An automated open field mouse gait analysis test

T. Leroy[1], S. Stroobants[2], J.-M. Aerts[1], R. D'Hooge[2], and D. Berckmans[1]
[1]*M3-BIORES, Katholieke Universiteit Leuven, Heverlee, Belgium, daniel.berckmans@biw.kuleuven.be*
[2]*Laboratory of Biological Psychology, Katholieke UniversiteitLeuven, Leuven, Belgium.*

Introduction

In the past, some efforts have been made to seek for automated systems to ease the job with monitoring laboratory animals. Commonly, these methods involve visually analyzing video recordings of the animal traversing a specially built runway [1,2,4]. Very recently, a more automated method, the "CatWalk" [3], uses a runway with internal reflection to increase contrast so image analysis software can recognize paw-like objects automatically. However, manual identification and labeling of the individual paws is still required, making the job time consuming. Also, all techniques are quite expensive because of the required material.

The objective of this research is to develop a system for fully automated mouse gait analysis using computer vision. The system automatically locates and identifies footprints of the mouse in camera images, acquired from below the transparent cage floor. From a sequence of footprints, the gait of the mouse is quantified using standardised gait parameters.

Materials & Methods

Data was acquired during 2 series of experiments on mice with a targeted disruption of the arsylsulphatase A (ASA) gene, with lowered coordinated locomotion abilities as a symptom. The first series were performed on 36 heterozygotes (12 females, 24 males) and 50 knock-out mice at the age of 6 months. A subgroup of 16 heterozygotes (9 females, 17 males) and 33 knock-out mice were used in a second series at the age of 12 months.

The mice were placed one at a time in the test setup, consisting of a plexi-glass cage (53x34.5x26cm) and two fluorescent bulbs for proper illumination (see Figure 1). The transparent cage allowed images to be captured from underneath the cage, so additional information could be obtained about the position of the limbs of the mice for gait reconstruction. Every mouse was recorded during 10 minutes.

Background subtraction and colour filtering were used to measure image features, such as the mouse's position, orientation, body outline and possible locations for the mouse's paws. A set of heuristic rules was used to prune implausible paw features and label the remaining ones as front/hind and left/right. After pruning implausible paw features, the paw features that are consistent over subsequent images are matched to footprints. Finally, from the measured footprint sequence, eight parameters were calculated to quantify the gait of the mouse: the stride lengths of the front & hind, left & right paws, the front & hind base and the left & right overlap.

Results

The system described above was used to automatically measure the gait of the 36 heterozygotes and 50 knock-out mice at 6 months. No gait information could be obtained for knock-out mice at the age of 12 months due to their decreased ability to move freely. Therefore, only results at the age of 6 months are regarded here. Furthermore, from the group at 6 months, 18 mice (5 heterozygotes and 13 knock-outs) were excluded from the analysis because a lack of movement.

There were clear distinctions between the gait pattern of heterozygotes and knock-outs (Figure 2). The maximal hind base (HB) displayed by knock-outs was significantly larger. The mean right overlap (RO) was significantly smaller for knock-outs than for heterozygotes. For the left overlap (LO), this difference also appeared but was less outspoken. Knock-outs also showed consistently larger mean and maximal stride lengths for left/right, front and hind paws (LFS, RFS, LHS and RHS).

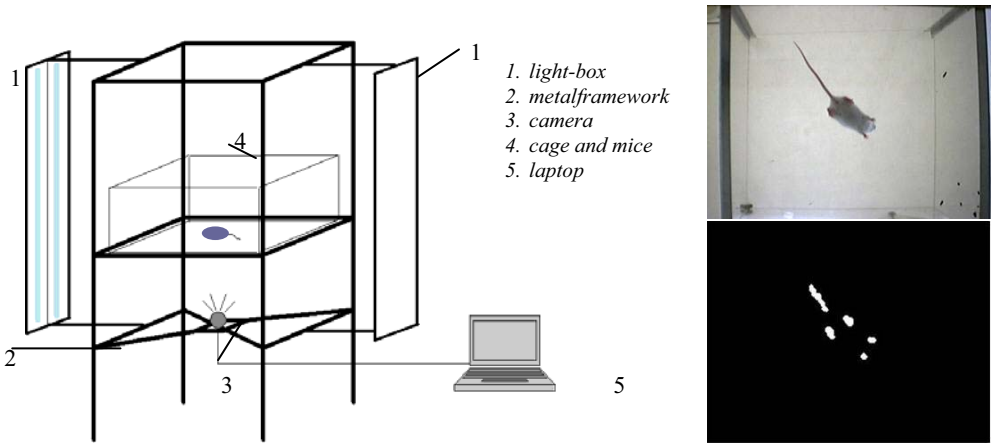

Figure 1. *A schematic overview of the experimental setup*

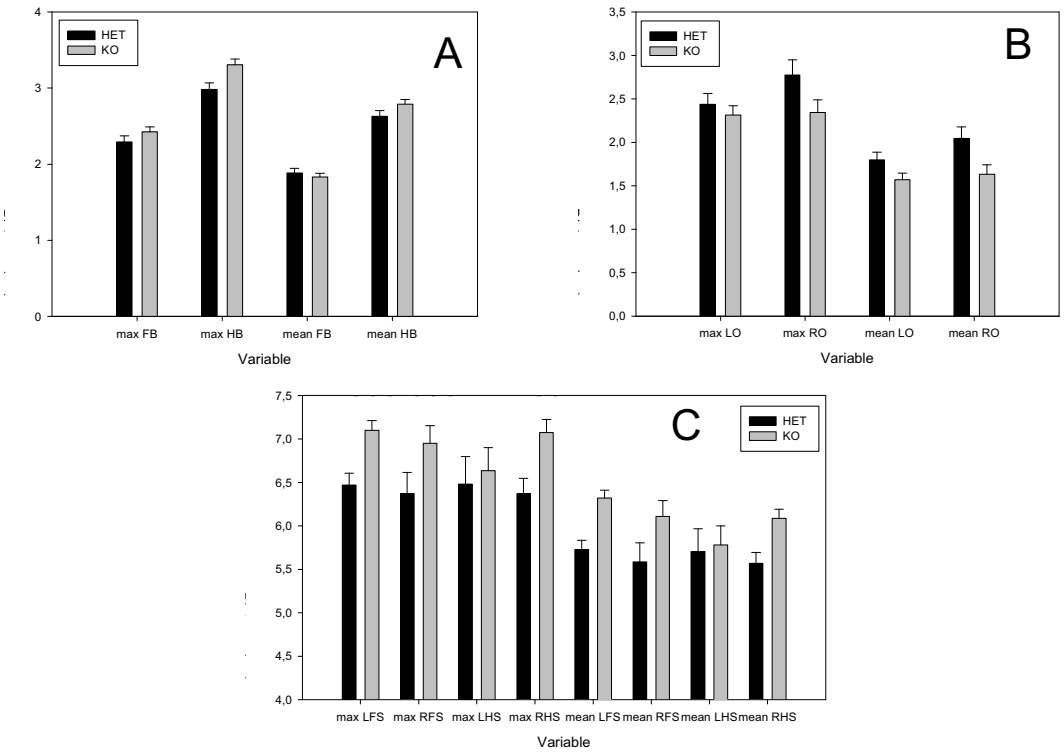

Figure 2. *Gait parameters of heterozygotes (HET) and knock-outs (KO) at the age of 6 months. Top left (A): The mean and maximal front base (FB) and hind base (HB). Top right (B): The mean and maximal left overlap (LO) and right overlap (RO). Bottom (C): The mean and maximal left front (LFS), right front (RFS), left hind (LHS) and right hind (RHS) stride lengths, respectively.*

References

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