The comparison of foot clearance in novice and experienced independent walking using statistical parametric mapping

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Background

The ability to clear the toe from the floor during swing has been proposed as a key requirement for the development of independent walking (Hallemans, 2005). The nature of this clearance in infant walkers differs to that in adults and therefore the standard discrete data (e.g. local minimum and maximum) used to describe foot trajectory may not identify differences within infancy.

Aim: to explore the clearance of the foot during swing between two time points of independent walking development (novice walking and experienced walking) using statistical parametric mapping (SPM).

Methodology

As part of a longitudinal study of gait development, 20 infants participated in two test sessions at walking milestones. Firstly, within 3 weeks of taking five independent steps (age 416±54 days) then again when they could walk in a confident stable manner (78±25 days later). For both sessions infants were instrumented with markers defining the feet, lower limbs and pelvis. Infants were encouraged to walk in a nursery style laboratory environment while kinematic data was collected (Qualisys, Sweden; 100 Hz). Vertical foot (1st and 5th metatarsal heads and heel) marker trajectories were tracked during this time and trajectories during swing were exported from Visual 3D (C-motion, USA). Five swing phase trajectories and their variability (SD) were compared for novice v experienced walking utilising paired sample SPM1D t-tests in Python (Pataky, 2016).

Results

- Trajectories with SD alongside SPM {t} for both comparisons for **novice** and **experienced** walking steps are presented in Figure 1.
- Metatarsal markers in novice walking steps higher in mid- to late-swing than experienced steps - - -.
- Heel marker trajectory lower in early-swing and higher in later-swing in novice steps - - -.
- Variability in metatarsal markers did not differ between the two visits - - - .
- Heel marker variability was higher in experienced steps than novice steps - - -.

Discussion

- Novice walkers increase ground clearance by elevating their foot off the floor to higher levels.
- Plantarflexion is not evident in novice steps so heel marker trajectory does not change relative to metatarsals: there is a flat foot-off and foot contact.
- Higher variability in confident walking steps is due to some mature trajectories and potentially due to more varied nature of the steps they took.

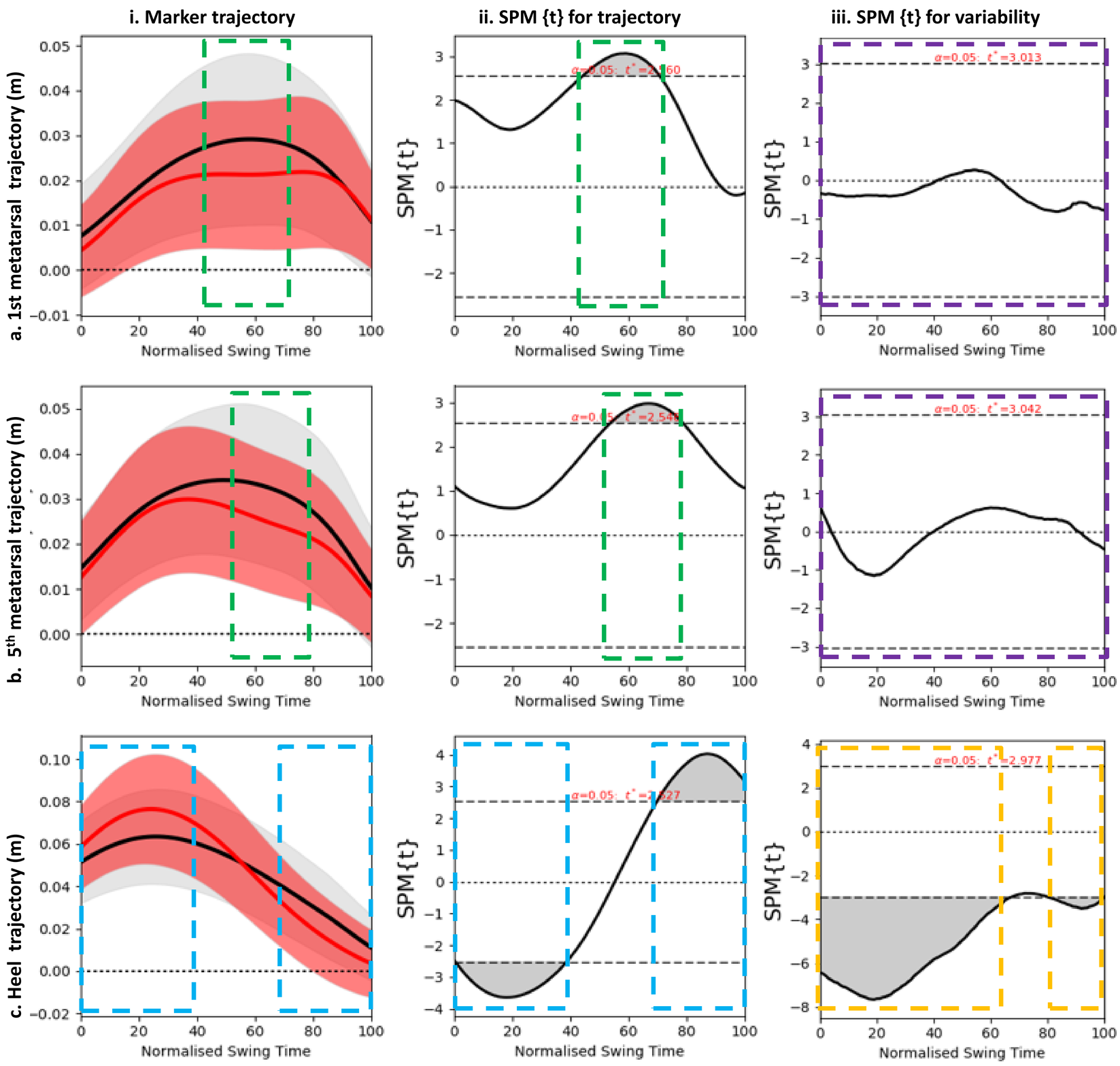

Figure 1. Novice (black) and experienced (red) foot marker trajectories (i) with SPM{t} for trajectory (ii) and variability (iii).
a) i) 1st metatarsal vertical trajectory ii) the paired samples t-test statistic SPM {t} for trajectory. Critical threshold was exceeded between time 45-70% of swing indicating a significantly higher marker trajectory in the novice walking visit iii) the paired samples t-test statistic SPM {t} for variability. Critical threshold was not exceeded. b i) 5th metatarsal vertical trajectory ii) the paired samples t-test statistic SPM {t} for trajectory. Critical threshold was exceeded between time 54-78% of swing indicating a significantly higher marker trajectory in the novice walking visit iii) the paired samples t-test statistic SPM {t} for variability. Critical threshold was not exceeded c i) heel vertical trajectory ii) the paired samples t-test statistic SPM {t} for trajectory. Critical threshold was inferior between time 1-38% and exceeded between time 70-100% of swing indicating a significantly different marker trajectory in the novice walking visit iii) the paired samples t-test statistic SPM {t} for variability. Critical threshold was inferior between times 0-67% and 81-99% of swing indicating a significantly greater SD in the confident walking visit.

References

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