RESISTANCE EXERCISE & TRAINING: SEX AND GENDER DIFFERENCES

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❖ **Physical activity** refers to body movement that is produced by the contraction of skeletal muscles and that increases energy expenditure.

❖ **Exercise** refers to planned, structured, and repetitive movement to improve or maintain one or more components of physical fitness.

❖ **Physical fitness** is the ability to perform regular moderate to vigorous levels of physical activity without excessive fatigue.
Aerobic exercise training (AET) refers to exercises in which the body’s large muscles move in a rhythmic manner for sustained periods.

Resistance exercise training (RET) is exercise that causes muscles to work or hold against an applied force or weight.
- **Sex** refers to the biological and physiological characteristics that define men and women.

- **Gender** refers to the socially constructed roles, behaviors, activities, and attributes that a given society considers appropriate for men and women.
Sexual Dimorphism is the phenotypic differences in appearance between males and females of the same species, such as in color, shape, size, and structure, that are caused by the inheritance of one or the other sexual pattern in the genetic material (genotype).
Different does not mean better or worse...
It just means different
Differences

❖ Physiological Differences

❖ Responses to RE, RT

❖ Training Considerations
Manipulation of Resistance Exercise Programme Variables Determines the Responses of Cellular and Molecular Signalling Pathway.


1.1 Muscle Activation
During RE, \( \alpha \)-motorneurons activate muscle fibres to produce force. The neuromuscular interaction determines which muscle fibres are activated and the amount of force exerted. Specifically, two variables regulate the force of muscle contraction: neural firing frequency and number of motor units recruited. Henneman's size principle describes the latter method, dictating that neural recruitment of muscle tissue begins with the smallest motor units (primarily type I) and progresses to larger motor units (primarily type II) until force production matches force requirements.

The size principle is a critical and often under-appreciated feature of motor unit recruitment. Practically, the size principle ensures that low-force activities recruit primarily type I, fatigue-resistant motor units. As the force requirements of the activity increase (e.g. by increasing the load for a given RE), additional, progressively higher-threshold motor units are recruited. RE that utilize very heavy, near-maximal loads activate the entire spectrum of motor units.

Although the size principle appropriately describes the relationship between exercise load and muscle activation, two important caveats exist: the influence of performing exercises 'explosively' (e.g. Olympic weight-lifting), and the influence of muscle fatigue/failure. Rapidly accelerating the load increases muscle force production (as force = mass \( \times \) acceleration) and therefore, as predicted by the size principle, recruits high-threshold motor units.

Performing explosive concentric muscle actions using a light load (~40% of maximal isometric force) increases electromyographic (EMG) activity when compared with performing the same exercise with a heavier load (~67% of maximal isometric force) at a slower velocity.

Muscle action
Loading and volume
Ex selection and order

Rest periods
Repetition velocity
Frequency

Overload
Progression
Adaptation

Specific training outcome
Muscular endurance
Hypertrophy
Maximal strength
Power

Key training principles
Specificity
Individualisation
Maintenance

Proper programme design

Acute programme variables

Resistance exercise prescription

Figure 1. Proper programme design of resistance exercise for specific training outcomes incorporates the acute programme variables and key training principles.

2.1 Muscle Action

Most resistance training programmes include dynamic repetitions of concentric (CON) and eccentric (ECC) muscle actions, with isometric muscle actions suggested to play a secondary stabilising role.

2.2 Loading and Volume

Alterations of training load and volume have been shown to affect hormonal, neural and muscular responses and changes in muscle have been greatest when both hypertrophic responses and subsequent adaptations to resistance training. Tan suggests that the interplay between load and volume is the critical factor in determining the optimal range of training load and volume.

Collectively, these data suggest that training should involve both CON and ECC muscle actions.
Sex Differences

- Body size & composition
- Muscle Fibers
- Number of Muscle Fibers
- Skeletal
- Hormones
- Neural
Body Composition

- Fat Mass
  - Essential
  - Non Essential
- Fat Free Mass
  - Bone
  - Muscle
  - Connective
- Water
- Organs
- Teeth
Body Size & Composition

- Before puberty
- Puberty
  - Estrogen
  - Testosterone
- Adult women and men
  - Body fat
  - Muscle

![Graph showing changes in fat-free mass, fat mass, and percent fat over age](image)

**Figure 16.3** Changes in percent fat, fat mass, and fat-free mass for females and males from birth to 20 years of age.

Body Size & Composition

- Before puberty
- Puberty
  - Estrogen
  - Testosterone
- Adult women and men
  - Body fat
  - Muscle

R.M. Malina and O. bar-Or. Growth, Maturation, and physical activity. 2nd ed. Champaign, IL: Human Kinetics. 2004
Skeletal muscle (SM) mass and distribution in men and women.


Muscle Mass

Skeletal muscle (SM) mass and distribution in men and women.

Men

Women

Upper Body

Lower Body

Muscle Mass (kg)

40
35
30
25
20
15
10
5
0

42.9%
54.9%

39.7%
57.7%
Muscle Fibers

- **Type I** (Women > Men)
- **Type II** (Women < Men)

Muscle Cross Sectional Area (Women < Men)

- **Number of Muscle Fibers** (Women ≈ Men)
- **Non-Contractile Proteins** (Women ≈ Men)
Hormones

- Testosterone

![Graph showing serum testosterone levels before and after workout. The graph compares female and male responses, with significant increases marked by an asterisk.](image-url)
**Growth Hormone**

- **Pituitary gland**
- **Growth hormone (GH)**
  - GHRH (GH-releasing hormone) stimulates the release of GH.
  - GHIN (GH-inhibiting hormone) inhibits the release of GH.
- **Muscle growth**
- **Bone growth**
- **Adipocytes break down triglycerides.**
- **The liver breaks down glycogen.**
- **Insulin-like growth factors (IGFs) stimulate amino acid uptake by target cells, promoting protein synthesis.**
Growth Hormone

![Bar chart showing changes in serum human growth hormone levels before, during, and after workout in females and males.](image)
Absolute Strength - the maximal amount of strength or force generated in a movement or exercise

Average Women vs. Average Men
- Whole body: ~60-64%
- Upper: ~55%
- Lower: ~72%

Fig. 6 Maximum hand-grip forces ($F_{\text{max}}$) of young adult men ($M$, $n = 1,654$), women ($W$, $n = 533$) and female elite athletes ($FA$, $n = 60$). Values are median ± interquartile (25th and 75th percentile) and absolute range
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Men’s and Women's World Weightlifting Records as of 2006, Total Weight Lifted

International Weightlifting Federation, Aug. 2006
Absolute Power

**Figure 2** — Absolute power output values for male (1978) and female (1987) athletes during the total pulling phase of clean lifts.

Figure 1 — Absolute power output values for male (1978) and female (1987) athletes during the total pulling phase of snatch lifts.

Relative Power

Figure. Displays the percentage increase in strength in the male training (MT) group (n = 20; black) and female training (FT) group (n = 20; gray) from baseline to week 8 (A) and from baseline to week 12 (B). The FT group made significantly (p ≤ 0.05) difference in percentage change in strength between the MT and FT groups from baseline to week 8 (A) and baseline to week 12 (B).

Task failure for sustained and intermittent contractions

- RE & RT


Bar graph showing mean (±SE) time to task failure for sustained and intermittent contractions performed by strength-matched men and women with the elbow flexor muscles at 20% and 50% of MVC torque, respectively.
Hypertrophy
• Genetic disposition to developing large muscle mass
• Greater hormonal response than normal to RT
• Ability to perform more intense or higher volume RT
• Higher than normal resting testosterone, growth hormone, or other hormone concentrations
• Lower than normal estrogen-to-testosterone ratio
The Female Athlete Triad

- **Hormones**
  - Menstrual cycle phase effects on training
    - Performance during the menstrual cycle and menstrual problems
  - Possible alterations to the menstrual cycle from RT
    - Oligomenorrhea
    - Secondary Amenorrhea
    - Premenstrual Symptoms
    - Dysmenorrhea
1 Bone mass changes throughout the life cycle

- **Growth phase**: optimise peak bone mass
- **Peak bone mass phase**: prevent premature bone loss
- **Increased fracture risk phase**: prevent and treat osteoporosis and reduce falls risk

Bone mass changes over age (years) for men and women.
Knee Injuries

- 4 to 6 times more likely
  - Sports where cutting is needed

- 4 major hypothesis
  - Anatomical
    - Q-angle
    - Femoral notch width
  - Neuromuscular
  - Hormonal
  - Multifactorial
- Body size differences
- Body composition differences
- Strength differences
- Power differences
- Hormonal Differences
- Skeletal differences
- Neural differences
• Total mass: Women < Men
• Fat free mass: Women < Men
• Larger muscle fibers: Women < Men
• Muscle cross sectional area: Women < Men
• Anabolic hormones: Women < Men
• Number of muscle fibers: Women = Men
• Non contractile proteins: Women = Men
• Both sexes can be train the same with RE
• Both sexes benefit greatly from RE
• Some special considerations