STATE HIGHER EDUCATION UNIVERSITY
"UZHHOROD NATIONAL UNIVERSITY"
MEDICAL FACULTY №2
INTERNAL DISEASES

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Guidelines to practical lessons

OK 42 PHYSICAL REHABILITATION, SPORTS MEDICINE

EXERCISE PRESCRIPTION. ELECTROCARDIOGRAPHIC RESPONSES TO EXERCISE TESTING (2HOURS)

Topic 3

Module 1 “Sports Medicine”

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The guideline is composed according to medical students' educational qualification characteristics and professional training programs.

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Physical activity is defined as any body movement produced by skeletal muscle that increases energy expenditure. An activity can be measured in kilojoules or kilocalories. It includes activities performed at work, for transport, domestic duties and leisure time.

Exercise is a bodily movement via skeletal muscle results in energy expenditure (kilocalories). Is a planned, structured and repetitive bodily movement to improve or maintain physical fitness components.

Physical exercise is classified as aerobic (endurance), anaerobic, resistance, flexibility and neuromotor training.

Aerobic exercise (Spinning, Running, Swimming, Walking, Hiking, Aerobic classes, Dancing) – requires the presents of oxygen, primarily works type I muscle fibers, increases muscle endurance and capillary size, sustain for an extended period of time, heart rate between 120 and 150 BPM.

Anaerobic exercise (Heavy Weight-Lifting, Sprinting (running, biking), Jumping Rope, Interval Training, Isometric) – does not requires the presents of oxygen, works type II muscle fibers, which leads to greater size and strength of muscles, can't sustain for an extended period of time and can exercise till gas out, oxygen builds up, lactic acid builds up – as a result felling of burn.

The exercise prescription

An exercise prescription (also referred to as an activity prescription) should include clear written instructions about the frequency, intensity, type, and duration (time) of activities that they should engage in. The mnemonic "**FITT**" (Frequency, Intensity, Type, Time) is a useful aid for guiding clinicians when writing an exercise prescription.

Frequency. The American College of Sports Medicine (ACSM) recommends that aerobic exercise be performed 3–5 days per week for most individuals. All patients should be encouraged to engage in at least 30 min of moderate to vigorous physical activities on most and preferably all days of the week. Less conditioned people may benefit from lower intensity, shorter duration exercise performed at higher frequencies per day and/or per week.

Intensity. ACSM recommends that exercise intensity be prescribed within a range of 70–85% of HRmax, 50–85% of VO2max, or 60–80% of max METs, or HR reserve (HRR).

1. Owing to the variability in estimating HRmax from age, whenever possible use an actual HRmax from a graded exercise test.
2. Lower intensities (40–50% of VO2max) elicit a favorable response in individual with very low fitness levels.

Calculating intensity: Owing to limitations in using VO2 calculations for prescribing intensity, the most common methods of setting the intensity of exercise to improve or maintain cardiorespiratory fitness use HR and RPE

Heart rate methods: HR is used as a guide to set exercise intensity because of the relatively linear relationship between HR and percentage of VO2max (%VO2max).

It is best to measure HRmax during a progressive exercise test whenever possible since HRmax declines with age. HRmax can be estimated by using the

following equation: (HRmax = 220 – age). This estimation has significant variance with a standard deviation of 10–12 beats per minute (SD = 10 – 12 bpm)

HRmax method: One of the oldest methods of setting the target HR range uses a straight percentage of the HRmax. Using 70–85% of an individual's HRmax approximates 55–75% VO2max and provides the stimulus needed to improve or maintain cardiorespiratory fitness. Example: If HRmax = 180 bpm then target HR (70–85% HRmax) would range 126– 152 bpm.

Heart rate reserve method: The HR reserve (HRR) method is also known as the Karvonen method. Target HR range = [(HRmax − HRrest) × 0.50 and 0.85] + Rrest.

Type. The type of activity should be based on the individual's fitness level and interests. The best improvements in cardiorespiratory endurance occur when large muscle groups are engaged in rhythmic aerobic activity. Various activities can be incorporated into an exercise program to increase enjoyment and improve compliance. Appropriate activities include—walking (walking is the easiest activity on which to base an exercise prescription., jogging, cycling, rowing, stair climbing, aerobic dance (aerobics), water exercise, and cross-country skiing

Duration (Time). All individuals should strive to accumulate 30–60 min of physical activity on each and every day of the week. However, deconditioned individuals may benefit from multiple, short-duration exercise sessions <10 min with frequent interspersed rest periods.

FITT Principles Chart

Fitness and/or Health Benefit	Variables			
	F Frequency	I Intensity	T Time	T Type
Cardiovascular endurance (aerobic)	• 3 to 5 times per week	• moderate to vigorous intensity (60% to 85% of maximum heart rate)	• minimum of 20 minutes	• continuous motion of large muscle group[s]such as running, cycling, xc-cross skiing
Muscular strength	• alternate days 3 times per week	• high resistance (sets to maximum capability)	• 1 to 3 sets of 8 to 12 repetitions	• free weights • universal gym • tubing • body weight
Muscular endurance	• alternate days 3 times per week	• low to moderate resistance	• 3 sets of 10 to 20 repetitions	• free weights • universal gym • tubing • body weight
Flexibility	• daily	• slow and controlled movement	• 20 to 30 seconds	• static
Body composition	• 5 to 7 times per week	• combination of intensities	• dependent on intensity	• aerobic • anaerobic • resistance
Anaerobic	• alternate days 2 or 3 times per week	• 90% of maximum heart rate	• 2 to 3 minutes per "bout"	• sprinting • jumping
Active daily living/ health	• daily	• low to moderate intensity	• 30 to 60 minutes	• gardening • walking • bowling

References:
Manitoba Fitness Council. *Active Healthy People: Fitness Theory Manual.* Winnipeg, MB: Manitoba Fitness Council, n.d.
- - -. *Resistance Training Manual.* Winnipeg, MB: Manitoba Fitness Council, n.d.

General components of an exercise program

Once the exercise prescription has been formulated, it is integrated into a comprehensive physical conditioning program which consists of the following components:

1. **Warm-up phase** (10 min): Warm-up phase facilitates the transition from rest to exercise, stretches postural muscles, augments blood flow, and increases the metabolic rate from the resting level (1 MET) to the aerobic requirements for endurance training.

2. **Endurance phase** (20–60 min): Endurance phase develops cardiorespiratory fitness and includes 20 to 60 min of continuous or intermittent (minimum of 10-min bouts accumulated throughout the day) aerobic activity.

3. **Cool-down** (5–10 min): This phase provides a period of gradual recovery from the endurance phase and includes exercises of diminishing intensities. It permits appropriate circulatory adjustments and return of the HR and BP to near resting values

While endurance training activities should be performed 3 to 5 days a week, complementary flexibility and resistance training may be undertaken at a slightly reduced frequency of 2 to 3 days a week. Flexibility training can be included as part of the warm-up or cool-down, or undertaken at a separate time.

Stages of an exercise program.

1. **Initial conditioning.** The initial stage should include light muscular endurance exercises and moderate level aerobic activities (40–60% of HRR), exercises that are compatible with minimal muscle soreness, discomfort, and injury. The duration of the exercise session during the initial stage may begin with approximately 15 to 20 min and progress to 30 min. It is recommended that individuals who are starting a moderate-intensity conditioning program should exercise 3 to 4 times per week
2. **Improvement stage.** The goal of this stage of training is to provide a gradual increase in the overall exercise stimulus to allow for significant improvements in cardiorespiratory fitness. This stage typically lasts 4 to 5 months, during which intensity is progressively increased within the upper half of the target range of 50 to 85% of HR reserve. Duration is increased consistently every 2 to 3 weeks until participants are able to exercise at a moderate-to-vigorous intensity for 20 to 30 min continuously.
3. **Maintenance stage.** The goal of this stage of training is the long-term maintenance of cardiorespiratory fitness developed during the improvement stage. This stage of the exercise program usually begins after the first 5 or 6 months of training, but may begin at any time the participant has reached preestablished fitness goals. During this stage, the participant may no longer be interested in further increasing the conditioning stimulus. Further improvement may be minimal, but continuing the same workout routine enables individuals to maintain their fitness

Sign of overtraining

Overtraining refers to a condition usually induced after prolonged heavy exercise over an extended period of time. Symptoms of overtraining may include the following:

1. Sudden decline in quality of work or exercise performance
2. Extreme fatigue
3. Elevated HRrest
4. Early onset of blood lactate accumulation
5. Altered mood states
6. Unexplained weight loss
7. Insomnia
8. Injuries related to overuse

Overtraining may require weeks to months of complete rest in order to recover

Sign of detraining

The results of detraining can physiologically occur in a short amount of time two to three weeks post reduction in training stimulus

1. Loss of muscular strength
2. Muscular atrophy
3. Reduction in cardiorespiratory fitness and VO2 max
4. Reduction in flexibility

WHO Global recommendations on physical activity for health

Children and youth aged 5–17 should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily. Amounts of physical activity greater than 60 minutes provide additional health benefits. Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone, at least 3 times per week. For this age group, bone-loading activities can be performed as part of playing games, running, turning or jumping.

In adults aged 18–64, physical activity includes leisure time physical activity (for example: walking, dancing, gardening, hiking, swimming), transportation (e.g. walking or cycling), occupational (i.e. work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities. In order to improve cardiorespiratory and muscular fitness, bone health, reduce the risk of NCDs and depression.

Adults aged 18–64 should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. Aerobic activity should be performed in bouts of at least 10 minutes duration. For additional health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity. Muscle-strengthening activities should be done involving major muscle groups on 2 or more days a week.

In adults aged 65 years and above, physical activity includes leisure time physical activity (for example: walking, dancing, gardening, hiking, swimming), transportation (e.g. walking or cycling), occupational (if the individual is still

engaged in work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities.

Older adults should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. Aerobic activity should be performed in bouts of at least 10 minutes duration. For additional health benefits, older adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate-and vigorous-intensity activity.

Older adults, with poor mobility, should perform physical activity to enhance balance and prevent falls on 3 or more days per week.

Muscle-strengthening activities, involving major muscle groups, should be done on 2 or more days a week.

When older adults cannot do the recommended amounts of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow.

Examples of physical activities

Type of physical activity	Children	Adolescents
Moderate-Intensity aerobic	Hiking, bike riding, brisk walking	Baseball, yard walking, hiking, brisk walking.
Vigorous-Intensity aerobic	Bike riding, jumping rope, running, soccer, basketball	Jumping rope, bike riding, karate, basketball
Muscle-Strengthening	Modified push-ups, sit-ups, climbing.	Exercise with hand-held weights, push-ups, pull-ups, climbing.
Bone- Strengthening	Jumping rope, running, gymnastics, hopping, skipping	Jumping rope, running, sport like gymnastics, basketball

Types of sports:

1. Collision or Contact Sports (Football, ice and field hockey, soccer, wrestling, basketball, diving, lacrosse, rodeo, ski jumping, water polo, team handball)

2. Limited Contact Sports (Baseball cheerleading, diving, floor hockey, softball, gymnastics, high jump, pole vault, skiing, volleyball)

3. **Non-Contact and Strenuous Sports** (Running, rowing, sailing, swimming, tennis, weight lifting, shot put, discus, javelin)

4. Non-Contact and Moderately Strenuous sports (Curling, badminton, table tennis

5. Non-Contact and Non-Strenuous sports (Golf)

6. Dynamic Sports (Distance Running) - Muscle length changes with rhythmic contractions, Small intramuscular forces generated.

7. Static Sports (Weight lifting) - Large intramuscular forces generated and little change in muscle length

A. Low Static Sports (<20% of maximal voluntary contraction)

- Low Dynamic (<40% maximal Oxygen Consumption) – Golf, Billiards, Bowling, Cricket, Curling, Riflery

- Moderate Dynamic (40-70% maximal Oxygen Consumption) – Volleyball, Baseball, Softball, Doubles Tennis, Table Tennis, Fencing

- High Dynamic (>70% maximal Oxygen Consumption) - Distance Running (>3 Km), Soccer (European Football), Classic Cross-Country Skiing, Singles Tennis, Badminton, Field Hockey, Orienteering, Race Walking, Racquetball, Squash.

B. Moderate Static Sports (20-50% of maximal voluntary contraction)

- Low Dynamic (<40% maximal Oxygen Consumption) – Diving, Archery, Equestrian, Motor Cross or Motorcycling, Auto Racing,

- **Moderate Dynamic** (40-70% maximal Oxygen Consumption) – Rugby, American Football, Sprint Running (<800 meters), Jumping Field Events, Figure skating, Rodeo, Surfing, Synchronized swimming.

- **High Dynamic** (>70% maximal Oxygen Consumption) – Basketball, Skate Cross Country Skiing, Ice hockey, Lacrosse, Swimming, Middle Distance Running (800-3000 meters), Team handball.

C. High Static Sports (>50% of maximal voluntary contraction)

- Low Dynamic (<40% maximal Oxygen Consumption) - Weight lifting, Gymnastics, Martial arts (e.g. Karate), Throwing Field events, Bobsledding or luge, Sailing, Sport climbing, Water Skiing, Weight lifting, Wind Surfing

- **Moderate Dynamic** (40-70% maximal Oxygen Consumption) – Wrestling, Downhill Skiing, Snowboarding, Body building, Skate Boarding

- **High Dynamic** (>70% maximal Oxygen Consumption) – Boxing, Cycling, Rowing, Canoeing, Kayaking, Decathalon, Triathalon, Speed skating.

Light Activity – 3 METs, < 3.5 kcal/min – Walking at 2 mph, shopping, fishing, housework, ironing, knitting, mowing the lawn)

Moderate Activity – 3-6 METs, 3 .5 to 7 kcal/min – Walking at a moderate or brisk pace of 3 3 to 4.5 mph on a level surface inside or outside, bicycling 5-9 mph, level terrain, few hills, softball, recreational swimming, yoga)

Vigorous Activity - >6 METs, >7 kcal/min – Race walking and aerobic walking – 5 mph or faster, jogging or running, bicycling more than 10 mph, or bicycling on a steep uphill terrain, football game, basketball, tennis, swimming laps

Expected ECG changes in the normal heart

The goal of ECG interpretation in athletes is to classify the ECG as: 'normal'—no further evaluation needed or 'abnormal'—further evaluation needed.

The altered action potential duration, conduction velocity, and contractile velocity associated with the increase in heart rate during exercise results in a number of ECG changes in normal people, including the following:

1. P-wave amplitude and morphology undergo minor changes
2. RR interval decreases
3. The PR segment shortens and slopes downward in the inferior leads.
3. Septal Q-wave amplitude increases

4. R-wave height increases from rest to submaximal exercise and then reduces to a minimum at maximal exercise

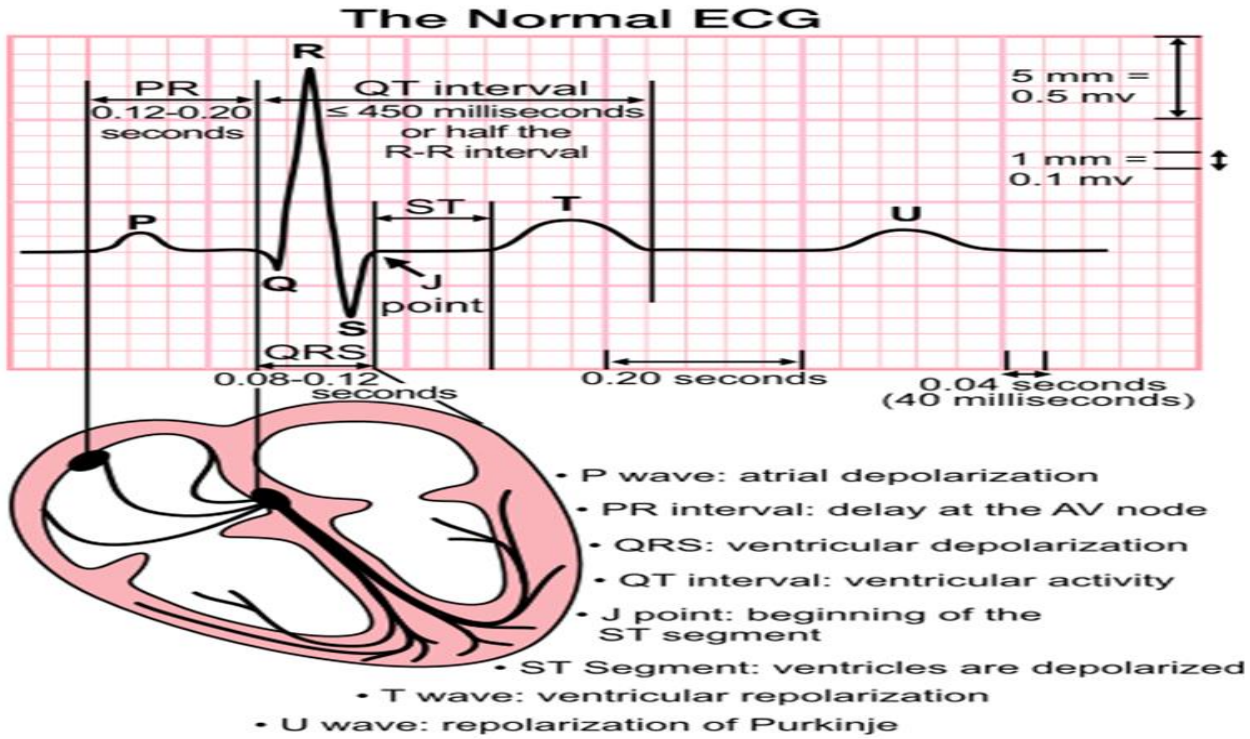
5. The QRS complex may show increased Q wave negativity and a decrease in R wave amplitude with an increased S wave depth.

6. J-point depression occurs (The J point is the junction between the termination of the QRS complex and the beginning of the ST segment. The J (junction) point marks the end of the QRS complex, and is often situated above the baseline, particularly in healthy young males.

7. Tall, peaked T waves occur (high interindividual variability)

8. ST segment becomes upsloping that returns to baseline within 60–80 m.

9. QT interval experiences a rate-related shortening



Abnormal responses with exercises

1. ST segment depression: This is the hallmark of ischemia and a positive treadmill.
2. ST segment normalization: ST segments that are depressed and return to normal (pseudonormalization) are suggestive of ischemia.
3. ST segment elevation: In patients without a prior history of MI, consider acute MI (if accompanied by chest pain), or serious transmural ischemia. ST elevation over Q waves in patients with a previous history of an MI suggests areas of dyskinesis or ventricular aneurysm.
4. U wave inversion: U wave inversion during exercise is suggestive of ischemia.

Final determination for myocardial ischemia

Positive

1. Horizontal or downsloping ST segment depression that is ≥1mm at 60 ms past the J point

2. Horizontal or upsloping ST segment elevation that is ≥1mm at 60 ms past the J point

3. Upsloping ST depression that is ≥1.5 mm depressed at 80 ms past the J point

Suggestive

1. Horizontal or downsloping ST segment depression between 0.5 mm and 1 mm at 60 s past the J point

2. ST elevation b/w 0.5–1.0 mm 3. Upsloping ST segment depression that is greater than 0.7 mm but less than 1.5 mm at 80 ms past J point

4. Exercise-induced hypotension

5. Chest pain occurring with exercise typical of angina

6. Frequent, high grade, ventricular ectopy

7. A new third heart sound or murmur at peak exercise

8. Abnormal 1-min HRR or 3-min systolic BP response

9. ST-segment depression in recovery only

10. Normalization of abnormal ST-segments/T-wave inversion

Negative

1. Above criteria not met and the patient exercised to at least 85% of predicted HRmax

Inconclusive

1. The patient does not reach 85% of maximum predicted HR and there is no evidence of ischemia based on the above criteria. (Be sure the patient is not on B-Blockers or has chronotropic incompetence.)

Abnormal ECG finding	**Definition**
T wave inversion	>1 mm in depth from baseline in two or more adjacent leads not including aVR or V1 (figure 1)
ST segment depression	≥1 mm in depth in two or more adjacent leads
Pathological Q waves	>3 mm in depth or >0.04 s in duration in two or more leads
Complete left bundle branch block	QRS >0.12 s, predominantly negative QRS complex in lead V_1 (QS or rS), and upright monophasic R wave in leads I and V_6 (figure 2)
Complete right bundle branch block	QRS >0.12 s, terminal R wave in lead V_1 (rsR′), and wide terminal S wave in leads I and V_6 (figure 3)
Intraventricular conduction delay	Non-specific, QRS >0.12 s
Left atrial enlargement	Prolonged P wave duration of >0.12 s in leads I or II with negative portion of the P wave ≥1 mm in depth and ≥0.04 s in duration in lead V_1
Left axis deviation	−30° to −90°
Right atrial enlargement	High/pointed P wave ≥2.5 mm in leads II and III or V_1
Right ventricular	Right axis deviation ≥120°, tall R wave in

hypertrophy	V1+persistent precordial S waves (R-V_1+S−V_5>10.5 mm)
Mobitz type II 2° AV block	Intermittently non-conducted P waves not preceded by PR prolongation and not followed by PR shortening
3° AV block	Complete heart block
Ventricular pre-excitation	PR interval <0.12 s with a delta wave (slurred upstroke in the QRS complex—figure 4)
Long QT interval	QTc ≥0.47 s (99% males) QTc ≥0.48 s (99% females) QTc ≥0.50 s (unequivocal LQTS; figure 5)
Short QT interval	QTc ≤0.34 s
Brugada-like ECG pattern	High take-off and downsloping ST segment elevation in V_1−V_3 (figure 6)
Epsilon wave	Small negative deflection just beyond the QRS in V_1 or V_2 (figure 7)
Profound sinus bradycardia	<30 BPM or sinus pauses ≥3 s
Atrial tachyarrhythmias	Supraventricular tachycardia, atrioventricular nodal reentrant tachycardia, atrial-fibrillation and atrial-flutter
Premature ventricular contractions	≥2 per tracing
Ventricular arrhythmias	Couplets, triplets and non-sustained ventricular tachycardia

Dangerous rhythms that indicate the need to stop exercise immediately during stress testing include ventricular fibrillation (VF), sustained ventricular tachycardia (VT), and ST-segment elevation (≥1 mm) in leads without diagnostic Q waves (other than V1 or aVR). Relative ECG stop test indicators include ST or QRS changes such as excessive ST-segment depression (>2 mm of horizontal or downsloping ST-segment depression) or marked axis shift; arrhythmias other than VT including multifocal PVCs, triplets, supraventricular tachycardia (SVT), heart block, and bradyarrhythmias; and the development of bundle branch block.

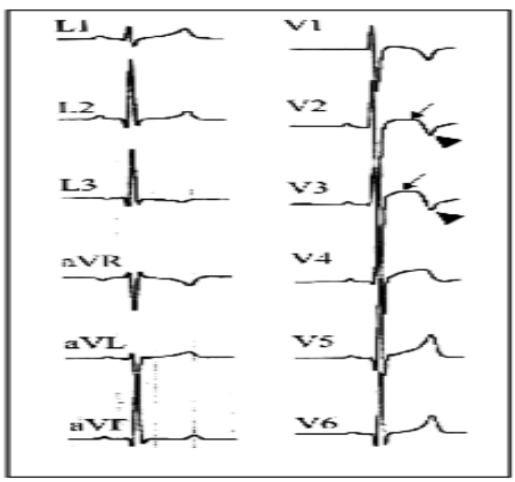


Figure 1
Normal variant of T wave inversion in athletes of African-Caribbean descent.

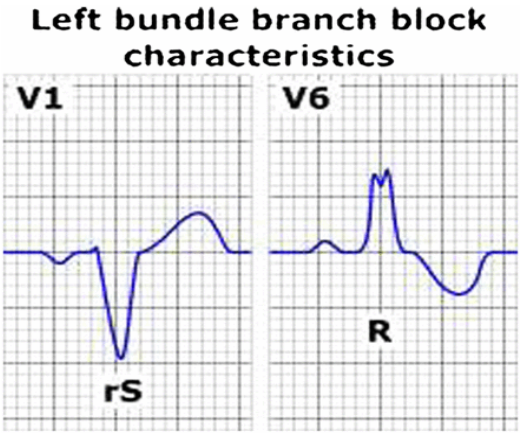


Figure 2

Left bundle branch block: QRS >0.12 s, predominantly negative QRS complex in lead V1 (QS or rS), and upright monophasic R wave in leads I and V6.

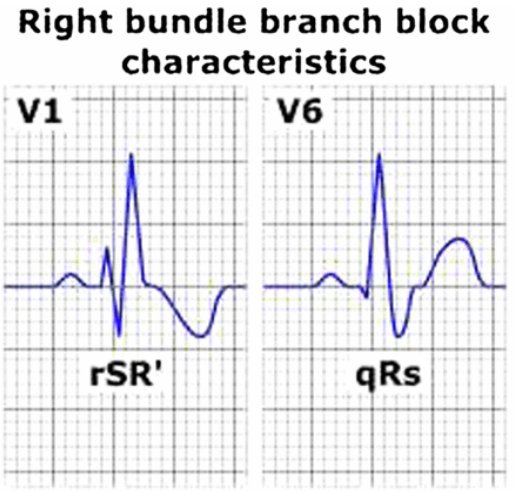


Figure 3

Right bundle branch block: QRS >0.12 s, terminal R wave in lead V1 (rsR′), and wide terminal S wave in leads I and V6.

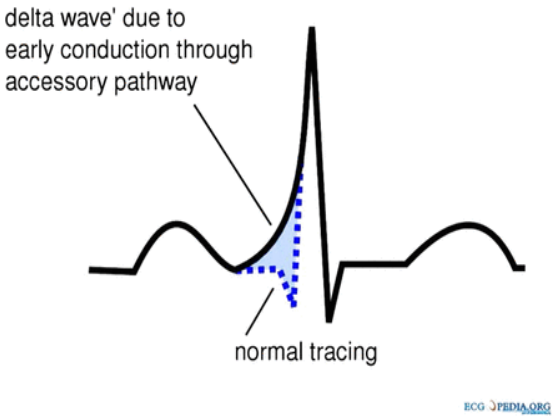


Figure 4

Delta wave: suggestive of ventricular pre-excitation; PR interval <0.12 s with or without a delta wave (slurred upstroke in the QRS complex).

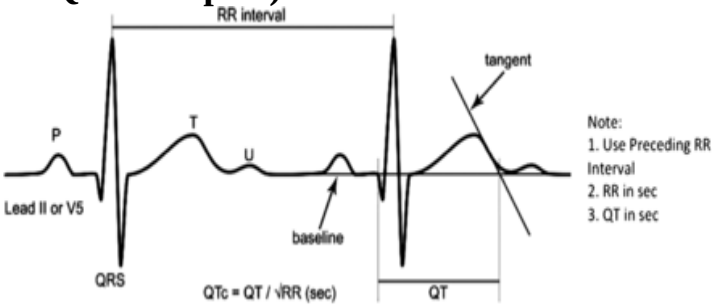


Figure 5

QTc interval: LONG QT: QTc ≥0.47 s (99% males) or QTc ≥0.48 s (99% females). (QTc ≥0.50 s (unequivocal LQTS)).

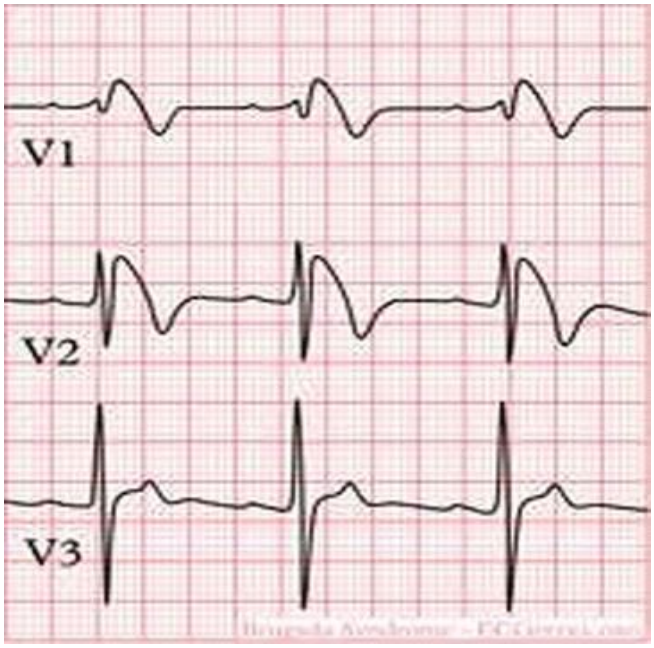
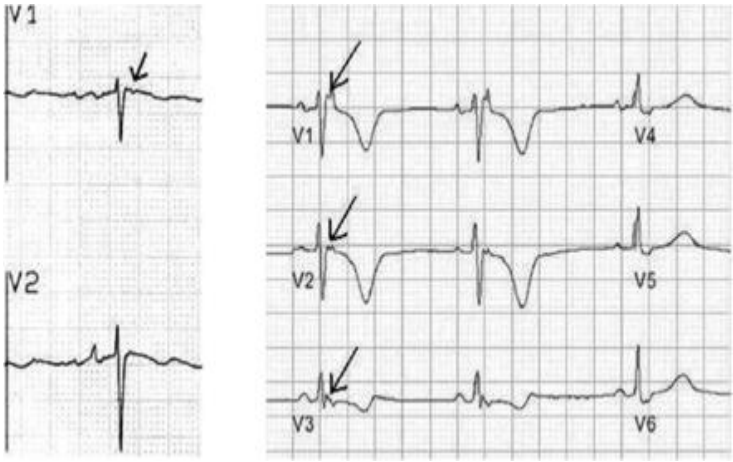


Figure 6

Brugada ECG: high take-off and downsloping ST segment elevation in $V_1 – V_3$.

Figure 7

Epsilon wave: small negative deflection just beyond the QRS in V_1 or V_2.



Athletic Heart Syndrome - normal reversible adaptations of heart to Exercise

Signs:

A. Increased Left Ventricular wall thickness by 15-20%
B. Increased Left Ventricular End Diastolic Volume by 10%
C. Resting Heart Rate: 40-60 bpm
D. Irregular pulse
E. Increased Pulse Pressure
F. S3 Gallup at Apex (S4 Gallup should raise red flag)
G. Physiologic split S2

Radiology:

A. Chest X-Ray
1. May show globular cardiomegaly
2. Increased pulmonary vasculature
B. Echocardiogram: Left Ventricular Dilatation (dynamic)
1. Left Ventricular wall thickening (static)
2. Normal Systolic and Diastolic function

Diagnostics: Electrocardiogram:

A. Electrocardiogram changes resolve when exercising
B. Sinus Bradycardia with or without arrhythmia

C. Atrioventricular conduction delays (First degree block, Mobitz I, Mobitz II)
D. Increased QRS Complex height (Left Ventricular Hypertrophy criteria, Right Ventricular Hypertrophy criteria)
E. Wide QRS Complex (incomplete Right Bundle Branch Block)
F. Repolarization changes (ST segment elevation, Flipped T Waves)
G. Increased false positive stress tests

LIST OF QUESTIONS:

1. Physical activity and exercise
2. The exercise prescription
3. General components of an exercise program
4. FITT principles chart
5. Stages of an exercise program.
6. Sign of overtraining
7. WHO Global recommendations on physical activity for health (Children and youth aged 5–17)
8. WHO Global recommendations on physical activity for health (In adults aged 18–64)
9. WHO Global recommendations on physical activity for health (In adults aged 65 years and above)
10. Types of sports
11. Expected ECG changes in the normal heart
12. Abnormal responses with exercises
13. Final determination for myocardial ischemia
14. Dangerous rhythms
15. Athletic Heart Syndrome
16. Electrocardiogram of Athletic Heart Syndrome

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