Terrestrial locomotion

Selection on locomotor performance of young

Ontogeny of locomotor performance

Locomotor versus Fighting Dichotomy

- **Fighting Specialists**
  - Selection: Male competition and territory defense

- **Fighting and Locomotor Generalists**
  - Selection: Predator-prey and migration

- **Distance or Speed Specialists**
The evolution of short legs?

Pleiotrophy

Selection on limb length:
- digging
- climbing
- branch walking
- agility
- fighting

Size sexual dimorphism - a proxy for aggression

Among mammals, body size sexual dimorphism is generally found in polygynous species in which males compete through fighting and the threat of fighting.

(Darwin, 1871; Clutton-Brock et al., 1977, 1980; Alexander et al., 1979; Parker, 1983; Jarman, 1983; Andersson, 1994; Mitani et al., 1996; Plavcan, 2004)
Forelimb length versus size dimorphism in Bovidae

The negative correlation between leg length and SSD is consistent with relatively short legs being an adaptation in Bovidae for physical aggression.

Lucy’s diminutive legs?

\[ R^2 = 0.46 \]
\[ P\text{-value} = 0.002 \]
Climbing Trunks

Minimizing d reduces $A_h$.
(Cartmill, 1974)

Body Size and Quadrupedalism on Branches

Larger primate species are less adept at arboreal locomotion and rely less on quadrupedal progression on branches.
Fleagle and Mittermeier (1980),
Crompton (1984)

Adult male and female chimpanzees differ in their arboreal locomotor behavior, with the larger males using less quadrupedalism and more climbing, scrambling, and aided bipedalism than females.
Doran (1993)
The best acrobats have long legs!

Short limbs for fighting?
Millions of years

Species used in the analysis

Purvis, 1995

Relative Hindlimb Length versus Relative Forelimb Length

R² = 0.210
P-value = 0.214

Relative Hindlimb Length versus Relative Forelimb Length

R² = 0.210
P-value = 0.214
Relative Hindlimb Length versus Size Sexual Dimorphism

The negative correlation between leg length and size sexual dimorphism is consistent with relatively short legs being an adaptation in Hominoidea for physical aggression.

de Waal, 1989
Australopiths were highly derived for striding bipedalism. Yet, the length of their legs did not increase during their 2 million year tenure.

Their short legs may be indicative of persistent selection for high levels of aggression.

The human portrait
Homo ergaster
Turkana Boy (12 years old)
Height - 5' 4" tall
Cranial capacity - 880 cm$^3$
Age - 1.6 mya

**Speed and gait**

![Diagram showing comparative ER performance in humans and quadrupeds.](image)

*Figure 2* Comparative ER performance in humans and quadrupeds. a. Range of speeds for human ER and sprinting, and minimum trot (Tm), preferred trot (Tp), trot–gallop transition (T–G), preferred gallop (Gp), and maximum sustained gallop (Gms) for ponies (ref. 26), and predicted for quadrupeds of 65 and 500 kg (ref. 25). Also indicated is Gld, the optimal long distance (~20 km), daytime galloping speed for horses (ref. 27). Note that quadrupeds sprint at speeds above Gms.

Figure 4 Comparison of stride length (a) and stride rate (b) contributions to running speed in humans and in quadrupedal mammals (calculated from ref. 25) for various gaits (as in Fig. 2a). A stride is a complete locomotor cycle (two steps for a human). Compared to similar-sized quadrupeds, humans have relatively long stride lengths and relatively low stride rates in the ER range. Humans increase speed within the ER range primarily by increasing stride length not rate.

Figure 4  Comparison of stride length (a) and stride rate (b) contributions to running speed in humans and in quadrupedal mammals (calculated from ref. 25) for various gaits (as in Fig. 2a). A stride is a complete locomotor cycle (two steps for a human). Compared to similar-sized quadrupeds, humans have relatively long stride lengths and relatively low stride rates in the ER range. Humans increase speed within the ER range primarily by increasing stride length not rate.


The human portrait

Anatomy -
Long legs (really long)
Short toes (feet)
Long Achilles tendon
Narrow pelvis
Short, wimpy arms
Small head and shoulders
"Pencil" neck

Physiology -
COT is independent of speed

Heat Dissipation -
No other species sweats as much.
Higher levels of neuronal control of sweat glands.
Hairlessness increases convection.
Aquatic locomotion

Undulation - Thrust is generated by small “propulsive elements”: small segments of the body.
Oscillatory propulsion -

Lift based

Drag based

Flying penguins