Video-based Measures of Balance Reveal Differences in Subjects with Varying Balance Ability during the Rise-to-Toes Task

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Summary

Quantitative metrics of balance and fall risk are needed to screen for balance impairments and measure the efficacy of balance training programs. Our goal is to leverage OpenCap, an open-source platform for motion capture with smartphone video, to develop an accessible and quantitative balance assessment tool. Towards this goal, we used OpenCap to record kinematics of 152 individuals with varying balance abilities performing a rise-to-toes task. We automatically computed features for this task to generate a balance score, which correlated with age. We found a relationship between whole-body angular momentum and balance performance. These results support the further development of OpenCap as a promising balance assessment tool.

Introduction

Towards the goal of designing a balance assessment tool with smartphone video, we have collected OpenCap [1] data from 152 individuals with a large variance in balance abilities (ranging from professional ballerinas to older adults) performing 23 balance challenging tasks. Here, we present preliminary work for the rise-to-toes (RTT) task. This challenging balance task, included in the minBEST test [2], requires anticipatory postural adjustments, postural control on a reduced base of support, and stabilization after self-perturbation. Our aim was to (1) use OpenCap to automatically compute a balance score for the RTT task and (2) understand how whole-body angular momentum (H), as a metric of stability, relates to RTT performance.

Methods

We recorded the individuals (ages 18-87) performing the RTT task with OpenCap (3 iPhones). The subjects were instructed to rise to their toes as quickly and as high as possible and then hold for 5 seconds. Using 3D kinematics, we automatically segmented the task into 4 regions: (1) Anticipatory, (2) Rise, (3) Hold, and (4) Lower. We defined and automatically computed features based on the 3 objectives of the task: peak vertical center of mass velocity during region 2 to assess speed, peak plantar flexion angle to assess height, and time of region 3 for the duration of hold. Each feature was normalized by the maximum value in the dataset and summed to generate the overall balance score. We computed sagittal plane H and characterized control of H by the time rate of change of H (dH/dt) and the peak-to-peak range of H (H_R) [3] for each RTT region.

Results and Discussion

The balance score for RTT captured the variability in balance abilities in the dataset, ranging from a score of 0.3 to 85.9 (Figure 1). We found a strong negative correlation between age and the balance score ($r=-.67$, $p<.001$). Mean dH/dt was negatively correlated with the balance score in region 3 ($r=-.46$, $p<.001$), indicating a larger negative mean dH/dt in region 3 was associated with better performance. This demonstrates these individuals were better able to counteract the destabilizing positive change in H generated during the rise phase of the task (region 2). Mean dH/dt had a weak correlation with the balance score in region 4 ($r=.20$, $p<0.05$) and no significant correlation in regions 1 and 2. We found a negative correlation between the balance score and H_R in each region of the RTT (Anticipatory: $r=-.55$, $p=<.001$, Rise: $r=-.27$, $p<.001$, Hold: $r=-.27$, $p=<.001$, Lower: $r=-.39$, $p<.001$). This demonstrated that subjects who better achieved the goals of the RTT task had a smaller range of H.

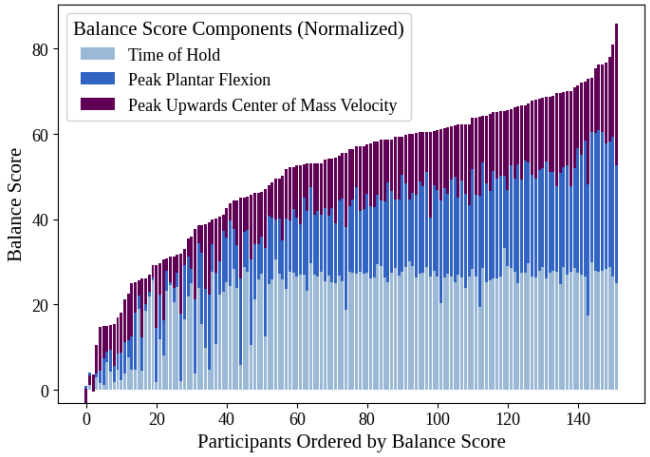

Figure 1: Balance score for rise-to-toes computed from OpenCap across participants

Conclusions

We used OpenCap to compute a balance score for the RTT task using smartphone video. We demonstrated how control of H was related to the subject's performance on the objectives of the task.

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References.

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