CHAPTER 6

DISCUSSION
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The aim of the current study is to determine the effectiveness of additional hip abductor strengthening exercises on the quality of life and functional outcome following 12 weeks of intervention post total knee replacement. The results of the current study proven that addition of hip abductor strengthening exercises for 12 weeks duration has the potential to improve the performance based measure of SMWT and TUG.

The primary objective of the study was to find the effects of hip abductor strengthening exercise on quality of life using the SF - 36 questionnaire. The SF -36 quality of life questionnaire describes the overall health status of the administered participants. The summary of the 8 health dimension domains of the SF - 36 subscale was computed as a physical component summary (PCS) and mental component summary (MCS).

6.1 Short Form - 36

Our study found significant changes in the PCS domains from a baseline value of 37.4 (6.5) to 50.3 (4.5) at 3 months in the experimental group and 35.7 (5.2) to 47.8 (5.2) in control group following the intervention. The between group analysis showed a 34.4% of change occurred in the experimental group and 28.9% of the change in the control group. An intensive functional rehabilitation study with a similar baseline value of PCS subscale didn’t show significant changes with a mean change of 3.1 ± 7.8 in control group and 6.0 ± 9.0 in the experimental group. 24

The findings of the current study were superior in the improvements observed with a mean change of 12.7 in the experimental group and 12 in the control group. A
PCS score of 50 is reflected to be normal and a change of 5 points is considered to be the minimal clinical importance difference for the PCS.\textsuperscript{121,122}

The present study didn’t found a statically significant change in the mental component summary. The MCS showed an 11.1\% of the change in the experimental group and -4.6\% of the change in the control group. Similarly, a previous study on MCS didn’t found significant changes in both the groups following the intervention. Tan et al.\textsuperscript{123} in their study reported that only 65\% of patients shown improvement in MCS scale at 6 months and 2 years following unilateral TKR. The authors stated the participants reported a normal value of 50 at all-time points and had a mean change of 51 to 55 at 2 years. The current study participants reported a change of 5 points from a baseline value of 43 (8.4) to 47.8 (7.5) at 3 months duration which was considered as clinically significant and it’s as good as the reported normal value of 50 points.

The SF - 36 physical domains (physical function, role physical, bodily pain, general health subscales showed a statistically significant change at 3 months post intervention in both the groups with a p value of (< 0.001). The within group analysis found the experimental group improved from a baseline value of 37.3 (21.8), 38.3(20), 35.9 (23.4), 57.7 (21) in physical function, role physical, bodily pain, and general health to 68.2 ± 12.7, 64.1(20.2), 74.1(15.3) and 81.6(11) points respectively. The control group participants improved in the physical function, role physical, bodily pain and general health from a baseline value of 30.9 (19.4), 40.2(21.9), 31.4(17.9) and 57.8(15.4) to 3 months value of 60.4 (13.7), 55.7 (19.6), 64.1(17.8) and 71.4 (14.1) respectively. The observed improvement both the group was statistically significant and exceeds the minimal clinically important difference of 11 to 16 points reported for the physical domain scales.
The mental health domain consists of vital health, social function, role emotion and mental health subscales. The observed baseline value was 53.3 (18.6), 55.6(23.3), 46.2 (24.4), 58.4 (18.5) in experimental group and 52.4 (14.8), 47.9 (24.3), 47.3 (23.7) and 60.6 (18.2) in control group in the subscales of vital health, social function, role emotion and mental health respectively. Both the groups showed a statistical significant change from a baseline value to 3 months post intervention in mental health domains. At the 3 months post intervention, the experimental group showed significant improvement of 64.6 (16.8), 63.2 (18.3), 65.4 (22), 71.5 (16.2) and 55.6 (23.3) in mental health domain subscales. The observed improvement in the control group also similar at 3 months following intervention with 74.3 (17), 65.4 (220, 57.2 (20.2) and 61.5 (16.1) in the mental domain subscales.

The previous study revealed more improvements were observed in physical function and bodily pain subscale of SF - 36 at 3 months duration. Our study results showed a change of 82.8%, 73.1 in experimental and 95.4%, 63.1 in control group on physical function and bodily pain domains respectively. Larsen et al. in their study assessed the effect of fast track rehabilitation on TKR subjects and displayed 62.8(23.0) at 4 months in SF -36 physical function subscale, the finding was similar to our study. A non randomized control trial on TKR in Asian participants did not found significant changes in mental domain scales at 6 months and 2 years post TKR, however, their study found significant changes in the physical function domains of SF- 36 at 6 months and 2 years following TKR.

Clement et al. in the prospective study found that physical component summary score of less than 40 would predict dissatisfaction following TKR, despite the improvements observed in the functional tests. Our study participants found a post-
operative score of 50.3 (4.5) in the experimental group and 47.8 (5.2) in control group at 3 months following the intervention. The findings in the current suggest the patient’s satisfaction and general wellbeing was improved in both the groups following the TKR.

Larsen et al.\textsuperscript{125} in their study found the general well-being is not improved to the level of the age matched population norms even when there is an improved quality of life. Becker et al. revealed the operated knee alone can’t predict the success following TKR, general health, emotional status and knee function could be considered for the full patient’s satisfaction. The findings of the current study with significant changes in PCS and other domains of the SF - 36 implies their general well-being, enhanced quality of life and satisfaction was achieved to the desired level following the TKR in both the group participants.

Thambiah et al.\textsuperscript{127} assessed the patient satisfaction compared with the commonly used scoring system SF- 36 for those who underwent TKR in the Asian population. Their study findings presented a change in mean score of 21.1 (7.6) in PCS and 11.8 (52.5) in MCS patients were satisfied following TKR. Our study participants found a mean change PCS and MCS subscale with 12.7, 4.7 in experimental and 12.0, 1 point in the control group at 3 months following TKR. However, a statistically significant improvement in PCS sub scale was observed in both the study, the patient satisfaction was not measured in the current study.

6.2 Knee Injury and Osteoarthritis outcome Score

The KOOS subscale showed significant changes in all the subscales expect the sports and recreation. Both the group participants showed a significant change in pain, symptom, function, and quality of life subscales at 1 month and 3 months post intervention regardless of the intervention.
Similar results were observed by Eli et al.\textsuperscript{128} in their randomized controlled trial, the preoperative physiotherapy versus no physiotherapy before the TKR found no significant changes between the groups at 6 weeks and 3 months post intervention. Their study found a mean difference of 20.9, 36.1, 29.2, 18.7, 35.4 in the experimental group and 14, 37.4, 27, 18.1, 37.4 in control group at 3 months in symptoms, pain, ADL, sports & recreation and quality of life KOOS subscales respectively. Our study findings were similar to their findings in all KOOS subscales except the sports and recreation subscale in experimental group and control group at 3 months following the intervention.

The participants in our study stated the questions in the sports and recreation subscale was inappropriate following TKR. The participants were asked to mark on activities like running, jumping, twisting or pivoting the injured knee on a Likert scale, these questions were inappropriate in the early recovery period of the TKR, this could probably a reason for not showing any significant changes in this subscale. Lowe CJ et al.\textsuperscript{129} in their pilot trial reported their phase III trial was not included this subscale due to the inappropriate questions and their subjects were not fully completed this subscale.

Skou et al.\textsuperscript{130} in their randomized Controlled trial compared the total knee replacement effectiveness versus non-surgical conservative therapy for knee osteoarthritis patients. Their study found the KOOS subscale was improved in the clinical pain, symptom, activities of daily living and quality of life subscales. Our study also found the improvements in subscales with their study other than KOOS sports and recreation subscale.

Villadsen et al.\textsuperscript{131} compared the effects of neuromuscular exercises post arthroplasty of the hip and knee. The 8 weeks of the neuromuscular training didn’t found any additional changes in the experimental group when to the total joint arthroplasty...
group alone. Their study conferred the short term benefit was observed in the intervention group on ADL, pain and QOL subscale with 5-8 points at 6 weeks post arthroplasty. The present study found a mean change of 15.4, 10.7, 15, 18 points at one month and 26.8, 21.1, 26.8, 34.7 at 3 months in the experimental group for KOOS subscales of pain, symptom, ADL, and QOL. The previous study revealed the difference of a minimum of 10 points on a total score of 100 is accepted as a clinically important difference in the KOOS self-reported survey instruments. Our study findings exceeds the clinically important differences of 10 points in both the groups at 1 month and 3 months post intervention following TKR.

6.3 Hip abductor strength

The baseline hip abductors strength in both the groups revealed there are no significant differences between the groups, the experiment group showed a statistically significant change at 4 weeks and 12 weeks post intervention. McGibbon et al. found significant changes in the hip abductor strength measured using a hand held dynamometer following six weeks of strengthening exercises and functional training exercises on OA participants. Both the groups improved on hip abductor strength following the interventions in their study.

Another study by sled et al. showed improvement in hip abductor strength following 8 weeks of home programme on knee OA participants. The increment in the hip abductor strength led to a reduction in pain and enhanced function measured using sit to stand test. Their study findings exposed that hip abductor strengthening can be beneficial in reducing the pain and increasing the function for those who diagnosed with knee OA.
Our study findings revealed similar findings, the participants who underwent hip abductor strengthening following TKR showed improved function. The participants showed a mean change of 7% at one month and 19 % at 3 months in hip abductor strength in the experimental group. The observed improvement in the control group was 0.2% at one month and 6 % in 3 months.

The augmentation in the hip abductor strength observed in the experimental group could possibly enhance the performance based measure of SMWT at one month and 3 months duration. The enhanced strength of the hip abductors may have reduced the lateral trunk lean during the performance based tests on the stance leg and increased trunk stability. The 12 weeks of hip abductor strengthening regime could have increased magnitude of the lever arm at the knee and nullify the knee adduction torque, which could further increase the speed and distance of the walking.

A recent pilot trial on hip abductor strengthening following TKR by Karvannan et al. found similar improvements in the performance based measure of SMWT, TUG and single leg stance test. Their study findings exposed that the hip abductor strengthening could be a potential contributor of function following TKR.

### 6.4 Performance based functional measure

The hip abductor exercise regime showed a better performance in the outcome measure of six minute walk test (SMWT) at one month and 3 months duration when compared to the control group exercises. The timed up and go (TUG) functional test showed significant changes at 3 months duration and maintained to preoperative functional level at one month in both the groups.
6.4.1 Six-Minute Walk Test

The participants in the experimental group walked further during SMWT when compared to the control group. The minimal detectable change MDC in the SMWT was reported to be 61.34 m in TKR cohorts. The within group analysis shown that MDC was observed in both the groups at 3 months following the intervention, between group analysis has shown that the participants in the experimental group improved 77% at 3 months post intervention whereas the control group participants found only 46% during the same period.

The improvement in the walking distance can be attributed to the hip abductor strength, which are well known stabilizers of the hip and pelvis during walking. The hip abductors are important in producing the lateral stability during walking by transferring the forces from lower limb to the pelvis. The hip abductors yield an abduction torque during the stance phase of the gait by stabilizing the pelvis in relation to femur which could possibly result in enhanced walking following hip abductor strengthening exercises. The previous pilot study found similar improvements in SMWT during 3 months and also at one year duration and concluded the hip abductors strengthening could be an important factor in improving the physical function following TKR surgery. A high intensity rehabilitation following TKR showed the significant changes in SMWT at 3 months duration with the difference of 71 m ($p = .06$; 95% CI: -4, 146). The control group participants in our study reported similar improvements with a mean change of 85.5 m at 95% CI (104.9, 66.2) with $p < 0.001$. However, the experimental group participants walked further with a mean change of 117.5 m at 95% CI (133.9, 101.2) with $p < 0.001$ at 3 months duration.
A study by Moffet et al.\textsuperscript{24} found the effectiveness of intensive functional rehabilitation following TKR and presented that the participants in their experimental group walked more distance 78.5 (56.3) meters in SMWT at 4 months following TKR. The findings of the study were similar to our participants and the same amount of improvements, which was achieved at 3 months following hip abductor strengthening in the current study.

6.4.2 Timed up and go test (TUG)

The TUG is designated as a global functional test which was made known to be a reliable and good prognostic factors for falls among elder peoples. Following the hip abductor strengthening exercises in the experimental group, the time taken to complete the timed up and go test (TUG) was reduced at 3 months and showed a statistically significant mean change of 3.9 sec at 95% CI of (2.9, 4.9). After 1 month post intervention, the TUG was similar to the preoperative levels in both the groups.

Earlier studies revealed a deficit in TUG at one month\textsuperscript{22-24} and 30% more time to complete the TUG at 2 months post TKR.\textsuperscript{24} However, our study found a significant change this could be possibly due to the reduction in pain following TKR since the reduction in pain is often the impetus to perform the functional activities. Also, the resultant functional recovery, superior to the previous findings may due to the early mobilization while preserving posterior cruciate ligament. The knee joint posterior cruciate ligament has mechanoreceptors thus preserving it would improve the joint position sense which could possibly enhance the early recuperation of knee ROM, pain, and TUG following rehabilitation.\textsuperscript{134-136}
A study by Bade et al.\textsuperscript{69} in their randomized controlled study found the high intensity rehabilitation patients performed TUG with 4.3 seconds faster at 4 weeks and 1.9 seconds faster at 12 weeks duration when compared to the control group. Our study findings revealed that the participants performed the test similar to the preoperative level at one month and significant changes were observed in performing the test at 3 month duration between the groups.

Liao et al.\textsuperscript{137} in their study with an additional balance exercise of 8 weeks of duration found a superior improvement in relation to the control group participants. Their study found an improvement in TUG at 95 \% CI of 2.6 to 3.4 sec. Our study found superior improvements with a mean change of 3.9 at 95\% CI of 2.9 to 4.9 sec after 3 months of hip abductor strengthening exercise post TKR.

The hip abductors strengthening regime following TKR lead to an early short term recovery in physical function which further improved the ability to perform daily activities. The participants performed their ADLs with less pain and difficulty which favored the more active life style of the experimental group participants at least in short term following the intervention post TKR.

Previous studies had reported that quadriceps strength is a strong predictor of the physical function following TKR, about 37 \% variability in the performance tests like TUG and SMWT was reported in relation to the strength of the quadriceps muscle.\textsuperscript{22, 23} However, the studies have proven the positive correlation between hip abductor muscle strength with physical function following TKR also the weakness of the hip abductors resulted in poorer function in older adults and patients with knee OA.
Our study findings revealed that the addition of hip abductor strengthening exercise for 3 months post TKR increased the performance based function for the study participants. The enhanced function following the interventions in the experimental group had proven that the hip abductor muscle plays an important role in physical function following TKR and it’s a prime contributor to the functional activities and ADLs.

### 6.5 Numeric pain rating scale

Relief of pain is strongly correlated with patient satisfaction, earlier studies showed that pain relief is an important correlate than knee ROM and functional measure. The participants in the experimental group found significant improvements in NPRS from a pre-operative score of 7.23 ± 1.2 to 3.85 ± 1.4, 1.4 ± 1 after 1 month and 3 months post intervention with a mean change of 3.3 and 5.8 respectively. The control group participants also showed similar improvements post intervention at 1 month and 3 months.

A recent study by Bade et al. compared high intensity rehabilitation with conventional exercises following TKR and found that the NPRS had shown significant changes at one month post and 3 month post TKR. The similar improvements were observed in our study on both the groups.

The perceived changes in both the groups were clinically and statistically significant, the observed difference may be due to the early mobilization and cryotherapy post TKR. Continuous infusion of analgesics via patient controlled analgesia could possibly relieve the pain, thereby enabling the initiation of mobilization within 24 hours of the surgery for all the enrolled participants. A study of patients who underwent unilateral TKR with traditional rehabilitation stated that 40% of participants had
moderate to severe pain at 1-month post-surgery during walking. The present study showed better improvement in NPRS which was more than the clinically significant change of 2 points.

In early stages, following TKR there will be a temporary reduction in arthrogenic quadriceps muscle inhibition which can reduce the voluntary contribution of the quadriceps activation. Interventions such as cryotherapy and early weight bearing on the operated leg could possibly facilitate the quadriceps muscle activation, reduction of knee joint effusion which in turn enhance the muscle activity and reduce the pain. This reduced quadriceps arthrogenic muscle inhibition post TKR is a corner stone for the early rehabilitation, this may enhance the rehabilitation with a greater contribution of the participants.

Early mobilization could possibly activate the mechanoreceptors and activation of $A_\beta$ fibers which may cause presynaptic inhibition at spinal cord level, which in turn blocks the pain pathway. In our study, mobilization started within 24 hours, post-surgery which could have led to inculcating the pattern of more balanced weight distribution between the lower limbs which may increase the muscle activity. The increase in lower limb musculature activity, especially the quadriceps which is enough to provide a stimulus for strength gain and thereby a decline in pain intensity. This finding can be considered to be important as the adequacy of pain relief and increments in the knee extensor strength post-surgery.

### 6.6 Knee strength

Knee extensor strength deficit following end-stage knee OA was well documented in the previous literature and becomes more intense after TKR. The mechanoreceptors located in the knee joint capsule alters its afferent input to the central
nervous system post-surgery due to the knee joint swelling or effusion, ensuing diminished efferent drive to the operated side quadriceps muscle.

Previous studies had shown that there is increased central activation failure following TKR in the quadriceps muscles. This reduction in activation further leads reduced quadriceps strength, which is a primary contributor in relation to muscle atrophy and post-operative pain after the surgery.\textsuperscript{141} Following TKR the reduction in the voluntary activation of the quadriceps muscle clues in strength decrements in the early stages with almost 60% compared prior to surgery.\textsuperscript{21} Our study showed statistical significant improvement of $2.3 \pm 3.5$ increase in quadriceps strength at 3 months following TKR ($p<0.001$).

Reduction in pain intensity following early mobilization may enhance the quadriceps femoris activity which further increased the strength. We believe that reduction in pain and increase joint loading will enhance the stability of the knee joint by improving the strength of the surrounding muscles especially quadriceps femoris.

Thus, exercise emphasized on quadriceps in the early postoperative period could possibly improve the functional measures by enhancing the stability of the knee joint. The study participants underwent a minimally invasive surgery which may further enhance the knee strength in the early post-operative period.\textsuperscript{143} Previous study in Indian elderly non-obese patients shown that the subvastus surgical approach has resulted in lesser damage to the quadriceps muscle which assisted in less pain, early rehabilitation and faster mobilization following TKR.\textsuperscript{144}

Previous studies have reported there is 5% to 20% of quadriceps strength reduction at one month following TKR.\textsuperscript{24, 145} Our study showed a similar change in
reduction of knee strength and found significant changes at 3 months post intervention in both the groups.

6.7 Knee ROM

In participants with end-stage knee OA, TKR found to be an excellent surgical procedure which substantially improves knee ROM, pain and function. The knee flexion range of motion is important following TKR, more knee flexion will improve the ability to perform the daily functional and occupational activities. The enhanced knee flexion is basis of function following the TKR, traditionally 90 degrees of flexion is target, however, early mobilization, enhanced recovery, recent implants and prosthetic design allows the operative knee to achieve the full knee ROM.\textsuperscript{146}

The current study found an improvement in knee flexion ROM from preoperative baseline measure 105.8\degree ± 18.2\degree to 109.1 ± 9.9 at one month and 115.5\degree ± 9.3\degree at 3 months following intervention in the experimental group. We observed a mean difference of 9.7 at 95\% CI (15.7, 3.5) with p value of <0.001. The knee flexion ROM following unilateral TKR improvement could be possible due to the early mobilization of the participants, removal of the posterior osteophytes and also the prosthetic design with extended posterior condyles which help to minimize the contact stresses in high flexion.

Similarly, a recent study by Mai et al.\textsuperscript{147} found a mean post-operative flexion ROM at 114\degree measured clinically following TKR. Laskin et al.\textsuperscript{148} reported a significant improvement in knee flexion ROM from 117\degree -133\degree which is in accordance with our study where the flexion range improved from 105\degree -115\degree. Weeden and Schmidith,\textsuperscript{149} reported a change of 122\degree to 133\degree in knee flexion and a reduction in the flexion contracture from 1.8 to 0.6\degree and our study reported with 105\degree - 115\degree in flexion and 3\degree - 0.8\degree in extension respectively. The improvements in average knee flexion ROM in the
present study is sufficient to perform most of the activities of daily living, we postulated that improvement in knee flexion of 10° at 3 months would exemplify a clinically meaningful improvement following TKR. The previous study by Denis et al. established an effect size of 10 degrees of active knee flexion ROM was considered to be effective following the interventions.

The deficit in knee extension ROM was reported only in few studies post TKR during the early phase or following discharge. The mean extension ROM deficit noted in the previous studies was about 5-10 degrees at 5–14 days following TKR. The current study found significant changes in extension at one month and 3 months following surgery, the deficit in knee extension ROM was less than 2 degrees.

6.8 Strength of the study

Our randomized controlled trial findings exhibited the hip abductor strengthening exercise regime following TKR resulted in improved functional performance. The strong hip abductor participants walked more distance during six minute walk test and took a lesser amount of time to complete timed up go test.

To our knowledge this is the first study assessed the health related quality of life using both generic and disease specific survey instrument following TKR in Indian population. Our study participants in both the group showed improvement in quality of life at 3 months duration.

The early mobilization following surgery showed a significant improvement in pain and knee range of motion at 1 month post intervention.
6.9 Limitations

Due to the present study design, we were not able to compare the results with healthy controls and the prevalence of osteoarthritis in the contralateral lower limb in the study population was not analyzed. The strength measurement using isokinetic dynamometer is a more reliable and valid tool than a hand held dynamometer, the access to an isokinetic dynamometer to the study participants is not possible. There is more necessity for the hip abductor strengthening exercises compared to healthy controls with long term follow up to acquire more knowledge regarding the effectiveness of hip abductor strength in the quality of life and functional outcome following TKR. The study results can’t be generalized to every setting, we included the participants who underwent TKR with a diagnosis of Knee OA.

The effect of the contralateral limb (non-operated) limb on function can also be analyzed preoperative and postoperatively to predict the exact improvement of the participants. There are other limitations include the patient’s expectation not measured preoperative and post-operative which could be predictors of function following TKR.

6.10 Scope for future research

Future studies are needed to be able to correlate the effect of hip abductor strengthening exercise regime to a healthy age-matched healthy controls. Our study opens an opportunity for the long term follow-up trials on quality of life, functional outcome and patients expectations following TKR.
6.11 Clinical Implications of the study

An additional hip abductor strengthening programme can be used to improve the functional performance in participants diagnosed with knee osteoarthritis after total knee replacement. Additional hip abductor strengthening showed more significant effects on physical performance measures of SMWT and TUG after total knee replacement than conventional therapy only. It is recommended that the hip strength assessment and strengthening exercises could be incorporated in the clinical practice following TKR for those who diagnosed with knee OA.

The hip abductor strengthening exercises management strategies for TKR is beneficial in improving functional performance by an increase in hip abductor strength for knee OA participants. Our study participants exhibited a rapid improvement in pain, knee range of motion at one month and 3 months post-intervention in both the groups. The health related quality of life measured using both generic and disease specific survey instruments revealed the desired effects can be accomplished in a short period.

Previous studies used a follow-up period of 6 months or more following TKR, findings of our study proven the effects can be objectively determined as early as 3 months.