Introduction: Wear discrepancies between retrieved and simulator-tested total knee replacement (TKR) polyethylene liners have been reported. Since standardized pre-clinical wear simulation uses load and motion from level walking only, the divergence between retrieved and simulator-tested liners could be related to the omission of other activities, such as stair ascent/descent and/or chair sitting/rising.

While walking has been regarded as the most frequent physical activity throughout the day, human life incorporates a greater variety of daily activities, with even more complex combinations and transitions. These activities, in spite of the lower frequency, may generate loads and motions that are more demanding for the polyethylene liner than walking.

In this study, the primary (flexion/extension) and secondary (anterior/posterior and internal/external) motions of the TKR joint were determined during level walking, chair and stair activities. The objectives were to identify significant differences between the joint motions of different activities, and to provide support for the development a multi-activity wear testing protocol. We hypothesized that the secondary motions of the TKR joint will be significantly different between walking and chair and stair activities.

Methods: Twenty-three TKR subjects (9M/14F, 60.8±7.1 years old, 41.8±29.7 months post-op) with a NexGen-CR prosthesis (Zimmer Inc., Warsaw, IN USA) participated in this IRB approved study. Participants were younger than 70, at least 12 mo. post-op and able to function independently without assistive devices. All 23 subjects were gait tested in the Rush Human Motion Laboratory using the point cluster technique. Knee flexion/extension angle (FE) anterior/posterior displacement (AP) and internal/external rotation (IE) were determined during walking, chair sitting and rising and stair ascent and descent activities for each subject. Three trials per subject and activity were conducted to calculate average kinematics for analysis to obtain a representative average, confirmed outliers (using Grubb’s test) were not included. All subjects’ AP and IE motions were then set to zero at 45 degrees of knee FE angle. This was done in order to establish an equal reference point in the motion data, since we were interested in relative motion only. For each activity, a representative motion pattern was created by averaging all the subjects’ motion data at every percent of the loading time. Ranges of motion for each activity and motion direction were computed and used to identify differences between activities. Paired-sample T Tests were conducted to evaluate if the amount of AP displacement or IE rotation was significantly different between activities. A p-value of 0.05 or less was considered significant.

Results: Range of motion (Figure 1) and motion profiles (Figure 2) were calculated for all activities. AP displacement and IE rotation were significantly higher for chair and stair activities when compared to walking (p < 0.04).

Discussion: Other activities are often neglected because of their lower frequency when compared to walking. While their frequency is lower, the amount of AP displacement and IE rotation exerted during chair sitting and rising and stair ascent and descent were significantly higher than those exerted during walking. These findings support our hypothesis.

Given that polyethylene wear is a function of load, sliding distance, and cross-shear, it is clear that the range of motion and thus sliding distance under load is much larger for chair and stair activities than walking.

In conclusion, this study provides kinematic data during chair and stair maneuvers which will be helpful in the establishment of multi-activity protocols for TKR wear testing. Secondary motion ranges were significantly higher during chair rising and sitting and stair ascent and descent compared with walking and thus will be more challenging for most prosthetic devices.


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