# Supporting Information

**EXPERIMENTAL SETUP**

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**Figure 1. Experimental setup for marker plate and IMU placement.** Subjects were outfitted with 8 IMUs (MTw Awinda, Xsens North America Inc., Culver City, USA), affixed to a thin plexiglass plate along with a cluster of at least 4 retro-reflective markers placed on the upper back (T2), lower back (L5), and the right and left thighs, shanks, feet.

**INVERSE KINEMATICS**

We used Eq. 1 to compute the difference, expressed as the angle () of the axis-angle representation between the experimentally measured IMU orientations (a rotation matrix expressed in Earth’s reference frame *N,* ), and the orientations of the model’s virtual IMUs (). We denote this difference as . We used an inverse kinematics algorithm (Eq. 2) that solved for the joint angles (*q*) that minimized this weighted-squared difference ().

(1) , where and   
(2)

We used to quantify the RMS differences between the experimentally measured IMU orientations and the virtual IMU orientations. From here we refer to these RMS differences as *inverse kinematics orientation differences.* In the inverse kinematics algorithm, we downweighted the terms corresponding to the distal IMUs (reduced the relative weighting on the shank IMUs and the foot IMUs, i.e. *wshank* and *wfo*ot) to minimize the influence of the IMUs that were closer to the in-ground metal force-plates (Table 1).

**Table 1. Weights used in downweighted inverse kinematics algorithm.** These weights were included in OpenSim’s inverse kinematics setup file (see GenericScripts/Setup\_IK\_Walking\_IMU\_extremely\_low\_feet\_weights.xml) included with the project.

|  |  |
| --- | --- |
| IMU location | Weight |
| pelvis | 1 |
| thigh | 1 |
| tibia | 0.5 |
| foot | 0.01 |

**PRE-SCREENING PROCESS FOR ASSESSING QUALITY OF IMU DATA**

The data were collected in a laboratory environment with ferromagnetic disturbances which resulted in distortions in IMU orientation estimates, especially in the heading direction. These erroneous IMU orientation estimates led to exaggerated hip adduction, hip rotation, and ankle flexion in the downstream inverse kinematics solution. To address this, we developed a pre-screening process that we used as part of the general pipeline, and recommend to achieve comparable results. The pre-screening criteria were based on the inverse kinematics orientation differences described above and were as follows: (i) if the differences exceeded a threshold of 45 degrees in the first 10s of the trial, indicating poor tracking of the IMU orientation and therefore poor sensor fusion estimates, then these data were excluded or (ii) if the average range of the difference over 60ms bins (in the first 10s of the trial) exceeded a threshold of 30 degrees, indicating unrealistic variability and therefore poor sensor fusion estimates, then these data were excluded. We share a subject information table indicating which IMUs were included in our analysis of joint kinematics (Table 2). The values of 45 degrees and 30 degrees were chosen based on the data of five trials and kept constant for all the 20 trials in this study. Seven of 11 subjects had at least one IMU excluded from analysis.

**Table 2. IMUs used in inverse kinematics per subject**

|  |  |  |
| --- | --- | --- |
| Subject | IMU sampling rate (Hz) | Excluded IMUs |
| 1 | 100 | both feet |
| 2 | 100 |  |
| 3 | 100 |  |
| 4 | 100 |  |
| 5 | 100 | right body (were not transmitting data), left foot; all data stopped transmitting for sequence of lower extremity movements and was excluded |
| 6 | 40 | right foot |
| 7 | 100 |  |
| 8 | 100 | left foot |
| 9 | 100 | both feet |
| 10 | 40 | right foot |
| 11 | 100 | both feet |