PHYSICAL ERGONOMICS

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MUSCULAR EFFORT AND WORK PHYSIOLOGY

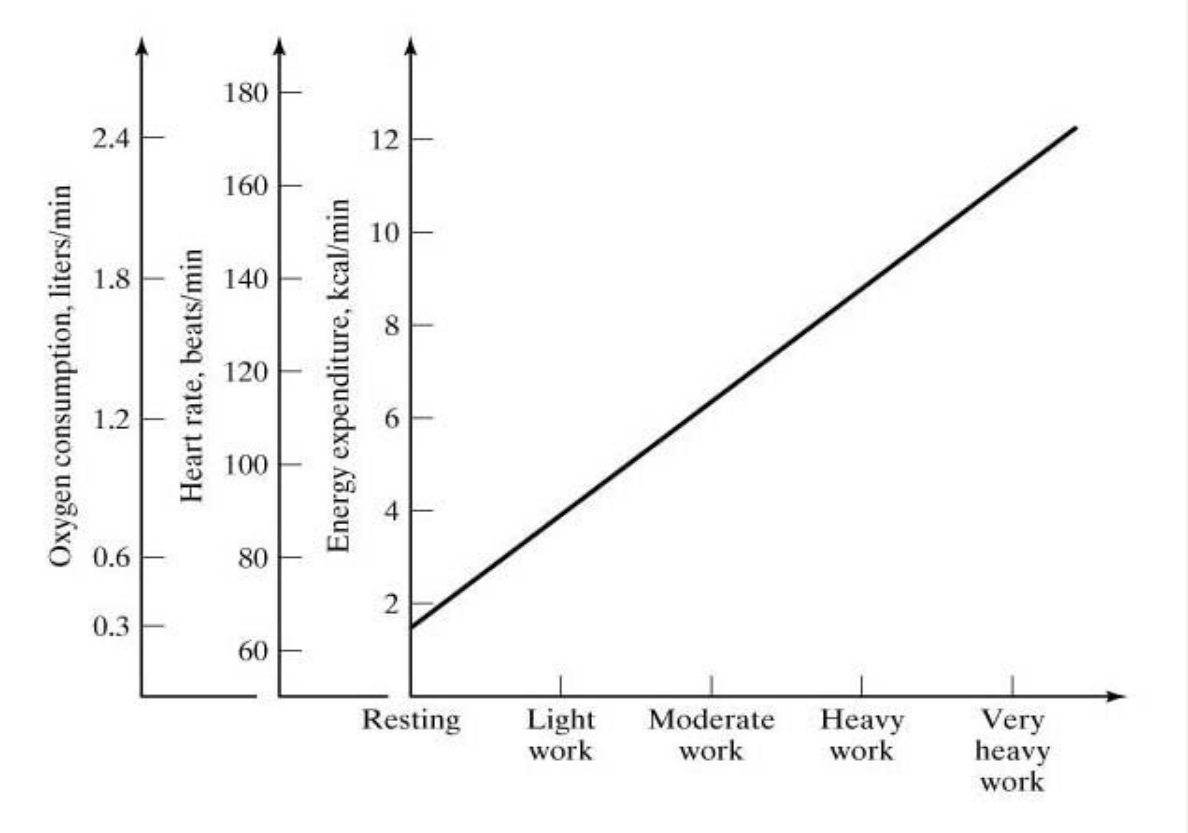
- Capacity of human body to use energy and apply forces depends on :
  1. Capacity of cardiovascular and respiratory systems to deliver required fuel and oxygen to muscles and carry away waste products
  2. Muscle strength and endurance
  3. Ability to maintain proper heat balance within the body

CARDIOVASCULAR/RESPIRATORY CAPACITY AND ENERGY EXPENDITURE

- Oxygen consumption and heart rate are proportional to energy expenditure in physical activity
  - 4.8 kcal of energy expenditure requires an average of one liter of O_2
- As physical activity becomes more strenuous, energy expenditure increases, and so does oxygen consumption and heart rate
  - $ER_m = BMR_m + AMR_m$
  - Where ER_m *is the energy expenditure rate of the acitvity (Kcal/min)*
  - BMR_m *and* AMR_m *is the sum of basal and activity metabolic rates (kcal/min)*

Work Activity and Energy Expenditure

Energy expenditure, heart rate, and oxygen consumption for several categories of work activity



Work Systems and the Methods, Measurement, and Management of Work
by Mikell P. Groover, ISBN 0-13-140650-7.

ENERGY EXPENDITURE RATES

Physical activities	Energy Expenditure rates (ER_m)
• Sleeping	BMR_m
• Standing (not walking)	2.2 kcal/min
• Walking at 4.5 km/hr	4 kcal/min
• Jogging at 7.2 km/hr	7.5 kcal/min
• Soldering work (seated)	2.7 kcal/min
• Mowing lawn (push mower)	8.3 kcal/min
• Chopping wood	8 kcal/min
• Shoveling in front of furnace	10 kcal/min

Energy expenditure rates are assumed to be for a person who weighs 72 kg (160 lb). If a person weight differs from 72 kg (160 lb), then an adjustment should be made by multiplying the ER value in the table by the ratio W/72, if the Weight is given in kg (or W/160 of weight is given in lb), W is weight of the person.

EXAMPLE: TOTAL DAILY METABOLIC RATE

- 35-year old woman
  - Sleeps 8 hours
  - Walks to and from work for 1 hour at 4.5 km/hr
  - Stands for 2 hours
  - Performs soldering work for 6 hours while seated
  - Watches TV and rests for 7 hr
- Determine her total metabolic rate for 24-hour period

TOTAL METABOLIC RATE – TMR

Activity	Time	ER	Weight factor	Total energy
Sleeping	480 min	0.86 kcal/min	(no correction)	413 kcal
Walking	60 min	4.0 kcal/min	130/160 = 0.81	194 kcal
Standing	120 min	2.2 kcal/min	130/160 = 0.81	214 kcal
Soldering work	360 min	2.7 kcal/min	130/160 = 0.81	787 kcal
Other activities	420 min	1.5 kcal/min	130/160 = 0.81	510 kcal
	1440 min		$BMR_d + AMR_d$=	2,118 kcal
Digestive metabolism			$0.10(BMR_d + AMR_d)$ =	212 kcal
			TMR_d =	2,330 kcal

OXYGEN DEBT

Difference between amount of oxygen needed by muscles during physical activity and amount of oxygen supplied

- Occurs at start of physical activity after body has been at rest
- There is a time lag before the body can respond to increased need for oxygen
- Glycolysis is anaerobic during this time lag
- Oxygen debt must be repaid, so when activity stops, breathing and heart rate continue at high levels

RECOMMENDED ENERGY EXPENDITURE

Physiological measure	Male worker	Female worker
Energy expenditure rate of the physical activity (maximum time-weighted average during shift) $\overline{ER}_m$	5.0 kcal/min	4.0 kcal/min
Energy expenditure of the physical activity for the entire 8 hr shift ER_{8h}	2400 kcal	1920 kcal
Heart rate (maximum time-weighted average during shift) $\overline{HR}_m$	120 beats/min	110 beats/min

REST PERIODS

- Common in industry
  - Paid for by the employer as regular work time
  - Rest breaks usually included in allowance factor built into the time standard
  - Relatively short duration - 5 to 20 minutes
  - Meal periods - not included

$$T_{rst} = T_{wrk} (ER_{wrk} – ER) / (ER- ER_{rst})$$

Trst = rest time
T_{wrk} = working time
ER_{wrk} = energy expenditure rate associated with the physical activity
ER = Average acceptable energy expenditure rate

NUMERICAL

- Determine the appropriate rest period for a given work time.

A male worker performs physical labor that has an energy expenditure rate of 8.2 Kcal/min. for 20 min. How long a rest break should a worker be allowed at the end of this work period

Recommended average energy expenditure rate is 5 kcal/min.

Appropriate duration of rest break is determined as follows:

Trst = 20 (8.2 – 5.0) / (5.0-1.5) = 18.29 min.

THANK YOU

PLEASE READ PHYSIOLOGY FROM RECOMMENDED REFERENCE BOOKS FOR A BETTER UNDERSTANDING OF NEXT LECTURE