

# Inter-session repeatability of joint positions with a simple alignment device combined with functional joint calibration

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## Summary

Repeated marker-based movement analysis challenges the determination of joint centers and reference position. This study combines a simple alignment device with functional joint calibration for knee and hip joints. Results show good repeatability, however, knee extension during the reference position may need to be monitored.

## Introduction

When performing marker-based movement analysis with repeated measurements, the repeatability of marker placement and neutral standing position influences the comparability of data. Marker placement is especially relevant when the underlying model depends on markers placed on specific anatomical landmarks, e.g. on the medial and lateral side of the knee joint axis. To overcome intra- and inter-tester differences in placing anatomical markers, joint axes and centers can be determined using functional calibrations [1,2].

Alignment devices have been described to increase repeatability of marker placement [3] or eliminate the need for anatomical markers in subsequent data collections [4]. These alignment devices are quite complex and may be susceptible to interrater variability.

The aim of this study was to assess whether joint positions differ between sessions when using functional calibrations and a simple alignment device for the static trial.

## Methods

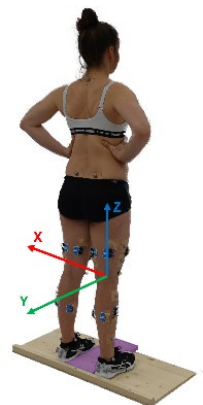
Data from 15 female participants were collected at two sessions at least 7 days apart. They performed a static standing trial in a simple alignment device. It consisted of a wooden plate with a slat against which the heels were positioned. Additionally, a wooden rectangle was placed between the feet with the medial border of the shoe soles touching it (Figure 1, in purple). The width of the rectangle was selected by the participant at the first session to allow for neutral hip-width stance. Markers were placed on the lower extremities according to a cluster model [2]. Functional calibration was performed for knee and hip joints to determine the knee joint axes and centers as well as hip joint centers.

To determine the repeatability of the standing trial, the position of the left knee (KJC) and right/ left hip joint centers (HJC) were expressed relative to the right knee coordinate system (Figure 1). Wilcoxon signed-rank test was used to find statistically significant differences between the sessions.

## Results and Discussion

The results (Table 1) showed no significant differences between the two sessions, indicating sufficient inter-session repeatability of the standing position.

The right HJC showed smaller differences than the left KJC and HJC which, given the proximity to the right KJC, seems plausible. In all three joints, the difference between sessions was greater in y-direction than in x- and z-direction. This may be explained by potential differences in knee (hyper-) extension that can shift the knee relative to the hip joint (or relative to the contralateral knee) with little influence on the vertical or medio-lateral direction.



**Figure 1:** orientation of coordinate system of right knee

## Conclusions

A simple alignment device in combination with functional joint calibrations determines joint centers and neutral standing position with high between-session repeatability. Standardizing the knee extension may further improve the repeatable standing position.

## Acknowledgments

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## References

- [1] Leardini A et al. (1999). *J Biomech*, **32**: 99-103.
- [2] List R et al. (2013). *J Strength Cond Res*, **27**: 1529-1538.
- [3] Noehren B et al. (2010). *J Orthop Res*, **28**: 1405-1410.
- [4] Hutchinson L et al. (2018). *J Biomech Eng*, **140**: 1-7.

**Table 1:** Median/ IQR of difference between the two sessions of position of left knee joint center (L KJC), right/ left hip joint center (R/L HJC) in x,y,z-coordinates of the right knee coordinate system. P-value based on Wilcoxon signed-rank test adjusted for multiple comparisons.

n = 15	L KJC x	L KJC y	L KJC z	R HJC x	R HJC y	R HJC z	L HJC x	L HJC y	L HJC z
Median difference [mm]	2.8	11.7	5.9	4.6	8.5	6.8	14.5	16.4	4.4
IQR [mm]	4.4	18.8	15.8	10.3	8.7	5.1	17.3	26.2	11.2
p-value	0.09	0.11	0.08	0.11	0.08	0.08	0.06	0.07	0.08