Running, a sporting event and aerobic exercise, is the series of rapid leg movements--coordinated with arm motions--through long strides while on foot. To be considered an act of running, both feet must be held off the ground at regularly spaced brief intervals. Running is considered the fastest means for a human to move while on foot. Organized running events are part of the sport called track and field--those events performed on a running track. Such running events include the 100-, 200-, 800-, 1,500-, and 5,000-m runs. Longer running events include marathon races that are often run as a distance of 26.2 mi (42.2 km) and in other events as distances of 50 mi (80 km) or longer.

The runner's objective is to travel a given distance in a certain amount of time. When competing in a race, that amount of time becomes the least amount of time possible. In any case, to maximize the efficiency of running, the application of physical concepts is helpful. For instance, the speed of a runner is determined by the distance traveled with each stride (stride length) and the number of strides taken in a given amount of time (stride frequency, sometimes also called cadence). Stride length times stride frequency equals speed. For instance, five ft (1.5 m) per stride times three strides per second equals a speed of 15 ft (4.5 m) per second. To increase one's speed, a runner must simply increase one parameter without causing the other parameter to be reduced by a (more) comparable amount. For instance, to increase the stride frequency to four strides per second by reducing the stride length to 4 ft (1.2 m) per stride would result in a speed of 16 ft (4.8 m) per second--a good tradeoff between stride length and stride frequency.

The length of each stride taken by a runner is considered the sum of three separate distances. The takeoff distance is the horizontal distance that the body's center of mass (CoM) is ahead of the toe of the front (leading) foot at the instant the rear (trailing) foot leaves the ground. The flight distance is the horizontal distance that the body's CoM travels while the runner is in the air. The landing distance is the horizontal distance that the toe of the leading foot is ahead of the CoM at the instant the runner lands. These distances can also be further broken down to speed of release, height of release, angle of release, and air resistance.

The frequency of each stride involves the time of the stride, which can be further broken down to time on the ground and time in the air. During running, each foot contacts the ground for only a brief amount of time. At that moment, an impulsive force powers the body along a parabolic trajectory until the opposite foot touches the ground. At the instant that the foot leaves the ground, the vertical (upward) component of velocity for the body's CoM should be equal to its horizontal (forward) velocity in order to produce maximum range before the opposite foot hits the ground. Energy is depleted in raising the body's CoM for each stride. This energy is not recovered when the CoM is lowered again. The more that the up and down movement is minimized, the smaller amount of energy will be expended in motion that is not used to move forward. Up and down movement can be minimized by leaning the body forward while running. Such movement adds more horizontal component to the energy usage and, thus, contributes to a faster running speed with less energy expended.

In order to further minimize expenditure of wasted energy, both the arms and legs should be bent as
much as possible. Hands and arms are swung from the shoulders and feet and legs are swung from the hips, similar to the swinging of a pendulum (from fingertip to shoulders and toe to hip). This arrangement is based on the principle of conservation of mechanical energy. As a result, the speed of a runner is directly related to the height of swinging objects (such as the length of arms and legs). If the arms and legs are bent while running, such positioning moves the CoM upward, which translates to a faster pace without increasing the amount of energy expended. This application of physics is the reason why runners run with their arms bent at the elbows, while holding their hands close to their waists, and why knees are bent as much as possible and shins are positioned parallel to the ground whenever the legs are swung forward.


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