

# Virtual Reality based Double Leg Squat Exercise: Preliminary Study

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## Introduction

- The double leg squat exercise is a very important functional performance test that involves generation of extensor moments at the hip, knee, and ankle to control the descent and ascent of the centre of mass to assess and improve lower body strength of individuals with knee problems [1,2].
- In our laboratory, knee patients were found to use various compensation strategies including asymmetry of the support moment during a double leg squat in order to reduce the knee moment in the injured knee [3].
- It has become important to explore how feedback about hip, knee, and ankle moments during squatting can be provided. An augmented targeted-biofeedback application is therefore being developed to help individuals with knee problems to perform the exercise with a symmetrical support moment and a similar contribution of the knee to the total support moment in both legs.
- The aim was to investigate if Virtual Reality (VR) based on kinetic feedback can be used in aiding individuals to alter their kinetic squatting strategy.

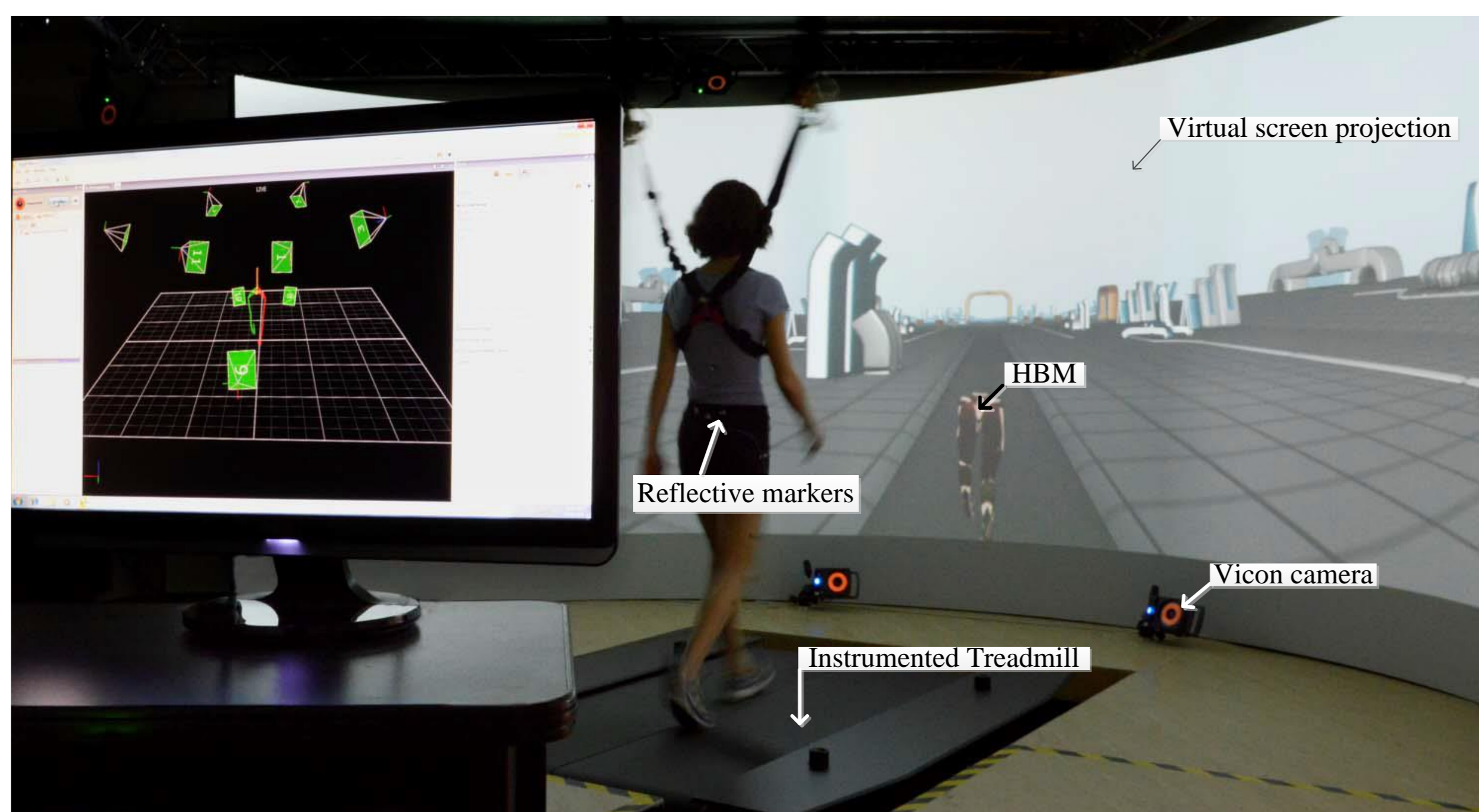


Fig. 1: The Cardiff Gait Real-time Analysis Interactive Lab.

## Method

### Application

- In-house VR environment was developed and implemented on the Cardiff Gait Real-time Analysis Interactive Lab as can be seen in Fig. 1 (GRAIL system, Motek Medical).
- The GRAIL system consists of an instrumented dual-belt treadmill, a 12-camera Vicon MX optical infrared tracking system (Oxford Metrics, Oxford, UK) and synchronised VR environments.
- HBM kinetic and kinematic calculations were used within D-Flow software to compute the symmetry of the support moment (%SYSM) between both legs, which was calculated using the following equation [4]:

$$\%SYSM = \frac{2 * \text{Left Moment}}{\text{Left Moment} + \text{Right Moment}} * 100$$

### Task

The volunteers were asked to perform 10 double leg squats at their comfortable speed during each condition. The conditions were:

- The first condition was without feedback.
- The second was augmented by means of a real-time lower limb stick-figure (see Fig 2.A).
- In the third condition they were instructed to move a virtual object towards a target that refers to 100% leg symmetry of their support moments (see Fig. 2.B).

## References

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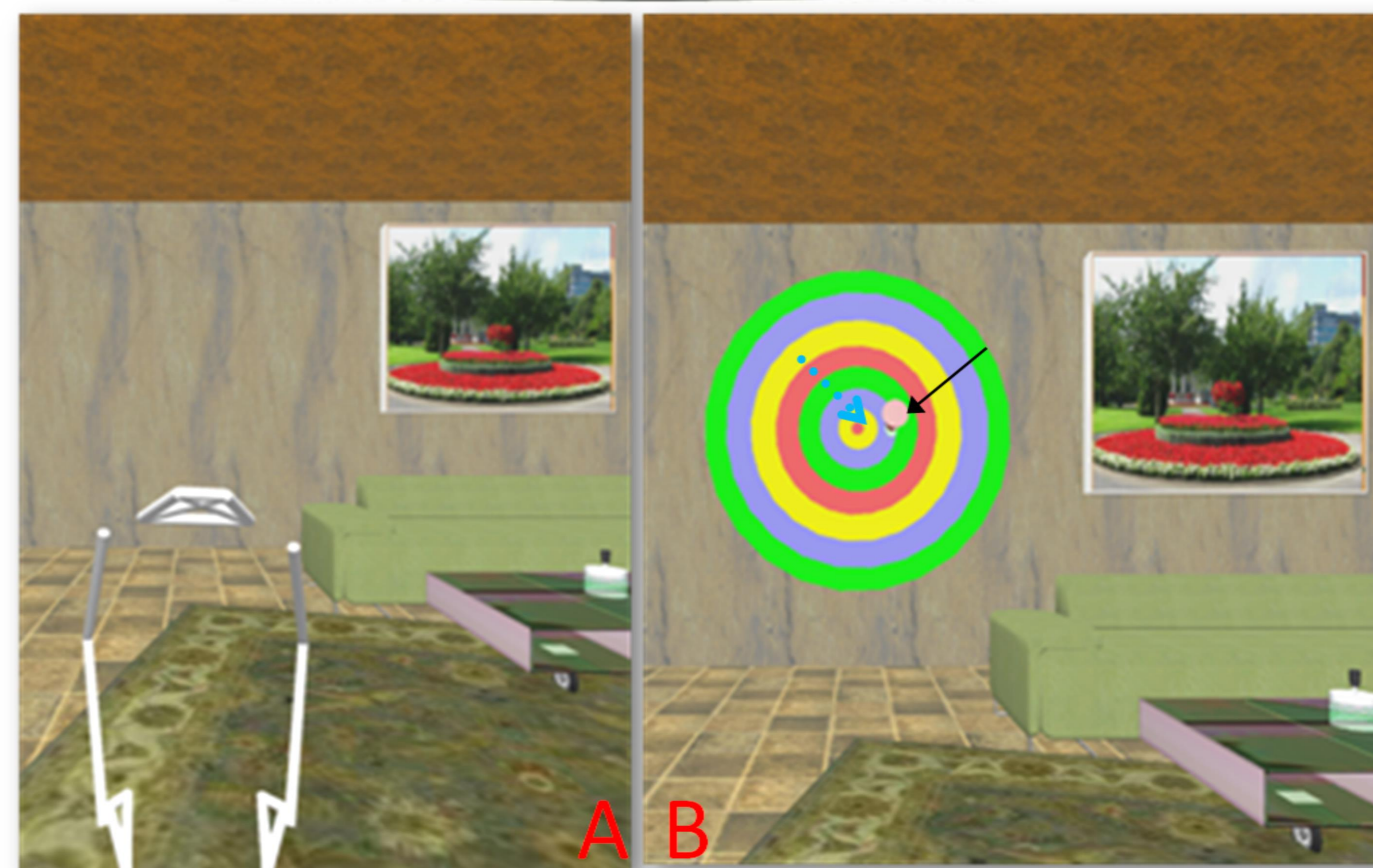


Fig. 2 : A screenshot of the virtual room. A: during the second trial, and B: during the third trial; the blue arrow refers to the target position (where %SYSM is 100) while the black arrow refers to the virtual object that driven by the SYSM.

## Outcomes

The study sought to explore the following:

- Analysis of Symmetry of the Support Moment between both legs.
- Collective feedback through responses to three closed-ended questions relating to safety, enjoyment, and ease of controlling the virtual object.

Table 1: Mean percentage of the total symmetry of the support moment with standard deviations.

	Condition 1	Condition 2	Condition 3
The mean of %SYSM (± StDV)	101.9 (12.3)	106.1 (13.1)	100.4 (9.4)

## Results and Discussion

- The preliminary results (see Table 1) indicate that controlling the virtual target can aid volunteers to equally distribute the support moment over both legs with least variation.
- Although the majority of the volunteers believed that their virtual stick-figure helped to squat with a better posture, the results demonstrate higher variation in symmetry of the support moment during this condition compared to the first and third condition.
- VR based on kinetic feedback is usually inaccessible to subjects in conventional approaches. This double leg squat exercise allowed them to succeed in using a biomechanically constrained strategy.
- The majority safely and easily controlled the virtual target with an adequate level of enjoyment.

## Conclusion

- The real-time visual targeted-feedback seems feasible in altering individuals' strategies to squat.
- The future development of the current biofeedback application is to present a combined visual targeted-feedback based on the moments around the hip, knee, and ankle in order to alter motor control in individuals with knee injuries to minimise the use of inappropriate compensation strategies.

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