Functional calibration for trunk and lower limb fixed inertial sensors Version 2

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Abstract

Calibration procedure for functionally aligning inertial sensors fixed to the shanks, thighs, and trunk (e.g. sacrum, sternum). The movements were originally designed for analyzing skiing movements where the person is wearing ski boots. However, the same protocol can be applyied also barefoot or with regular shoes.

Please refer to the protocol's guidelines for more information how to obtain a sample data set and the matlab code needed to process the functional calibration.

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Guidelines

- Before each movement, the person should remain motionless for 1-2 seconds to allow better data segmentation.
- Trunk rotation: ski poles are only needed to ensure a better control of the rotation axis. The movement can also be performed with the hands held behind the head.
- Hip ad/abduction: ski poles are only needed for balance. The movement can be performed without ski poles but requires quite good balance control abilities of the person.

The code to analyze the data and the data from the functional calibration filmed from the lateral view has been posted on Code Ocean, under the DOI 10.24433/CO.3f699198-4e77-4d51-8482-13d1b9ad93b8

Before start

Place the inertial sensors on the shanks, thighs, and trunk (e.g. sacrum, sternum). The exact sensor orientation does not matter, i.e. they don't need to be put in the exact same way for each new experiment. However, the sensors should be placed such as to reduce soft tissue artefacts. A good example of soft tissue artefacts of the thigh can be seen at the beginning of the functional calibration

for the hip ad/abduction movement. Activation of the thigh muscles at the start of the movement are moving the inertial sensor visibly upwards.

For example, a good location for the shank sensors is the tibial plateau, about 10-15cm below the knee, slightly medially.

Protocol

Squats with rolling spine

Step 1.

Slow squats with knee, hip, trunk, head flexion. Arms are parallel to the leg. Perform the flexion movements until the fingers reach the ankles. Perform the movement three times.

Squats front view

Squats lateral view

Trunk rotations

Step 2.

Slow trunk rotations around the vertical axis with hips fixed. Arms hold a ski pole lying horizontally behind the neck. Head turns with the trunk. Perform the movement three times where the rotation starts by looking to the right.

Trunk rotations frontal view

Trunk rotations lateral view

Hip ad/abduction

Step 3.

Slow hip ad/abductions of first the right leg. Control balance using the ski poles. Right heel is

positioned in-line with left toe. Keep knee straight through the entire movement. Perform the movement of slow hip abduction and adduction three times. Then perform the same with the left leg.

Note: Athletes have the tendency to externally rotate their hip during the hip abduction. The toes should always remain pointing forwards, with no external hip rotation. Train the correct movement a few times prior to perform the entire functional calibration procedure.

Hip ad/abduction frontal view

Hip ad/abduction lateral view

Upright standing

Step 4.

Stand upright with knees slightly flexed. Keep equal weight on both feet. Look straight to the front. Stand still for 10 seconds.

Upright frontal view

Upright lateral view