

Introduction

Bears (family Ursidae) are a group of large, quadrupedal, plantigrade animals, which makes them unique. There are eight extant species of bear, but limited research has been conducted on their locomotion. Previous work has demonstrated that grizzly bears (*Ursus arctos horribilis*) do not show the same locomotor patterns as other quadrupedal mammals [1], including higher mediolateral forces. The aim of this study was to investigate whether other bear species demonstrate these same locomotor patterns. Specifically this study involved studying American black bears (*Ursus americanus*) and comparing their results to those from the grizzly bears.

Methodology



Figure 1 Grizzly bear data collection. The force plate is in the centre of the image, directly perpendicular to the high speed camera.

Grizzly bear data was collected for a previous study (Fig 1; [1]) and used for comparison to the black bears. Force plate and high-speed camera data were collected from three captive adult male black bears at Oregon Zoo. The custom built force plate was positioned in the centre of a runway along the fence of the black bear enclosure (Fig 2). Two cameras (GoPro, Inc) were used, one perpendicular to the force plate and the other filming the frontal plane. The bears were encouraged to move across the runway by the zookeepers with food rewards. Video data was analysed (VirtualDub, version 1.10.4) to calculate speed and gait of the animals. Force plate data was analysed (MatLab, R2012a) for peak ground reaction force and impulse in three directions.



Figure 2 Black bear data collection. The force plate is in the centre of the image, directly perpendicular to the high speed camera.

Results

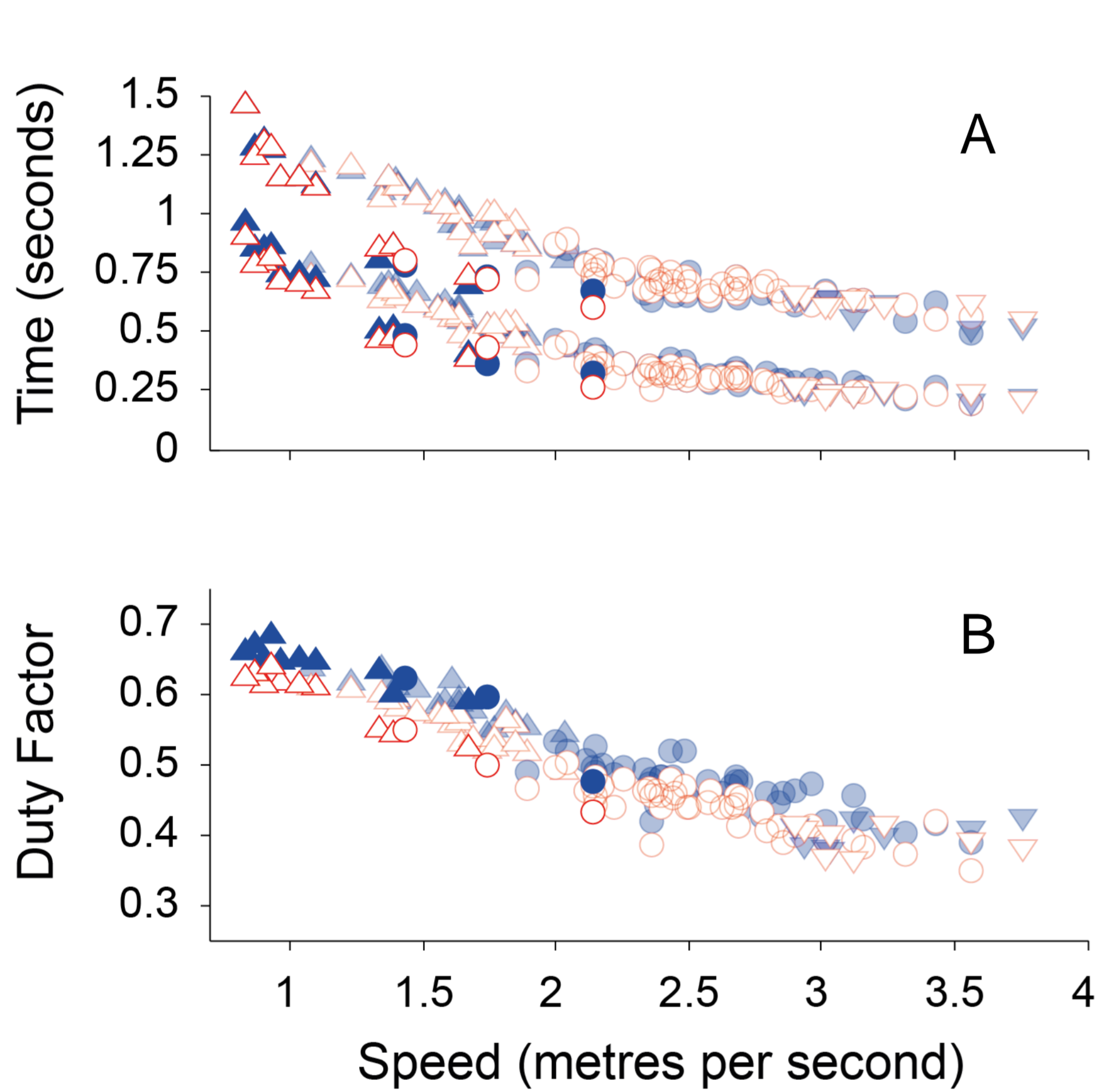


Figure 3 Stride parameters. Stride time (A: upper row) and contact time (A: lower row) are lower for black bears than grizzly bears at similar speeds. Duty factor (B) is similar for both species. Figure adapted from [1].

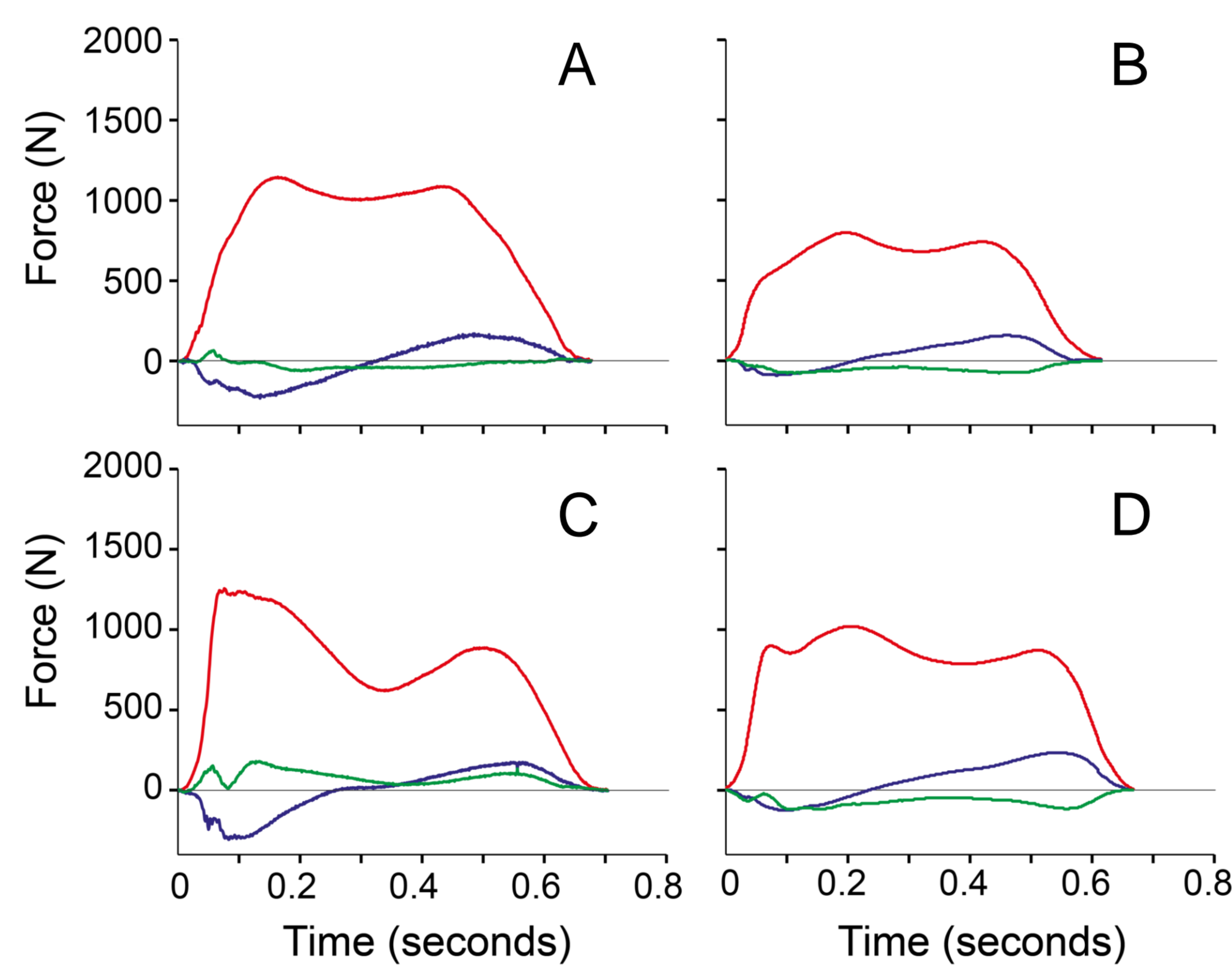


Figure 4 Representative force traces from Grizzly (A, C) and Black (B, D) bears. Both bear species produce the 'M' shaped walking curve, with a higher rate of force development in the hind limbs (C, D). Figure adapted from [1].

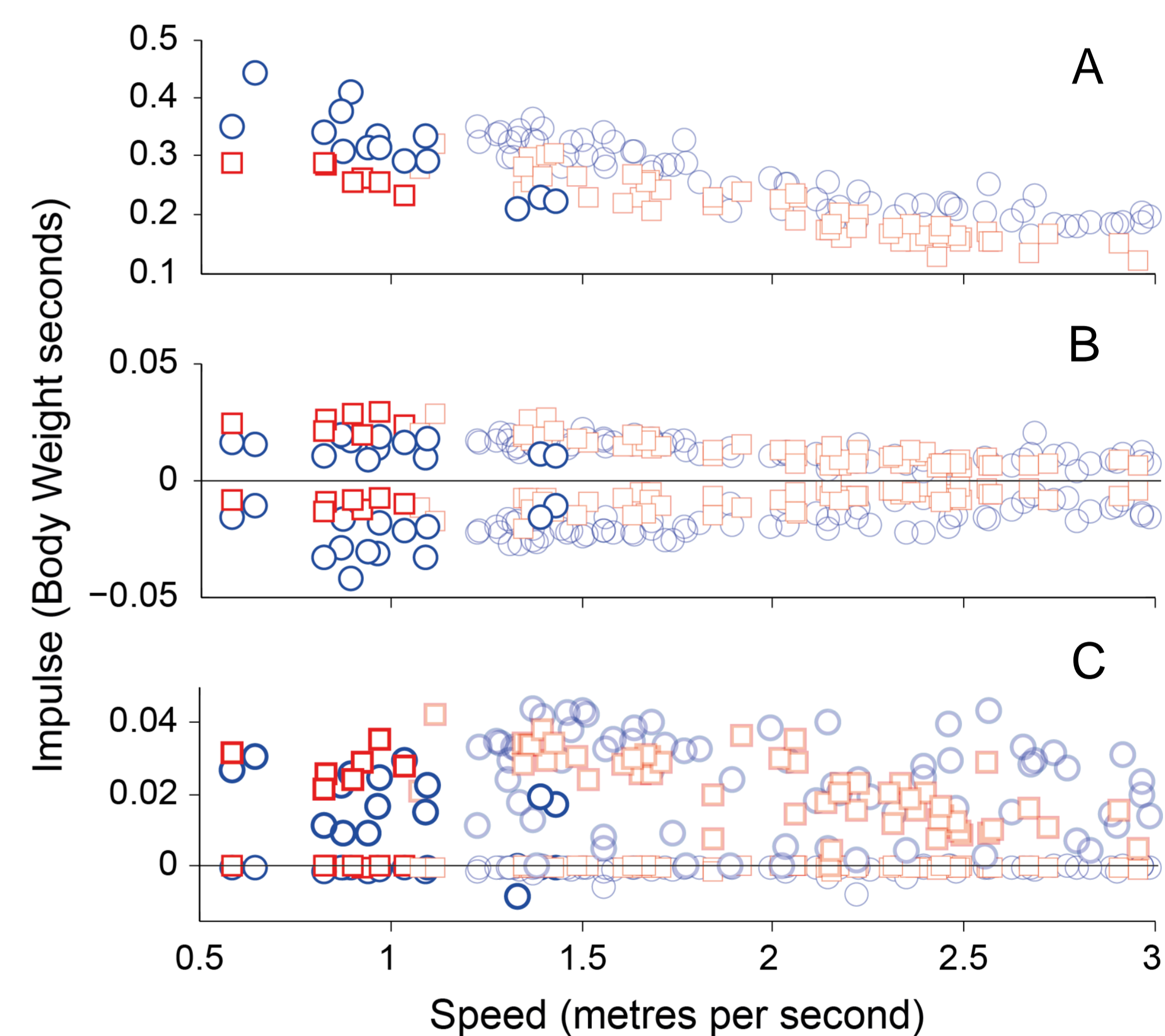


Figure 5 Normalised vertical (A), anterior-posterior (B) and mediolateral (C) impulse. Grizzly and black bears produce higher vertical and braking impulses with their forelimbs. Black bears produce slightly lower medial GRF impulse than grizzly bears. Figure adapted from [1].

Grizzly and black bears move at slow speeds with a transverse walk. However, grizzly bears then use a running walk at intermediate speeds, while the data suggests black bears use both a running walk and a pace. Black bears have lower stride and contact times than the grizzly bears at similar speeds, although duty factor remains consistent (Fig 3). Overall, the force traces produced by the two bear species were similar in shape (Fig 4) with an increased rate of force development (i.e. a steeper slope at foot contact) in the hind limbs. Due to the low speed used by the black bears, statistical tests were run using only trials at less than 2.0ms⁻¹ (IBM SPSS, version 24). Grizzly bears and black bears have significantly higher peak vertical force and vertical impulse in their forelimbs than hind limbs (Fig 5; Grizzly: $p < 0.001$; Black: $p = 0.045$). Similarly, both bear species have significantly higher braking impulse in the forelimbs (Grizzly: $p < 0.001$; Black: $p = 0.001$). Unlike grizzly bears, black bears have significantly different propulsive impulses between their fore and hind limbs (Grizzly: $p > 0.05$; Black: $p < 0.001$).

Discussion

Our results suggest that while there are similarities between the locomotor patterns of the two species there are also differences. This could be expected due to the different ecological niches occupied by the different species. Due to the small sample size of trials and speeds analysed so far from the black bears, we were unable to directly compare the two species. However, a more detailed analysis could be conducted to characterise the differences in the mediolateral ground reaction forces produced by the two bear species. Additionally, we would aim to collect data from additional bear species to compare the locomotor patterns across the whole family.

Acknowledgements

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References

[1] Shine, C.L., et al., (2015). *J Exp Biol*, **218**(19) p3102.