INTRODUCTION

Balance Recovery (BR) threshold is a critical parameter in understanding the ability of individuals to maintain balance and recover from perturbations. In this study, we investigate the influence of perturbation parameters, including jerk and maximal intensity, on BR thresholds.

METHODS

We conducted an experiment with 13 young adults (age: 23 ± 1 yrs; height: 1.72 ± 0.1m; mass: 67 ± 18.3kg) without any balance disorders. Participants were subjected to waist-pull perturbations consisting of a linear increase of perturbation (J) followed by a constant force (Fmax) plateau. The perturbation profile was divided into three sets. Each participant went through 60 waist-pull perturbations divided into three sets. Each set was defined by 20 perturbations with different initial slopes (J = 2, 4, 8, and 16 m/s²) and five plateau values (Fmax = 30, 35, 40, 45, 50% of subjects body weight) presented in a random order. The total duration of each perturbation was set to 2s. Each perturbation was applied after random delays between 1 and 10s. Participants were asked to recover their balance without stepping over a line marked on the ground at 30% of their body height. After each perturbation, participants were also asked to rate the difficulty to recover their balance thanks to a Category Partitioning Scale CP50.

RESULTS

BR was significantly more successful during the second and third set of perturbations when subjects were more trained at recovering their balance (Fig 1). A multiple logistic regression was performed and showed a significant effect of the jerk (pvalue < 0.01) and Fmax (pvalue < 0.001), without interactions, on the probability to recover balance.

Thus, the probability to fail BR (Pfail) can be estimated throughout the Equation 1. An ANOVA was performed on volunteers CP50 scores and shows similar results with a significant effect of the J (pvalue < 0.001) and Fmax (pvalue < 0.001), without interaction. The CP50 scores (CPexp) can be estimated throughout a linear model (cf. Equation 2).

Discussion

Not surprisingly, the BR threshold depends on the intensity of the perturbation (Fmax). However, results also show the influence of the variation of the perturbation (J). This study brings new quantified value of the influence of the J and Fmax on 1°/ the BR threshold using a limited step length and 2°/ the difficulty to recover balance. This study also suggests that the perturbation profile should be well characterized in order to ensure a good evaluation of the BR. More investigations have to be done to investigate the effect of the maximal step length allowed and also the effect of the population group studied (i.e., age, balance disorder, etc.).

Equations

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\text{logit}(P_{\text{fail}}) = -15.7 + 0.45 \cdot \text{Jerk} + 0.32 \cdot F_{\text{max}} \quad (1)
\]

\[
\text{CP}_{\text{exp}} = -8.4 + 1.65 \cdot \text{Jerk} + 0.66 \cdot F_{\text{max}} \quad (2)
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References