INTRODUCTION

Total knee arthroplasty (TKA) is one of the most common surgeries in the United States for end stage knee osteoarthritis (OA). TKA reduces pain and disabilities in this population; however, the patient’s functional performance is not comparable to that in people without any knee problems 1 year after TKA [1]. After TKA, patients demonstrate functional improvement and more satisfaction with their functional abilities; however they still have marked impairments, functional limitations, quadriceps weakness and asymmetrical movement patterns [2, 3, and 4]. Quadriceps strength symmetry explains a small portion of symmetry in biomechanical variables [3] and even patients who participate in rehabilitation programs that focus on progressive strengthening after surgery demonstrate persistent kinetic and kinematic asymmetries [5]. During a sit to stand task (STS), subjects who underwent TKA demonstrated altered movement patterns that unloaded the operated limb and shifted the weight to the non-operated side [3,4,6]. This altered movement pattern may lead to excessive loading in the non-operated limb, thus predisposing the joints of the non-operated limb to OA progression in the long term. Therefore, rehabilitation strategies for individuals after TKA may need to address impairments in movement symmetry in addition to progressive strengthening in order to maximize movement symmetry after TKA.

The purpose of this study is to evaluate the effectiveness of adding a symmetry training component into post-operative rehabilitation. Our first aim was to examine longitudinal changes in STS mechanics in subjects received symmetry training along with strengthening exercise after TKA. The second aim was to evaluate the biomechanical differences between subjects who received symmetry training and subjects who received standard of care alone after TKA.

METHODS

Eight subjects with primary unilateral TKA were recruited for this study. Four subjects received strengthening exercises plus symmetry training (2 women, Age 58 ± 4.2y) and the other four subjects underwent standard of care rehabilitation (2 women, Age 58.5±3.7). The standard of care protocol consisted of progressive quadriceps strengthening, functional retraining, appropriate manual therapy and modalities to reduce post-operative inflammation that began 3-4 weeks after TKA. The symmetry training consisted of the same protocol, but also includes a progressive symmetry retraining program that focused on improving symmetry of weight distribution between limbs during strengthening and functional retraining exercises.

All subjects underwent 3D motion analysis of STS task using an 8 camera infrared motion system (Vicon) and 2 force-plates (Bertec). Inverse dynamic techniques were used to calculate Joint angles and joint moments for each limb. Subjects in the symmetry group were tested before surgery, 3 months, and 6 months post-surgery while subjects in the other group were tested only 6 months after surgery. The outcome measures used were the symmetry ratio of peak sagittal knee moment (PSKM) during standing, peak vertical ground reaction force (PVGRF) during standing, during sitting and vertical ground reaction force (VGRF) while standing. Symmetry ratio was calculated by dividing the outcome value of operated side by that of the non-operated side. 3-month follow up was not obtained for one subject in symmetry group. Qualitative comparisons were made between time points and groups.

RESULTS AND DISCUSSION

For the first aim, subjects in symmetry group showed improvements in symmetry in all outcome
variables across time. The ratio of PSKM increased by 11.3% from pre-operative to 3 months and 27.3% from 3 months to 6 months. Ratio of PVGRF during standing increased from pre-operative to 3 months by 2.1% while increased by 10.3% from 3 months to 6 months. Symmetry in PVGRF during sitting increased from pre-operative to 3 months by 8.3% while increased by 7.7% from 3 months to 6 months. While VGRF symmetry while standing increased from pre-operative to 3 months by 16.4% while increased by 3.1% from 3 months to 6 months. Results for the second aim showed more symmetry in Symmetry group compared with standard of care group. Persons 6 months after TKA in symmetry group demonstrated more symmetry in all outcome variables. Symmetry subjects at 6 months after TKA showed more symmetry than the other group by 38.3%, 11.3%, 25.4%, and 16.5% in PSKM during standing, PVGRF during standing, PVGRF during sitting, and VGRF while standing respectively.

CONCLUSIONS

The improvements in biomechanical symmetry in the subjects who received symmetry training suggest the need to include elements beyond strengthening in the rehabilitation programs for patient after TKA. Although early post-operative strength deficits may resolve with training, this protocol may improve normal and symmetrical dynamic movement pattern. These protocols may provide a reduction in loading on the non-operative side and restore normal movement on the operated side. Most post-surgical rehabilitation regimes address muscular and functional deficits; however no regimens have been established to overcome the asymmetrical movement patterns that result in excessive loading on the uninvolved limb. In our sample, we also noticed a marked improvement between the 3 and 6 month time points and symmetry ratios at 6 months exceeded the standard of care group. It is possible that this improvement is attributable to continued use of a more asymmetrical movement pattern that promotes strength on the operated limb during daily tasks. We will continue to evaluate this novel symmetry protocol in a larger subject pool.

REFERENCES


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| Table 1: Sit to stand parameters [mean (standard deviation)] |
|---------------------------------|----------------|----------------|----------------|----------------|
|                                | Symmetry Group | Standard care |
| Outcome measure                | Pre-surgery    | *3-months after TKA | 6-months after TKA | 6-months after TKA |
| PSKM Ratio                     | 0.58 (0.2)     | 0.64 (0.09)    | 0.82 (0.22)    | 0.59 (0.18) |
| PVGRF Ratio during standing    | 0.84 (0.15)    | 0.86 (0.19)    | 0.95 (0.14)    | 0.85 (0.14) |
| PVGRF Ratio during sitting     | 0.84 (0.14)    | 0.91 (0.09)    | 0.98 (0.15)    | 0.78 (0.1)  |
| VGRF Ratio while standing      | 0.86 (0.12)    | 1.01 (0.08)    | 1.00 (0.13)    | 0.89 (0.1)  |

* This is the data of 3 subjects; one session couldn’t be obtained for one subject.