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Research Paper

Physical Education

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Scientific Aspects of Lever

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ABSTRACT

The lever is a movable bar that pivots on a fulcrum attached to a fixed point. The lever operates by applying forces at different distances from the fulcrum, or a pivot. For your arm, leg or any body part to move the appropriate muscles and bones must work together as a series of levers. A lever amplifies an input force to provide a greater output force, which is said to provide leverage. The ratio of the output force to the input force is the mechanical advantage of the lever. Anatomical leverage system can be used to gain a mechanical advantage. Improve simple or complex physical movements. Some habitually use human levers properly. Some develop habits of improperly using human levers. The mechanical advantage of a lever can be determined by considering the balance of moments or torque. Torque is the turning effect of an eccentric force. Eccentric force is the force applied in a direction not in line with the center of rotation of an object with a fixed axis. In objects without a fixed axis it is an applied force that is not in line with object's center of gravity. For rotation to occur an eccentric force must be applied. Class 1 lever built for equilibrium, class 2 lever for saving effort and class 3 lever for speed and range of movement.

Introduction

Sports Biomechanics analyzing human movement patters provides a genuinely accessible and comprehensive guide to all of the bio mechanics topics covered in an undergraduate sports and exercise science degree.

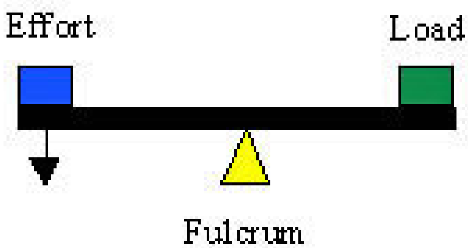
Types of machines found in the body: Musculoskeletal system arrangement provides for 3 types of machines in producing movement.

Levers

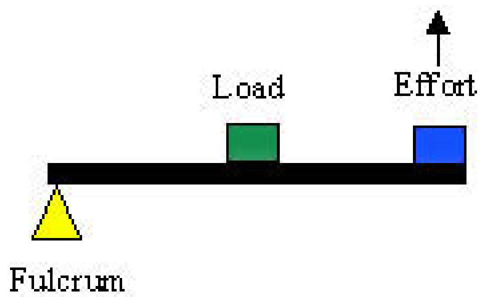
Humans moves through a system of levers.Levers cannot be changed, but they can be utilized more efficiently. lever is a rigid bar that turns about an axis of rotation or a fulcrum. Axis is a point of rotation about which lever moves.Levers rotate about an axis as a result of *force* (effort, *E)* being applied to cause its movement against a *resistance* or weight.In the body Bones represent the bars, Joints are the axes and Muscles contract to apply force.For your arm, leg or any body part to move the appropriate muscles and bones must work together as a series of levers. A lever comprises of three components –

Levers

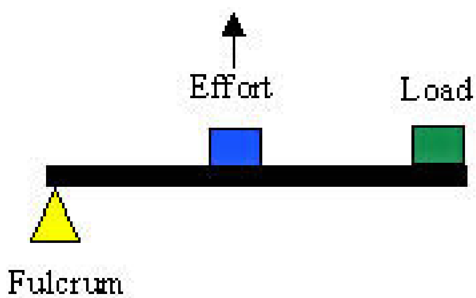
1st class lever – axis *(A)* between force *(F)* & resistance *(R)*
2nd class lever – resistance *(R)* between axis *(A)* & force *(F)*
3rd class lever – force *(F)* between axis *(A)* & resistance*(R)*
Three points determine type of lever & for which kind of motion it is best suited
Axis *(A)* fulcrum or pivot- the point of rotation
Point *(F)load* of force application (usually muscle insertion)
Effort-Point *(R)* of resistance application (center of gravity of lever) or (location of an external resistance) or the force applied by the lever system



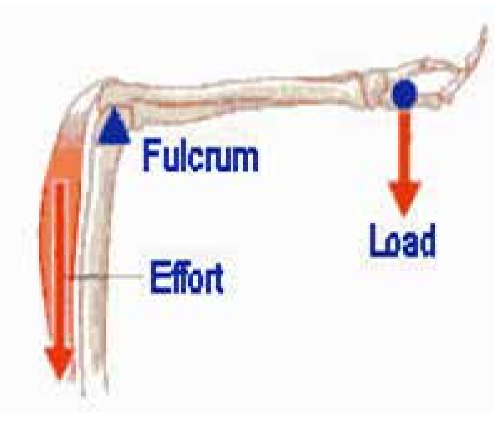
Class 1 Lever



Class 2 Lever



Class 3 Lever



Class 1 Lever in the Body

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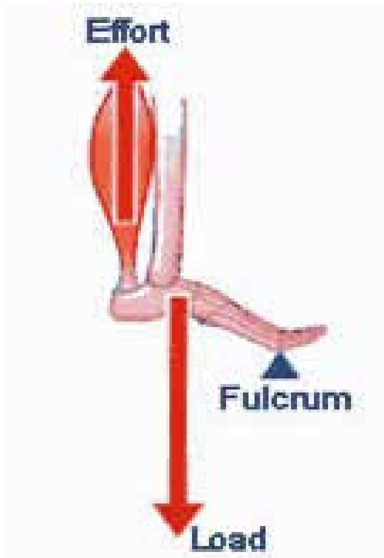
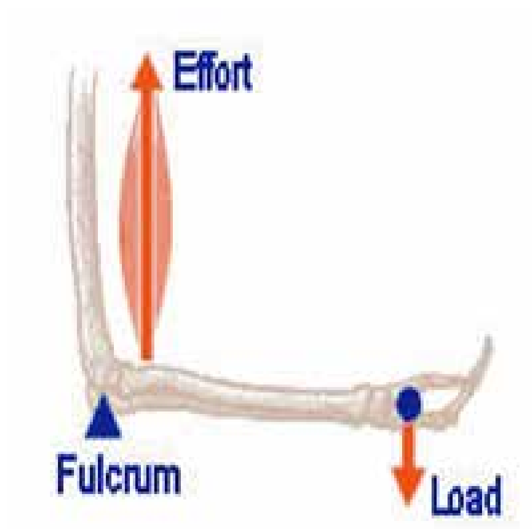


Class 2 Lever in the Body



Class 3 Lever in the Body

The mechanical advantage of levers may be determined using the following equations

$$\text{Mechanical advantage} = \frac{\text{Resistance}}{\text{Force}}$$

Or

$$\text{Mechanical advent age} = \frac{\text{Length of force arm}}{\text{Length of resistance arm}}$$

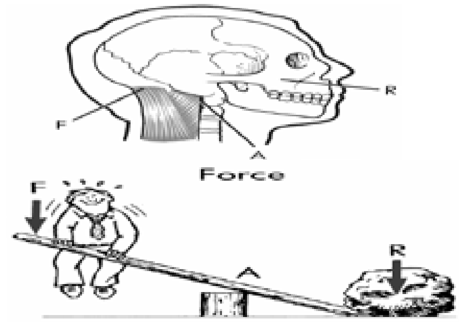
First-class Lever

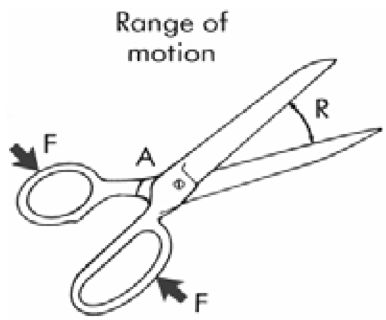
Produce balanced movements when axis is midway between force & resistance (e.g., seesaw).

Produce speed & range of motion when axis is close to force, (triceps in elbow extension).

Produce force motion when axis is close to resistance (crowbar).

Seated dumbbell.



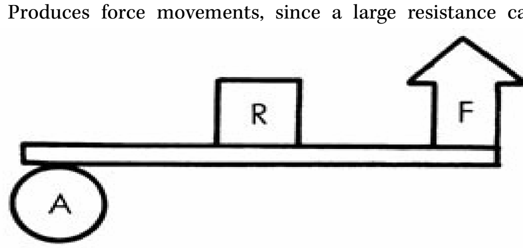


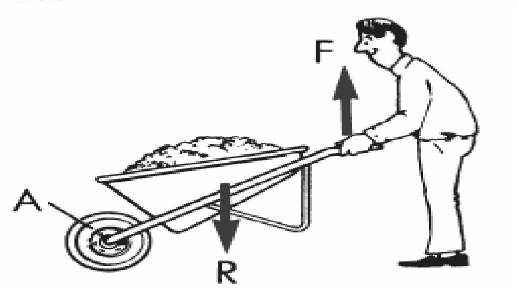
Head balanced on neck in flexing/extending.Agonist & antagonist muscle groups are contracting simultaneously on either side of a joint axis.Agonist produces force while antagonist supplies resistance.Elbow extension in triceps applying force to olecranon *(F)* in extending the non-supported forearm *(R)* at the elbow *(A)*.

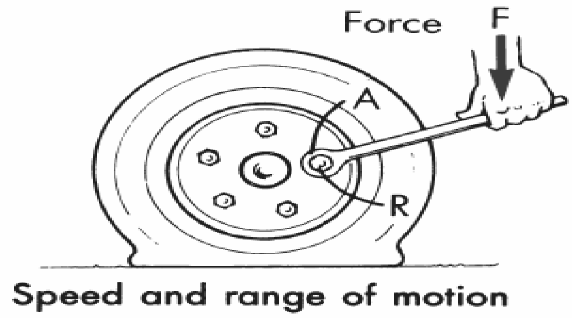
Force is applied where muscle inserts in bone, not in belly of muscle Ex. in elbow extension with shoulder fully flexed & arm beside the ear, the triceps applies force to the olecranon of ulna behind the axis of elbow joint.As the applied force exceeds the amount of forearm resistance, the elbow extends.

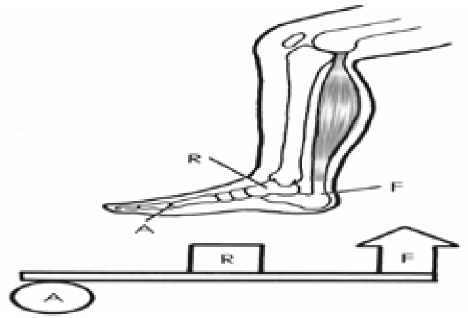
Second-class Levers

Produces force movements, since a large resistance can be









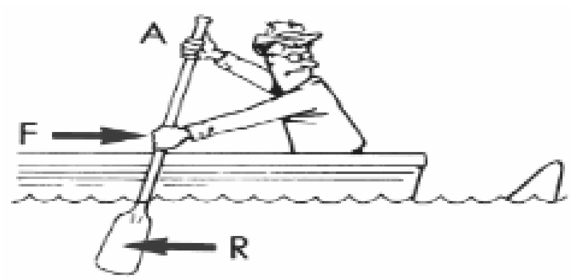
Plantar flexion of foot to raise the body up on the toes where ball (A) of the foot serves as the axis as ankle plantar flexors apply force to the calcaneus (F) to lift the resistance of the body at the tibial articulation (R) with the foot.Relatively few 2nd class levers in Body.

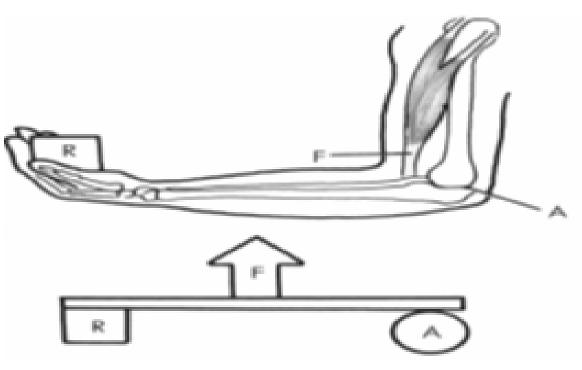
Third-class Levers
Produce speed & range of motion movements. Most common in human body.Requires a great deal of force to move even a small resistance.

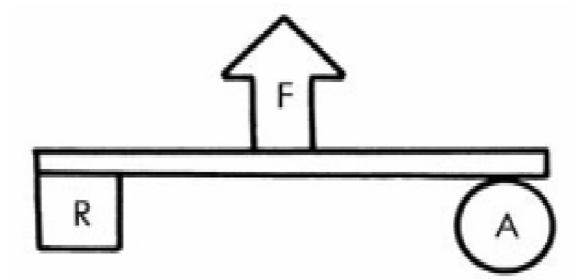
Shoveling - application of lifting force to a shovel handle with lower hand while upper hand on shovel handle serves as axis of rotation.

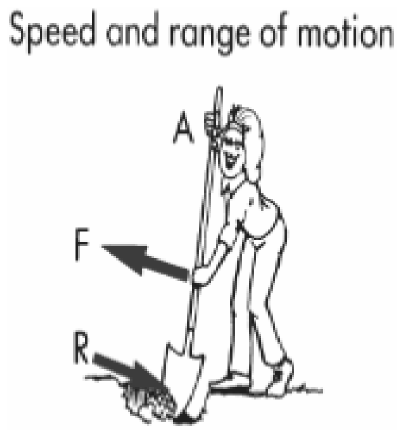
Seated biceps curl.

Paddling a boat.









Biceps brachii in elbow flexion.Using the elbow joint (A) as the axis, the biceps brachii applies force at its insertion on radial tuberosity (F) to rotate forearm up, with its center of gravity (R) serving as the point of resistance application

Brachialis - true 3rd class leverage pulls on ulna just below elbow pull is direct & true since ulna cannot rotate.Biceps brachii supinates forearm as it flexes.Hamstrings contracting to flex leg at knee while in a standing position using iliopsoas to flex thigh at hip.

Factors in use of anatomical levers
Anatomical leverage system can be used to gain a mechanical advantage.Improve simple or complex physical movements. Some habitually use human levers properly.Some develop habits of improperly using human levers.

Torque and length of lever arms
In humans, contracting muscle applies an eccentric force (not to be confused with eccentric contraction) to bone upon which it attaches & causes the bone to rotate about an axis at the joint. Amount of torque is determined by multiplying amount of force (*force magnitude*) by *force arm.* Force arm is perpendicular distance between location of force application & axis. That's why shortest distance from axis of rotation to the line of action of the force and greater the distance of force arm, more torque produced by the force. Often, we purposely increase force arm length in order to increase torque so that we can more easily move a relatively large resistance (increasing our leverage).*Resistance arm* - distance between the axis and the point of resistance application. Inverse relationship between length of the two lever arms between force & force arm between resistance & resistance arm. The longer the force arm, the less force required to move the lever if the resistance & resistance arm remain constant. Shortening the resistance arm allows a greater resistance to be moved if force & force arm remain constant. Proportional relationship between force components & resistance components. If either of the resistance components increases, there must be an increase in one or both of force components. Greater resistance or resistance arm requires greater force or longer force arm. Greater force or force arm allows a greater amount of resistance

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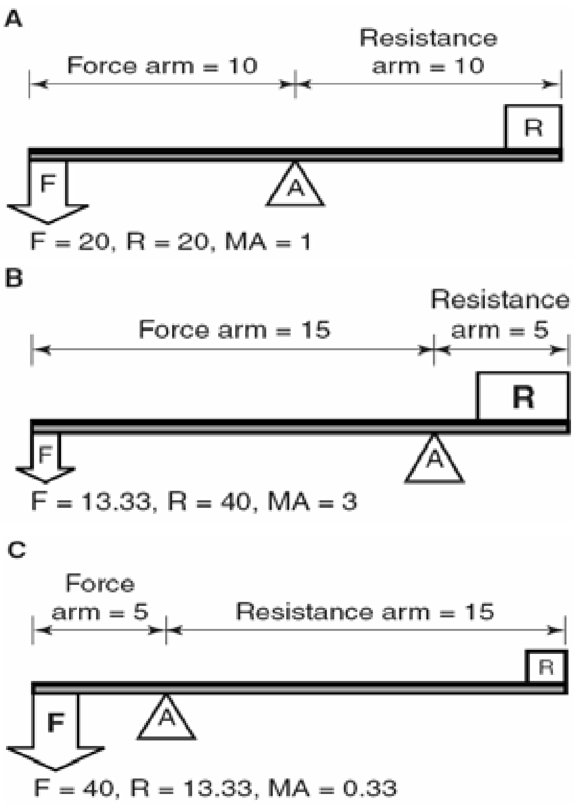
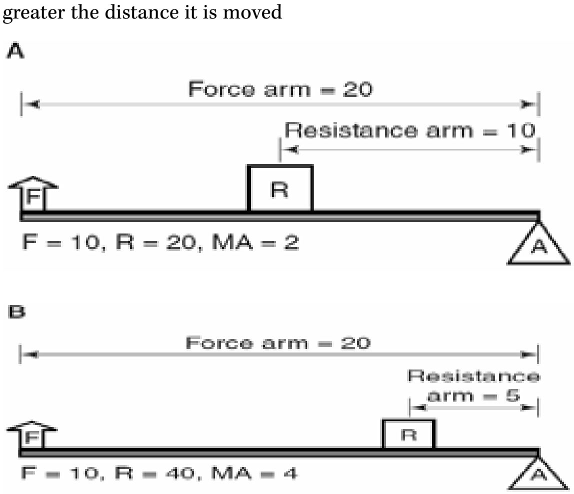
to be moved or a longer resistance arm to be used.

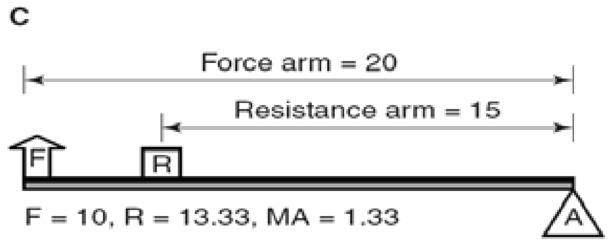
Even slight variations in the location of the force and resistance are important in determining the effective force of the muscle.

Torque and length of lever arms in First class levers
A, If the force arm & resistance arm are equal in length, a force equal to the resistance is required to balance it; **B,** As the force arm becomes longer, a less amount of force is required to move a relatively larger resistance; **C,** As the force arm becomes shorter more amount of force is required to move a relatively smaller resistance.

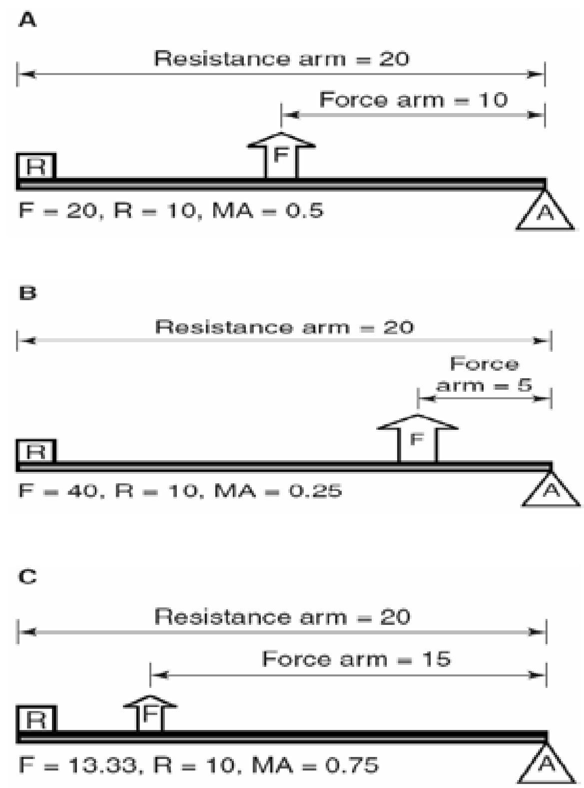


Torque and length of lever arms in Second class levers
A, Placing the resistance halfway between the axis & the point of force application provides a MA of 2; **B,** Moving the resistance closer to the axis increases the MA,but decreases the distance that the resistance is moved; **C,** the closer the resistance is positioned to the point of force application the less of a MA,but the greater the distance it is moved



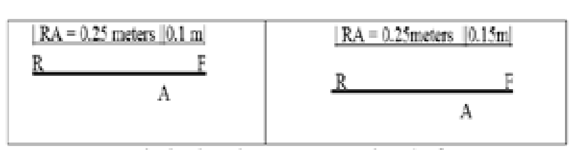


Torque and length of lever arms in Third class levers
A, a force greater than the resistance,regardless of the point of force application, is required due to the resistance arm always being longer; **B,** Moving the point of force application closer to the axis increases the rangeof motion & speed;**C,** Moving the point of force application closer to the resistance decreases the force needed.



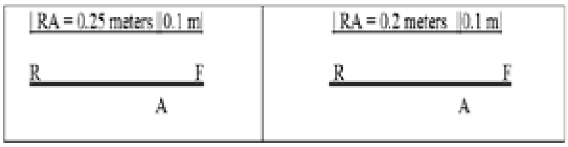
A 0.05 meter increase in insertion results in a substantial reduction in the force necessary to move the resistance.

EXAMPLE: biceps curl
F x FA = R x RA
(force) x (force arm) = (resistance) x (resistance arm)
F x 0.1 meters = 45 newtons x 0.25 meters
F = 112.5 newtons
Increase insertion by 0.05 meters
F x 0.15 meters = 45 newtons x 0.25 meters
F x 0.15 meters = 11.25 newton-meters
F = 75 newtons



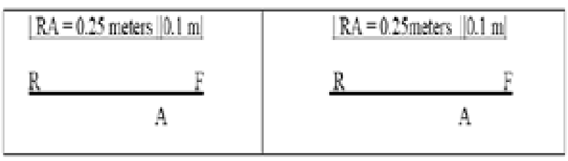
A 0.05 meter reduction in resistance arm can reduce the force necessary to move the resistance.

EXAMPLE: biceps curl
F x FA = R x RA
(force) x (force arm) = (resistance) x (resistance arm)
F x 0.1 meters = 45 newtons x 0.25 meters
F = 112.5 newtons
Decrease resistance arm by 0.05 meters
F x 0.1 meters = 45 newtons x 0.2 meters
F x 0.1 meters = 9 newton-meters
F = 90 newtons



Reducing resistance reduces the amount of force needed to move the lever.

EXAMPLE: biceps curl
F x FA = R x RA
(force) x (force arm) = (resistance) x (resistance arm)
F x 0.1 meters = 45 newtons x 0.25 meters
F = 112.5 newtons
Decrease resistance by 1 Newton
F x 0.1 meters = 44 newtons x 0.25 meters
F x 0.1 meters = 11 newton-meters
F = 110 newtons



Conclusion
Human leverage system is built for speed & range of movement at expense of force. Short force arms & long resistance arms require great muscular strength to produce movement Ex. biceps & triceps attachments biceps force arm is 1 to 2 inches triceps force arm less than 1 inch. Human leverage for sport skills requires several levers, throwing a ball involves levers at shoulder, elbow & wrist joints. The longer the lever, the more effective it is in imparting velocity. A tennis player can hit a tennis ball harder with a straight-arm drive than with a bent elbow because the lever is longer & moves at a faster speed. Long levers produce more linear force and thus better performance in some sports such as baseball, hockey, golf, field hockey, etc.

For quickness, it is desirable to have a short lever arm baseball catcher brings his hand back to his ear to secure a quick throw sprinter shortens his knee lever through flexion that he almost catches his spikes in his gluteal muscles.

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