

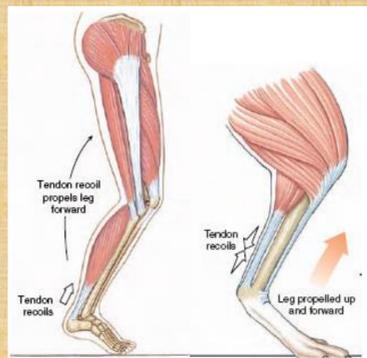


Introduction

- Since the first mobile organism crawled onto the earth (443.4-419.2 Mya) (1) a 'race' for the most efficient terrestrial locomotion has taken place.
- Tendons have evolved to recycle kinetic energy that would otherwise be lost.
- Kangaroo legs (Achilles tendon) have become so efficient that efficiency increases with speed (2, 3)
- The ski has evolved over the last 5000 years (4) as a tool not only to travel on deep snow but also to improve the efficiency of travel on hard snow
- The ski has become so efficient that it surpasses regular human locomotion (running)
- Skiing thus became one of the most efficient modes of terrestrial locomotion across a range of speeds in the animal kingdom

Objectives

- Compare locomotion costs among mammals
- Compare the efficiency of skier locomotion to kangaroo locomotion
- Assess the ski as an evolutionary adaptation



Methods

- Energetic cost functions of speed were acquired for red kangaroos, echidnas and humans from the literature (2, 3, 4, 5, 6, 7)
- Functions transformed into comparable units and averaged
- VO^2 measurements were used as a metric for energy consumption
- Measurements were taken well below VO^2_{max} (80% heart rate of VO^2_{max}) so that anaerobic respiration has little effect (5)
- All functions are in per-kilogram units to allow for direct comparison
- Functions were plotted for visual comparison (Figure 1)

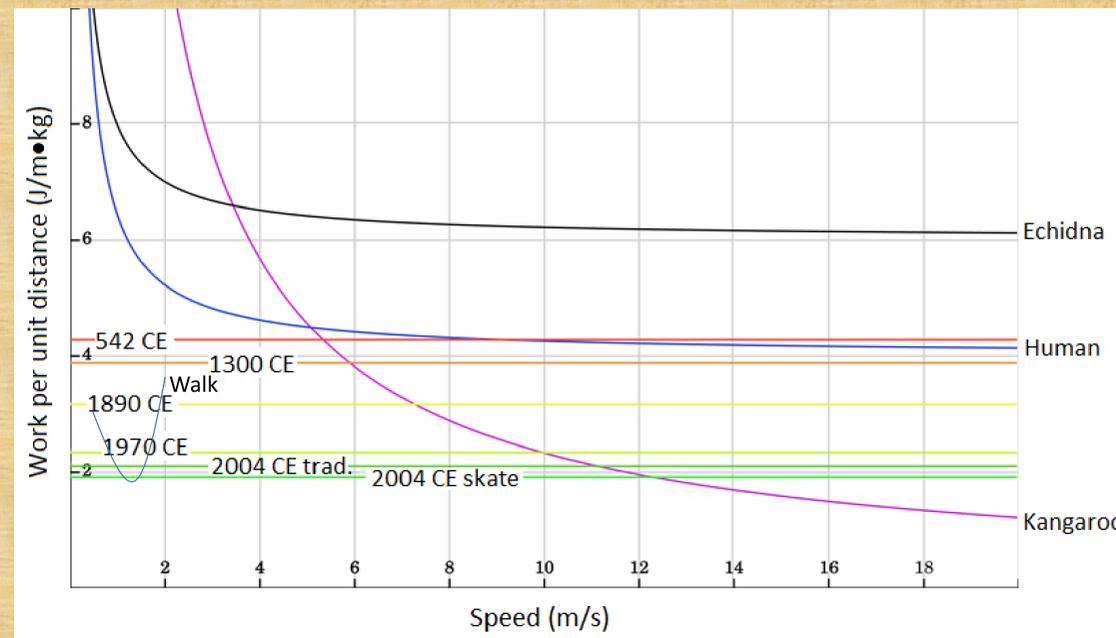


Figure 1: Plotted functions of work per unit distance dependant upon speed of historical skis, human echidna and kangaroo.

Results

- Kangaroo efficiency decreases drastically with speed
- Human efficiency becomes somewhat constant with speed
- Both human and kangaroo are very inefficient runners at low speeds
- The oldest cross country ski is similar in efficiency to human running
- Newer skis are comparable in efficiency to walking
- Intercepts between ski and kangaroo functions indicates the speed beyond which the kangaroo is more efficient

Discussion

- The ski has evolved, becoming more efficient with technological advances
- Improved efficiency in human locomotion rivals that of a human walk and kangaroo run
- Kangaroos, on average travel 6 m/s (3) while running suggesting that the ski was similar to the kangaroo in efficiency around 1300 CE

Caveats of Generalized Functions

- Generalized functions do not account for other types of gaits that humans and kangaroos employ
- Functions don't consider anaerobic respiration which occurs at high speeds (6, 5)
- Measurements were taken on a treadmill which negates air resistance
- An echidna cannot run 20 m/s

Conclusion

- Human inventiveness has resulted in an evolved locomotion that not only better its own efficiency, but becomes comparable to one of the most efficient runners in the animal kingdom.

References

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