Evaluation of a Novel Knee Sensor That Requires Neither Calibration Nor Strict Sensor Placement

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Disclosures

Consultant/Speaker

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S&N

Introduction

- Measurement of knee range of motion (ROM) is crucial in the assessment of knee replacement recovery.
- Inability to regain proper knee flexibility can lead to pain, stiffness, limited function, manipulation, or revision surgery.
- Goniometers are used generally used in clinical settings because of simplicity, but its accuracy and reproducibility are limited.
- Recently, wearable sensors have gained popularity for ROM measurement overcoming the limitations of traditional goniometers.
- However, modern sensors can be limited by placement relative to the studied joint axis of rotation and by calibration requirements.

Objective

• The purpose of this study is to evaluation a novel wearable sensor system which eliminates sensor placement issues and does not require calibration movements.

Methods

- This wearable system employs two wearable sensors that are placed on the thigh and calf with adhesive patches to measure knee ROM.
- No calibration is required after sensors are placed on the limb.
- The sensors communicate to a mobile device through Bluetooth and display real-time knee ROM via mobile app.
- Twenty-nine participants were asked to perform three repetitions of sitting, sit-to-stand transition, and standing.
- ROM was measured with the wearable system and simultaneously the participant's activity video recorded and processed with Google Media Pipe Pose tool to extract knee ROM for comparison.

Results

- Knee angle MAE mean ± std for 29 participants was 3.195 deg ± 2.191 deg.
- The results are displayed in Table 1.
- It can be seen from Table 1 that the participants wore sensors at different distances from the knee joint.
- The wearable system can still be able to reliably measure knee ROM for various sensor placements.

Results

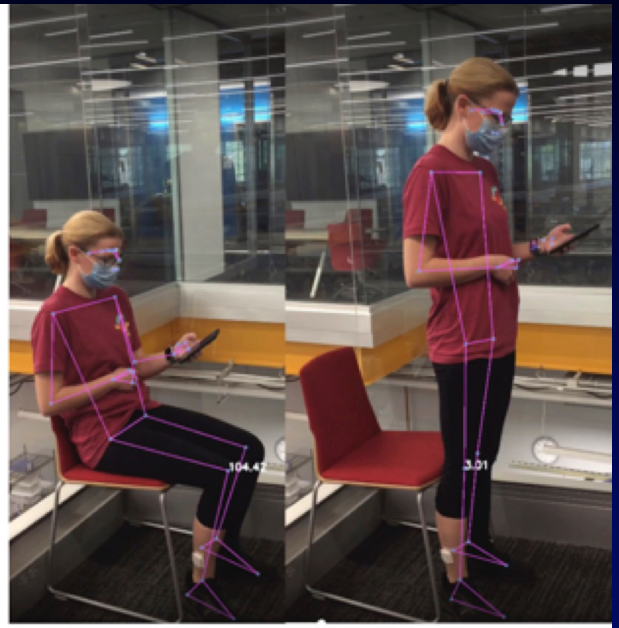

Figure 1: On the left, the participant holding a sitting position leaning back to the chair. On the right, the participant is holding a standing position. The points and lines are the Google Media Pipe tool derived pose estimation key points and line segments connecting body key points. The numbers shown in the image are the knee angle computed by video pose tool at that instant of time.

Participant ID	Thigh sensor lateral placement from the knee joint (cm)	Calf sensor lateral placement from the knee joint (cm)	Mean Absolute Error (degree)
2	34	35	1.33
3	39	37	1.33
4	29	32	4.67
5	32	31	2.33
6	35	34	2.33
7	31	37	4.33
10	36	31	7.67
11	N/A	N/A	5
12	N/A	N/A	0.67
13	30	29	5
14	26	28	3.33
15	37	32	4.67
16	33	30	1
17	20	23	0.33
18	29	28	1
19	28	29	8.33
20	29	29	1.67
21	31	24	2
22	27	30	3.33
23	19	23	4.67
24	36	27	2.33
25	33	36	1
26	30	29	2.33
27	27	29	2.67
28	30	28	2
29	18	29	5.67
30	33	37	1.67
31	25	29	2.33
32	33	27	7.67

Table 1: displaying thigh and calf sensors placement for 29 participants and corresponding knee total motion MAE in degrees, calculated by taking the mean of the difference between wearable system knee angle output and video pose tool knee angle output.

Discussion

• This wearable system eliminates the drawbacks of current wearable sensors in terms of sensor placement, avoiding tedious calibration movements, and reliably measuring joint range of motion. Ease of use is critical for patient compliance and data gathering.