

BRIEF COMMUNICATIONS

No force limit on greyhound sprint speed

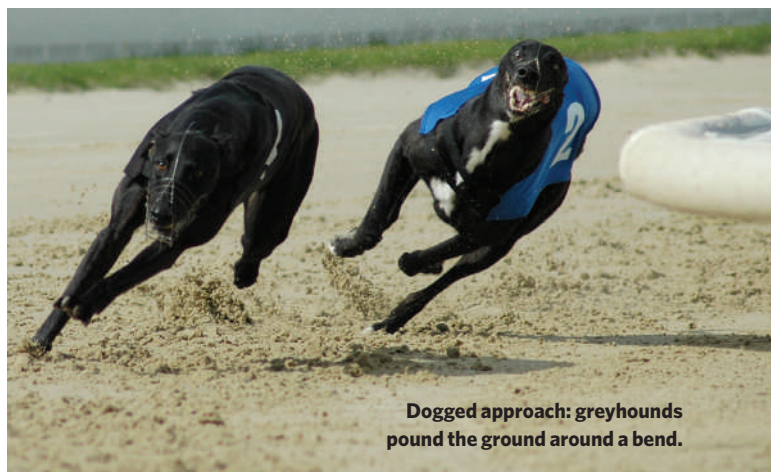
Unlike human athletes, these dogs do not need to slow down when racing round a tight bend.

Maximum running speed is constrained by the speed at which the limbs can be swung forwards and backwards, and by the force they can withstand while in contact with the ground. Humans sprinting around banked bends change the duration of foot contact to spread the time over which the load is applied, thereby keeping the force on their legs constant¹. We show here that, on entering a tight bend, greyhounds do not change their foot-contact timings, and so have to withstand a 65% increase in limb forces. This supports the idea that greyhounds power locomotion by torque about the hips, so — just as in cycling humans — the muscles that provide the power are mechanically divorced from the structures that support weight.

Sprinting around a bend increases effective body weight, as body mass experiences both gravity and centripetal acceleration (Fig. 1a). Human athletes respond to this by increasing the proportion of time per stride that each foot spends on the ground (the 'duty factor'). As swing time of the foot and its angle during

contact (stance angle) are constrained², this results in a reduction in speed¹. Athletes running on inside lanes, where bends are tighter, are at a disadvantage — see, for instance, the results from the 2004 World Indoor Championships 200-metre race³; the bias is so extreme that the indoor event has now been abandoned by the International Association of Athletics Federations.

To investigate the biomechanics of bend-running in greyhounds, we determined speed and footfall timings for 17 greyhounds from high-speed video recordings (250 frames per second) as they came to the end of the first straight (after more than 11 strides, 40 m), and then at the apex of the subsequent bend, which had a radius of 22.4 m (for movies, see supplementary information). Another 23 greyhounds, of similar ability to the first 17 dogs, were monitored as they started the second straight, directly after the bend. The dogs were undergoing pre-competition time trials, racing in small groups (1–3 individuals) around an arena composed of two straights and two semicircular bends of minimal banking. A



Dogged approach: greyhounds pound the ground around a bend.

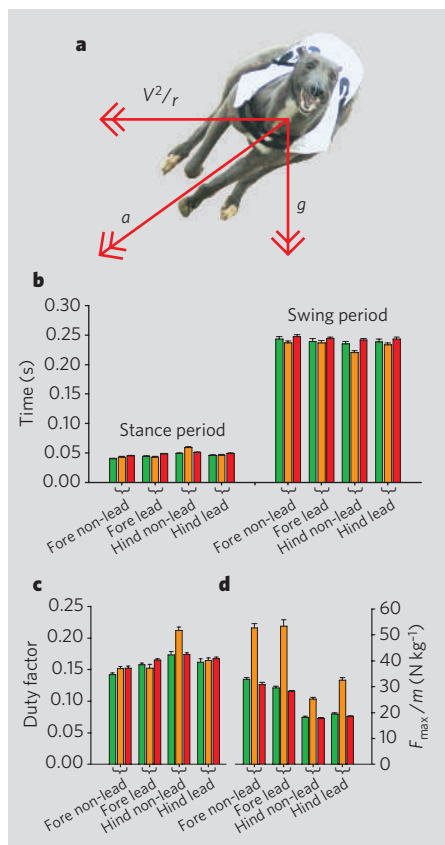


Figure 1 | Mechanics of bend-running in greyhounds. **a**, Mean acceleration vectors (drawn to scale) opposed by limb forces for greyhounds sprinting around a bend, where g is the acceleration due to gravity, V^2/r is the centripetal acceleration, and a is the resultant acceleration. **b**, Stance period (duration of foot contact with the ground) and swing period (the remainder of the stride) for individual limbs. Bars: green, first straight; orange, bend; red, second straight. **c**, Proportion of each stride spent by foot on the ground (duty factor) for individual limbs. **d**, Derived peak force on limbs estimated for greyhounds sprinting on the first straight and around a bend of radius 22.4 m (means ± 1 s.e., $n = 17$), where F_{max} is the maximum reaction force on each limb and m is body mass. Parameters for dogs of similar ability ($n = 23$) at the beginning of the second straight were similar to those for dogs on the first straight. Greyhounds experience substantially higher peak limb forces when running around the bend.

mechanical 'hare' on the outside of the track acted as a lure and was speed-controlled to elicit near-maximal performance.

Speed on the first straight ($V = 16.3 \pm 0.3$ m s⁻¹; mean ± 1 s.e. throughout) was significantly lower than on the bend (17.6 ± 0.2 m s⁻¹); however, net fore-aft acceleration was negligible and so these speeds are near-maximal (track sprint records require averages of 16–17 m s⁻¹). The mean speed for the second group of dogs was slightly lower at the start of the second straight ($V = 15.2 \pm 0.08$ m s⁻¹). The centripetal acceleration requirement (V^2/r) on the bend was high, resulting in an increase in effective weight of $71.0 \pm 2.3\%$.

Changes in the dogs' foot-contact timings (Fig. 1b) were mostly insignificant. Unlike humans, greyhounds do not compensate for the increased mean-force requirements of bend running by increasing the duty factor (Fig. 1c). Estimates of peak limb forces calculated from foot-contact timings^{4,5} (Fig. 1d, and see supplementary information) show that, compared with straight running before the bend, all four limbs experience a large increase in peak force during bend running (by $64.5 \pm 4.3\%$ on average for each leg). We conclude that the peak force on the legs does not constrain sprint speed in greyhounds during straight running under race conditions.

We attribute the different constraints on top speed in greyhounds and humans to their different mechanisms for producing power and supporting weight. In humans, the muscles that power sprinting are loaded by weight-induced compression forces along the leg. In contrast, the dogs power locomotion by torque

about the hips^{6–8} and by back extension; weight support is biased towards the forelimbs⁸. This mechanism is characteristic of cursorial quadrupeds. It is associated with muscular hip retractors and with forelimbs that are dominated by bone, tendon and highly pennate muscles, which act almost like passive springs^{9,10} and are capable of opposing considerable weight-induced forces. This means that the muscles that power greyhounds are virtually independent of weight support and so are not affected by an increase in effective weight.

James R. Usherwood*, Alan M. Wilson*†

*Structure and Motion Laboratory, The Royal Veterinary College, North Mymms, Hertfordshire AL9 7TA, UK

e-mail: jusherwood@rvc.ac.uk

†Centre for Human Performance, University College London, Stanmore, Middlesex HA7 4LP, UK

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ASTROPHYSICS

Is a doomsday catastrophe likely?

The risk of a doomsday scenario in which high-energy physics experiments trigger the destruction of the Earth has been estimated to be minuscule¹. But this may give a false sense of security: the fact that the Earth has survived for so long does not necessarily mean that such disasters are unlikely, because observers are, by definition, in places that have avoided destruction. Here we derive a new upper bound of one per billion years (99.9% confidence level) for the exogenous terminal-catastrophe rate that is free of such selection bias, using calculations based on the relatively late formation time of Earth.

Fears that heavy-ion collisions at the Brookhaven Relativistic Heavy Ion Collider might initiate a catastrophic destruction of Earth have

focused on three possible scenarios: a transition to a lower vacuum state that propagates outwards from its source at the speed of light²; formation of a black hole or gravitational singularity that accretes ordinary matter²; or creation of a stable 'strangelet' that accretes ordinary matter and converts it to strange matter³. A careful study¹ concluded that these hypothetical scenarios are overwhelmingly more likely to be triggered by natural high-energy astrophysical events, such as cosmic-ray collisions, than by the Brookhaven collider.

Given that life on Earth has survived for nearly 4 billion years (4 Gyr), it might be assumed that natural catastrophic events are extremely rare. Unfortunately, this argument is flawed because it fails to take into account an observation-selection effect^{4,5}, whereby observers are precluded from noting anything other than that their own species has survived up to the point when the observation is made. If it takes at least 4.6 Gyr for intelligent observers to arise, then the mere observation that Earth has survived for this duration cannot even give us grounds for rejecting with 99% confidence the hypothesis that the average cosmic neighbourhood is typically sterilized, say, every 1,000 years. The observation-selection effect guarantees that we would find ourselves in a lucky situation, no matter how frequent the sterilization events.

Figure 1 indicates how we derive an upper bound on the cosmic catastrophe frequency τ^{-1} that is free from such observer-selection bias. The idea is that if catastrophes were very frequent, then almost all intelligent civilizations would have arisen much earlier than ours. Using data on planet-formation rates⁶, the distribution of birth dates for intelligent species

can be calculated under different assumptions about the rate of cosmic sterilization. Combining this with information about our own temporal location enables us to conclude that the cosmic sterilization rate for a habitable planet is, at most, of the order of 1 per 1.1 Gyr at 99.9% confidence. Taking into account the fact that no other planets in our Solar System have yet been converted to black holes or strange matter^{1–3} further tightens our constraints on black hole and strangelet disasters. (For details, see supplementary information.)

This bound does not apply in general to disasters that become possible only after certain technologies have been developed — for example, nuclear annihilation or extinction through engineered microorganisms — so we still have plenty to worry about. However, our bound does apply to exogenous catastrophes (for example, those that are spontaneous or triggered by cosmic rays) whose frequency is uncorrelated with human activities, as long as they cause permanent sterilization. Using the results of the Brookhaven analysis¹, the bound also implies that the risk from present-day particle accelerators is reassuringly small: say, less than 10^{-12} per year.

Max Tegmark*, Nick Bostrom†

*Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

e-mail: tegmark@mit.edu

†Future of Humanity Institute, Faculty of Philosophy, University of Oxford, Oxford OX1 4JJ, UK

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CORRIGENDUM

Avian flu: Isolation of drug-resistant H5N1 virus

Q. Mai Le, Maki Kiso, Kazuhiko Someya, Yukio T. Sakai, T. Hien Nguyen, Khan H. L. Nguyen, N. Dinh Pham, Ha H. Ngyen, Shinya Yamada, Yukiko Muramoto, Taisuke Horimoto, Ayato Takada, Hideo Goto, Takashi Suzuki, Yasuo Suzuki, Yoshihiro Kawaoka
Nature **437**, 1108 (2005)

We omitted the accession numbers for the sequences of the A/Hanoi/30408/2005 clones, which are registered in the DNA Data Bank of Japan. These are:

AB239125 20051020120345.25409 for the haemagglutinin gene in clone 9; and
AB239126 20051020122743.63420 for the neuraminidase gene in clone 7.

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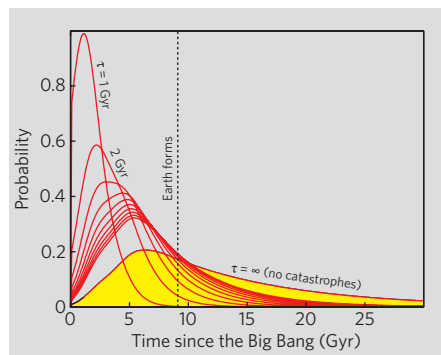


Figure 1 | The catastrophe timescale cannot be very short. The probability distribution is shown for observed planet-formation times, assuming catastrophe timescales, τ , of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 Gyr and infinity (shaded yellow), respectively (from left to right). The probability of observing a formation time ≥ 9.1 Gyr for Earth (area to the right of the dotted line) drops below 0.001 for $\tau < 1.1$ Gyr.