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ANALYZING PACE FREQUENCIES IN BIPEDAL PRIMATES AND PRIMATE "PREDECESSORS" REVEALS MECHANISMS THAT REGULATE FOOT INVERSION AND THUS ENSURE FOOT STABILITY AT TOUCHDOWN

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Introduction and hypothesis: High-pitched sounds of unintentional lateral foot-shuffling along the ground during the swing phase of gait have been recognized as almost pathognomonic signs of fatigue in lower leg and foot evertor muscles in the early stages of Multiple Sclerosis (MS) [1]. MS patients diagnosed in the early stages of the disease encounter several ominous events like tripping and falling. Recovery from foot inversion at toe-off and during the swing phase by lower leg internal rotation as well as stabilization of foot inversion after touchdown by subsequent foot eversion are affected. Inversion is defined as turning the sole of the foot inward, while eversion is defined as turning the sole outward. In order to explore the key features of this phenomenon extensive investigation of normal functional morphology of the lower leg is worthwhile. Studying normal functional morphology of the lower leg, particularly in primates and predecessors, is an alternative approach that may enlighten the evolutionary path leading to this phenomenon. Recent literature shows that in walking bipedally, various arboreal New World primate species use a "forefoot first" strategy, after which heel contact occurs [2]. A similar walking scenario is seen in arboreal New World marsupials like the opossum, a quadrupedal primate "predecessor". In opossum walking the swing phase ends with the foot in the inverted position to the next touchdown with the forefoot [3]. We therefore hypothesized that those quadrupedal marsupials which are mainly or exclusively terrestrial like e.g., wombats, will also display a "forefoot first" strategy at touchdown. However, while lower leg rotational mechanisms in wombats are well-described [4], currently "no detailed analyses of wombat locomotion have been carried out. (…) Wombats are plantigrade, walking on the soles of their feet with three distinct gaits, walk, trot and bound" [5].

Material and methods: Various semi-domesticated fully terrestrial *Vombatus ursinus* (common wombats) were videotaped (November 2013) before dusk, walking in their natural environments at Cradle Mountain Road (C132), Cradle Mountain, Tasmania. Following current guidelines, we took utmost care to leave all animals undisturbed [6]. Posterior and lateral views were analyzed frame by frame.

Observational results: Average wombat walking speed is about 2,5 km/h, with hind-limb pace frequencies of about 1 Hz. In man, this is : 0,5 Hz (walking) - 2,5 Hz (running) [3]. Wombat toe-off occurs with the foot in the everted position (Fig. 1). Halfway recovery there is inversion of the foot, coupled to shank external rotation (Fig. 2). At touchdown a “forefoot first” position is observed. The wombat recovery phase namely ends with a first ground-contact by the (presumably metatarsophalangeal) plantar pads [7, 8] (Fig. 3, red arrowhead), with the foot still in inversion. This is immediately followed by a rapid full foot placement, foot in eversion.

Conclusion: Marsupials such as wombats, though being exclusively quadrupedal and non-arboreal, show basically the same strategies of foot eversion to ensure safe touchdown as bipedally walking arboreal New World primate species [2], with morphologically guided adjustments. Analyzing this hopefully helps to understand gait training problems in patients too, with emphasis on foot inversion and eversion.

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Figure 1.


Figure 2.

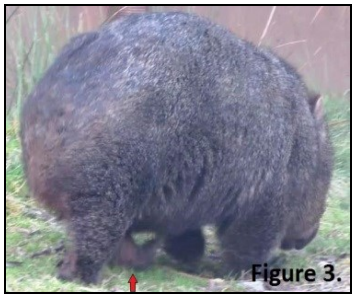
Figure 3.

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