, A. S., ... & Parziale, A. L. (2019). Low energy availability symptoms correlates with health and performance consequences of Relative Energy Deficiency in Sport. *British journal of sports medicine*, 53(70), 628-633.

Alborg, H. G., Johnell, O., Turner, C. H., Hansen, G., & Kastrup, M. K. (2000). Bone loss and bone size after menopause. *New England Journal of Medicine*, 343(9), 327-334.

Alkhalil, I. & Zimels, H. (2016). Osteoporosis: current concepts. *Israels Journal of Medicine*, 46(2), 123-127.

American College of Obstetricians and Gynecologists. (2015). Physical activity and exercise during pregnancy and the postpartum period. Committee opinion 550 (No Title).

Aspinos, Y. A., Flor-Alamany, M., Merlo-Limones, N., Cobi-Roca, L., & Avenda, F. (2021). A 16-week concurrent exercise program improves emotional well-being and muscular strength in middle-aged women: the FLAMENCO project randomized controlled trial. *Menopause*, 28(7), 764-771.

Atari, R., & O'Toole, M. (2003). Guidelines of the American College of Obstetricians and Gynecologists for exercise during pregnancy and the postpartum period. *British journal of sports medicine*, 37(1), 8-12.

Balachandrar, V., Meechai, J. L., Vial, O., & Balachandrar, C. (2017). Effects of the menstrual cycle on lower-limb biomechanics, neuromuscular control, and anterior cruciate ligament injury risk: a systematic review. *Muscles, ligaments and tendons journal*, 7(1), 1-8.

Beak, K. A., & Meyen, N. L. (2007). Female athlete triad update. *Clinics in sports medicine*, 26(1), 69-85.

Be, K., Anzi, R., Barakat, R., Brown, W., Davies, G. A., Doolley, M., ... & Khan, K. M. (2016). Exercise and pregnancy in recreational and elite athletes: 2016 evidence summary from the IOC expert group meeting, Lausanne. Part 1—exercise in normal pregnancy and those who are pregnant. *British Journal of Sports Medicine*, 50(10), 571-589.

Bondarev, D., Spill, S., Fava, T., Kogala, U. M., Aukes, P., Laakkonen, E. K., ... & Kohko, K. (2020). The role of physical activity in the link between menopausal status and mental well-being. *Menopause (New York, N.Y.)*, 27(1), 338.

Borg-Steen, J., Dugan, S. A., & Collins, C. (2005). Musculoskeletal aspects of pregnancy. *American journal of physical medicine & rehabilitation*, 34(2), 180-182.

Borg-Steen, J., Dugan, S. A. (2007). Musculoskeletal disorders of pregnancy: delivery and postpartum. *Physical medicine and rehabilitation: clinics of North America*, 18(2), 458-476.

135

Copyright Sara Ziegele 2023

135

References

Brown, K. A., Dewoolkar, A. V., Baker, N., & Dulech, C. (2017). The female athlete triad: special considerations for adolescent female athletes. *Translational pediatrics*, 6(3), 144.

Burger, H. G., Hale, D. E., Robinson, D. M., & Christensen, L. (2007). A review of hormonal changes during the menopausal transition: focus on findings from the Melbourne Women's Midlife Health Project. *Human reproduction update*, 13(6), 569-682.

Calamak, B., Ribeiro, A. P., & Invern, A. (2016). Postural balance and the risk of falling during pregnancy. *The Journal of Maternal-Fetal & Neonatal Medicine*, 29(10), 1623-1625.

Clynes, M. A., Harvey, N. C., Curtis, E. M., Fuggle, N. R., Davidson, E. M., & Cooper, C. (2020). The epidemiology of osteoporosis. *British medical bulletin*.

Cook, J. L., Bass, S. L., & Black, J. E. (2007). Hormone therapy is associated with smaller Achilles tendon diameter in active post-menopausal women. *Scandinavian journal of medicine & sports science*, 17(2), 129-132.

Dewey, M. H., Mendenhall, A. A., Mitchell, M. F., Pollock, V. J., Gray, C. E., Garcia, A. J., ... & Ruchat, S. M. (2016). Exercise for the prevention and treatment of low back, pelvic girdle and lumbopelvic pain during pregnancy: a systematic review and meta-analysis. *British journal of sports medicine*, 53(2), 90-98.

De Souza, M. J., Mativ, A., Joy, E., Mora, M., Williams, N. I., Matinson, R. J., ... & Patel, E. (2014). 2014 Female Athlete Triad Coalition Consensus Statement on treatment and return to play of the female athlete triad. 1st International Conference held in San Francisco, California, May 2012 and 2nd International Conference held in Indianapolis, Indiana, May 2013. *British journal of sports medicine*, 48(4), 289-293.

Dubrov, G., Brzozowski, A., & Berry, E. M. (2003). Weight control and the management of obesity after menopause: the role of physical activity. *Menopause*, 4(2), 89-101.

El Khoury, S. R., Aggarwal, B., Beckie, T. M., Hodge, H. N., Johnson, A. E., Langer, R. D., ... & American Heart Association Prevention Science Committee of the Council on Epidemiology and Prevention, and Council on Cardiovascular and Stroke Nursing. (2020). Menopause transition and cardiovascular disease risk: implications for timing of early prevention a scientific statement from the American Heart Association. *Circulation*, 142(23), e406-e432.

Elkay-Sale, K. J., Terforte, A. S., Parziale, A. L., Holman, B., & Ackerman, K. E. (2018). Endocrine effects of relative energy deficiency in sport. *International journal of sport nutrition and exercise metabolism*, 28(4), 320-340.

Enriquez-del-Castillo, L. A., Ornelas-López, A., De León, L. G., Cervantes-Hernández, N., Quintana-Medina, E., & Flores, L. A. (2022). Strength and VO2max Changes by Exercise Training According to Maturation State in Children. *Children*, 9(7), 928.

136

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136

References

Fiegenbaum, A. D., Kraemer, W. J., Birnka, C. J., Jeffries, J., Michal, J. J., Nilka, M., & Rowland, T. W. (2009). Youth resistance training: updated position statement paper from the national strength and conditioning association. *The Journal of Strength & Conditioning Research*, 23, 566-576.

Fisher-Samuel, U., Dwyer, P., Aziz-Samad, U., Kucukhan-Selvi, C., & Patissonman, P. (2020). Osteoporosis: Pathophysiology and Therapeutic options. *EXCLI Journal*, 19, 1017.

Foti, T., Davila, J. R., & Bagley, A. (2005). A biomechanical analysis of gait during pregnancy. *JBJS*, 82(5), 625.

Gilbert, W. L., & Brown, J. M. (1995). Structure and function of the abdominal muscles in primiparous subjects during pregnancy and the immediate postpartum period. *Physical therapy*, 76(7), 750-762.

Givler, N. M., & Sarnes, N. F. (2015). Menopause and exercise. *Menopause*, 22(12), 1301-1308.

Hansen, T. G., Li, A. Y., Spina, Z., Kuo, L., Ok, J., Michalek, F., ... & Chouffot, T. (2021). Sex-related differences in the incidence, severity, and recovery of concussion in adolescent athletes between 2005 and 2015. *The American Journal of Sports Medicine*, 49(7), 1520-1527.

Hansen, M., Kongsgaard, M., Holm, L., Skovgaard, O., Magnusson, S. P., Overgaard, K., ... & Qvortrup, K. (2005). Effect of estrogen on tendon collagen synthesis, tendon structural characteristics, and biomechanical properties in postmenopausal women. *Journal of Applied Physiology*, 105(4), 1385-1393.

Hewitt, T. E., Myer, G. D., & Font, K. R. (2004). Decrease in neuromuscular control about the knee with maturation in female athletes. *JBJS*, 86(9), 1801-1808.

Hodges, S., Doherty, C., Bohannon, C., & Oudizet, E. (2015). Sex differences in sagittal plane control emerge during adolescent growth: a prospective investigation. *Knee Surgery, Sports Traumatology, Arthroscopy*, 21(2), 419-426.

Hovels, I., & Ruge, D. (2022). Risk factors for accidental falls during pregnancy—a systematic literature review. *The Journal of Maternal-Fetal & Neonatal Medicine*, 35(25), 7015-7024.

Huamern, K. (2020). Boreas repays energy: a review of how disordered eating, excessive exercise, and high stress lead to menstrual irregularities. *Clinical Therapeutics*, 42(3), 401-407.

137

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137

References

Inani, A., Calamak, B., Hsin, Y., & Demirtas, F. (2014). Evaluation of postural equilibrium and fall risk during pregnancy. *Gait & posture*, 39(4), 1122-1125.

Jayanthi, N. A., & Dugas, L. R. (2017). The role of sports specialization in the adolescent female athlete. *Strength & Conditioning Journal*, 39(2), 29-36.

Kami, J., Hyman, K., & Fisher, M. (2022). Etiology and management of amenorrhea in adolescent and young adult women. *Current Problems in Pediatric and Adolescent Health Care*, 10714.

Liaw, L. J., Hsu, M. J., Liao, C. F., Liu, M. F., & Hsu, A. T. (2011). The relationships between inter-rect distance measured by ultrasound and abdominal muscle function in postpartum women: a 6-month follow-up study. *Journal of Electromyography and Kinesiology*, 21(2), 80-86.

Lodge, M. T., Ackerman, K. E., & Clapp, J. (2020). Knowledge of the Female Athlete Triad and Relative Energy Deficiency in Sport Among Female Cross-Country Athletes and Support Staff. *Journal of Athletic Training*, 57(16), 385-392.

Macdonald, L. A., Waters, T. R., Napolitano, P. G., Goddard, D. E., Ryan, M. A., Nelson, P., & Hubold, S. D. (2013). Clinical guidelines for occupational lifting in pregnancy: evidence summary and practical recommendations. *American journal of obstetrics and gynecology*, 208(2), 80-88.

Makins, M. L., Desroches, J., & Dornes, I. J. (2005). Changes in muscle mass and strength after menopause. *J Musculoskeletal Neuronal Interact*, 5(4), 186-207.

Matt, A. T., Gual, B., Linton, V., Zheng, A., & Pike, I. (2022). Prevention of non-contact anterior cruciate ligament injuries among youth female athletes: An umbrella review. *International Journal of Environmental Research and Public Health*, 19(8), 4648.

Matta, N., & Matta, V. N. (2011). Exercise beyond menopause. *Dis and Dis*. *Journal of mid-life health*, 2(2), 51.

Moran, J., Sandrock, G., Ramirez-Campiglo, R., Clark, C. C., Fernandez, J. P., & Drury, B. (2016). A meta-analysis of resistance training in female youth: its effect on muscular strength and anthropometry in the literature. *Sports Medicine*, 46(7), 1061-1071.

Morales, J., Forns, A., Dominguez-Balmeada, D., Gonzalez-de-Far, A., Sainza-Arenas, J., & Garcia-Pérez-de-Savall, G. (2022). The Influence of the Menstrual Cycle and Oral Contraceptives on Knee Lateral or Anterior Cruciate Ligament Injury Risk: A Systematic Review. *Applied Sciences*, 12(24), 12327.

138

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138

References

- Morton, S., Montminy, D., Valla, X., Chen, O., Langberg, H., & Mellissas, P. (2015). Equivalence of online and clinician administration of a postural landingposture risk factor and severity questionnaire. *Scandinavian journal of medicine & science in sports*, 25(5), 670-677.
- Niederquist, N. J., Dabab, S., Parniani, S. V., Zabala, M. K., & Bencke, J. (2020). Biomechanical and neuromuscular comparison of single- and multi-planar jump tests and a side-cutting maneuver: Implications for ACL injury risk assessment. *The Knee*, 27(2), 324-333.
- Nunes, P. R. P., Barreira, L. C., Oliveira, A. A., Furtado Junior, R., Martins, F. M., Ozaiti, C. L., & Ozaiti, F. L. (2016). Effect of resistance training on muscular strength and indicators of abdominal adiposity, metabolic risk, and inflammation in postmenopausal women: controlled and randomized clinical trial of efficacy of training volume. *Ages*, 36(2), 1-13.
- Olive, F., Picotri, E., Barak, A. C., Frizziero, A., Tarantino, U., & Mallal, N. (2016). Hormones and landingpostures: the current evidence. *British medical bulletin*, 117(1), 39-56.
- Oyuku, A. A., Al-Jumayli, M., & Kemp, J. C. (2023). Obesity and Menopause. *Best Practice & Research Clinical Obstetrics & Gynaecology*, 102348.
- O'Leary, K., McDonald, F., McInnes, S., & Peters, K. (2022). An exploration of women's knowledge and experience of perimenopause and menopause: An integrative literature review. *Journal of Clinical Nursing*.
- Papadopoulou, S. K., Papadimitiou, K., Vouglitoiu, G., Georgaki, E., Tsoukous, E., Zambou, O., & Papadopoulou, D. (2021). Exercise and nutrition impact on osteoporosis and Sarcopenia—the incidence of Osteosarcopenia. *A nutrition review*, 39(12), 449-459.
- Pang, K. L., Tricoli, R. P., Ballard, R. M., Carlson, S. A., Fatori, J. E., Galaska, D. A., ... & Olson, R. D. (2018). The physical activity guidelines for Americans. *Jama*, 320(19), 2020-2028.
- Quarman-Yates, C. C., Meyer, G. D., Ford, K. R., & Howell, T. E. (2013). A longitudinal evaluation of maturational effects on lower extremity strength in female adolescent athletes. *Pediatric physical therapy: the official publication of the Section on Pediatrics of the American Physical Therapy Association*, 25(3), 271.
- Rahke, J. R. (2020). Osteoporosis considerations during pregnancy. *Clinical obstetrics and gynecology*, 46(2), 456-466.
- Salehi, N., Oshamsi, H., Mohammadi, L., Ralaeeini, E., Shamsi, S., & Mohammadi, M. (2021). The global prevalence of osteoporosis in the world: a comprehensive systematic review and meta-analysis. *Journal of orthopaedic surgery and research*, 16(1), 1-20.

References

- Scarborough, D. M., Lindeman, S. E., Cohen, V. A., Berkson, E. M., Eckert, M. M., & Oh, L. S. (2018). Neuromuscular control of vertical jumps in female adolescents. *Sports Health*, 11(6), 343-349.
- Schauberg, C. W., Rowley, B. L., Goldsmith, K., Sherten, D., Saks, P. D., & Schugar, A. (1993). Peripheral joint laxity increases in pregnancy but does not correlate with serum relaxin levels. *American journal of obstetrics and gynecology*, 174(2), 667-671.
- Shargold, M. M., & Mink, G. (Eds.). (1994). (1994). *Women and exercise: Physiology and sports medicine*. Oxford University Press.
- Shaw, L., & Smith, C. F. (2017). Trauma in Pediatric and Adolescent Anterior Cruciate Ligament Injuries in Victoria, Australia 2005-2015. *International journal of environmental research and public health*, 14(8), 556.
- Shrestha, E. A., Dahi, R. E., & Pulkas, S. D. (2005). Pubertal development: correspondence between hormonal and physical development. *Child development*, 80(2), 327-337.
- Sivola, J., & Riihimäki, T. (2005). Muscle performance after the menopause. *British Menopause Society Journal*, 11(2), 45-50.
- Smith, M. W., Mercus, P. S., & Wurst, L. D. (2008). Orthopedic issues in pregnancy. *Obstetrical & gynecological survey*, 63(2), 103-111.
- Summerville, L. M., Herston, C. B., Villalobos, C. S., & Mastler, P. S. (2022). Relationship between strength, athletic performance, and movement skill in adolescent girls. *Journal of Strength and Conditioning Research*, 36(5), 674-679.
- Stojanovic, L., Apostolopoulou, V., Polman, R., & Borkoles, E. (2014). To exercise, or not to exercise, during menopause and beyond. *Maternal & Child Health*, 77(4), 318-323.
- Syed, N., Shayan, T., & Thoma, K. D. (2021). ACOG committee opinion no. 804: Physical activity and exercise during pregnancy and the postpartum period. *Obstetrics & Gynecology*, 137(2), 375-376.
- Thain-Nissardbaum, J. (2016). The postpartum triathlete. *Physical Therapy in Sport*, 21, 95-106.
- Williams, N. I., Kuban, K. J., Stock, N. C., & De Souza, M. J. (2018). Female athlete triad and relative energy deficiency in sport: A focus on scientific rigor. *Exercise and sport sciences review*, 47(4), 197-205.
- Zyha, A. (2013). Cervical tunnel syndrome in pregnancy: a review. *Finnish orthopaedics and neurology*, 78, 223-227.