

## Original Article

# IMPORTANCE OF ILIOPSOAS AND ERECTOR SPINAE MUSCLES IN PREDICTING THE FUNCTIONAL COMPETENCE OF TRANSFEMORAL AMPUTEES

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## ABSTRACT

**Purpose:** Muscle imbalance in transfemoral amputees impair physical mobility and activities of daily living. Aim of this study was to correlate the muscle imbalance with functional competence in transfemoral amputees.

**Methods:** Thirty amputees were evaluated under inclusion criteria and randomly allocated into 2 groups. Group A received stretching(1 week) followed by strengthening(3 weeks) and in group B strengthening(3 weeks) were followed by stretching(1 week) . Phase I includes values after 1 week stretching program in group A and 3 weeks strengthening program in group B. Data were recorded at baseline, after phase I completion and end of treatment. Physical mobility was assessed by "Timed up and go" test.

**Results:** Muscle imbalance and physical mobility improved significantly in both groups at the end of treatment. The correlation values of "Timed up and go" test with Iliopsoas and Erector spinae muscle showed significant improvement in both groups.

**Conclusion:** Baseline measurements showed that Iliopsoas and Erector spinae muscles were tight whereas Gluteus maximus and Abdominal muscles were weak in transfemoral amputees. Functional mobility improved after correction of muscle imbalance. Stretching followed by strengthening gave more significant results than vice versa. Good posture in transfemoral amputee prevents muscle dysfunction and improves functional mobility.

**KEYWORDS:** Muscle imbalance, Lower cross syndrome, Stretching, Strengthening.

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## INTRODUCTION

Amputation is one of the major cause of disability in India.<sup>1</sup> According to the Census 2001, prevalence rate of disability in India accounts 1.8% -2.2% (locomotor disability- 28%), global being 4% - 10%.<sup>2</sup>

Lower limb amputation reduces the muscle

strength of the hip muscles. Hip flexor muscle contracture limits hip extension and is associated with increased lumber lordosis. The common causes to develop muscle imbalance in Transfemoral amputees is poor posture, abnormal movement pattern, disuse, misuse and overuse.<sup>3</sup>

According to Janda, one of patterns of muscle imbalance commonly seen in Transfemoral amputees is the lordotic posture with involvement of Iliopsoas, Gluteus maximus, Abdominals, and Back extensors.<sup>4</sup> Kendall believes that prolong sitting posture and weak abdominal muscles leads to back extensor muscle tightness.<sup>9</sup> Norris stated that back extensor muscle tightness in low back pain patients is a compensatory mechanism to tight hip flexor, weak gluteals and abdominal muscles.<sup>6</sup>

Janda introduced Lower Crossed Syndrome concept to explain this pattern of muscle imbalance (Figure 1). Short iliopsoas muscles anteriorly tilt the pelvis, creating excessive lumbar lordosis while erector spinae myofascial contractures hold this "bowing" pattern. The weak abdominals and gluteals, unable to stabilize the pelvis allow this aberrant swayback pattern to develop.<sup>3</sup>

The mixture of tightness and weakness seen in the muscle imbalance process alters body segment alignment and changes the equilibrium point of joint. According to Janda, stretching of the tight muscles alone will help eliminating the effect of reciprocal inhibition causing regaining of normal muscle tone in weak antagonist muscle group.<sup>7</sup>

Muscle Energy Technique (METs) is highly effective stretching technique for tightness. It is a form of active stretch commonly used in manual therapy to increase range of motion.<sup>7</sup>

Musculoskeletal imbalance affects quality of life of people with lower-limb amputation. Alteration in the function of these muscles (weakness/tightness) decreases the cadence and increases the risk of fall.

Hence in this study we hypothesized that treating the shortened muscles (Iliopsoas and erector-spinae) alone can correct the muscle imbalance pattern and thus improve the gait (functional competence).

## METHODOLOGY

After ethical clearance (IEC/1610/R&D/08/NIOH/455), We conducted this study in National Institute for the Orthopedically Handicapped (NIOH), Kolkata, West Bengal, India for a period

of 1 year. 30 trans-femoral amputees with the following characteristics were included in the study: Unilateral amputation, age between 18-60yrs (both genders), duration after amputation greater than 3 months up to 1 year, involvement of at least 4-muscles (Iliopsoas, Transverse Abdominals, Back Extensors, Gluteus Maximus), stump length- 50 to 70% of the intact limb (from greater trochanter), prosthetic user with above knee prosthesis; quadrilateral socket with uni-axial knee joint and SACH foot, intact vascularity and sensations of the stump.

Patients suffering from the following conditions were excluded:

History of back surgery or any pre-diagnosed musculoskeletal disorders, pain or deformity of hip joint before amputation, amputees with adductor roll, neuroma, and any pathology in amputated limb hip joint leading to restricted hip extension.

### Procedure:

The procedure was explained to the amputee in the language that was known to them. The amputees were made acquainted to the instruments used. After getting the consent from each amputee, the first reading to find muscle imbalance was taken termed as L0 in Data collection chart. The amputees were assigned into groups A and B based on Randomization (lottery method). Group A amputees were given stretching of Iliopsoas<sup>17</sup> (Figure 8) and Erector Spinae<sup>17</sup> (Figure 9) for 1 week and Group B were given strengthening of Gluteus Maximus<sup>18</sup> (Figure 10) and Abdominals<sup>19</sup>(Figure 6) for 3 weeks, thereafter second reading was taken, termed as L1 in Data collection Chart. Finally Group A amputees were given 3 weeks strengthening (Gluteus Maximus and Abdominals) and Group B one week of stretching (Iliopsoas and Erector Spinae) and final third reading was taken, termed as L2 in Data collection chart. Finally Timed Up and Go<sup>16</sup> test was used to check the functional competence-Figure 7.

The following procedures were used to check the muscle imbalances:

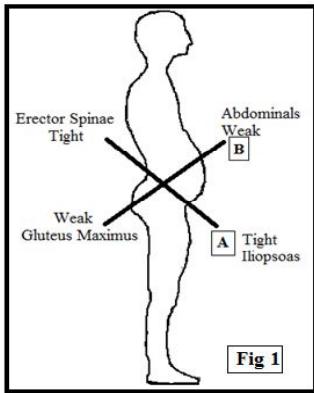
Iliopsoas length (tightness)<sup>12</sup>: ROM (Universal Goniometer) Figure 3.

Abdominals Endurance<sup>15</sup>: Fitness test (Sit-ups), Figure 6.

Back extensor length (tightness)<sup>13</sup>: Modified Modified Schober Test-Figure 4.

Gluteus Maximus strength<sup>14</sup>: Jamar Hand held Dynamometer- Figure 5.

**Fig. 1:** Lower crossed syndrome.



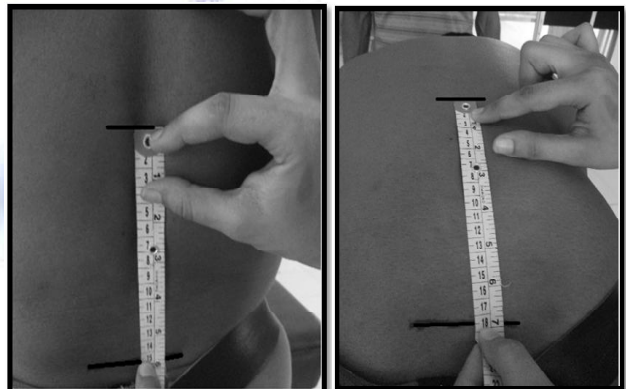
**Fig. 2:** Hand Held Dynamometer (Kg)<sup>20</sup>



**Fig. 3:** Modified Thomas Test using Universal Goniometer.



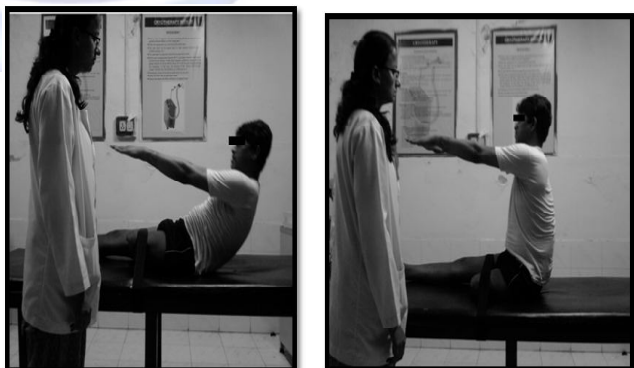
**Fig. 4:** Modified Modified Schober Test.



**Fig. 5:** Gluteus Maximus strength by Jamar Hand held Dynamometer.



**Fig. 6:** One minute Sit-up Test.



**Fig. 7:** Timed up-Go Test.



**Fig. 8:** Muscle energy Technique for stretching Iliopsoas.



**Fig. 9:** Muscle energy technique for Erector Spinae stretching.



**Fig. 10:** Antigravity Gluteus Maximus strengthening.



## RESULTS

Statistical Analysis: SPSS 16, Ms Excel (MS Office 97-2003) were used for the analysis. A two-tailed ( $\alpha=2$ ) probability (P) value between 0.05 ( $P \leq 0.05$ ) & 0.01 was considered statistically significant;  $P \leq 0.01$  as highly significant and  $P > 0.05$  had no significance (ns). One-way ANOVA was done to determine differences between the groups (A and B) at rest (Baseline-L0), after phase I (L1) and at the end of the treatment (L2). Pearson co-relation was used to find relation of Timed up-go test with Iliopsoas and Erector Spinae for both the groups.

The purpose of the study was to find the muscle imbalance of the Iliopsoas, Gluteus Maximus, Erector Spinae, and Abdominals forming Lower Crossed Syndrome (Cross A and Cross B) in transfemoral amputees. Cross A comprises of tight Iliopsoas and Erector Spinae muscle and Cross B consist of the weak Gluteus Maximus and Abdominal muscle. We attempted to find the importance of treating Cross A only (Iliopsoas and Erector spinae muscle) in predicting the functional competence (mobility) in transfemoral amputees.

Thirty transfemoral Amputees were divided randomly (lottery) into two groups (A and B). Table 1 describes the demographic details (Graph 1) of all the amputees, fifteen in each group (all males). It includes mean, and standard deviation of age, weight (with and without above knee prosthesis), height of amputee, length of the stump, duration of amputation, and BMI of both the groups.

In group A stretching (1 week) was followed by

strengthening (3 weeks) and in group B strengthening (3 weeks) was followed by stretching (1 week). Phase I includes measurement values after 1 week stretching program in group A and 3 weeks strengthening program in group B. baseline data represents the readings after completion of Phase I treatment L1 and at the end of treatment L2 for group A and group B. L0 shows the baseline values. No statistical differences were present between the groups for baseline values.

Cross A: Both the groups showed significant improvement after completion of Phase I treatment but Group A had shown better improvement for Iliopsoas length (Graph 2) both after completion of Phase I L1 ( $F=32.54$ ,  $p \leq 0.01$ ) as well as at the end of the treatment L2 ( $F=5.88$ ,  $p=0.032$ ) as compared to Group B i.e. L1 ( $F=10.83$ ,  $p \leq 0.01$ ) and L2 ( $F=4.87$ ,  $p=0.04$ ).

The length of Erector Spinae muscle improved significantly in both the groups (Graph 4) but Phase I result i.e. L1 showed better improvement in Group B ( $F=10.42$ ,  $p \leq 0.01$ ) as compared to Group A ( $F=6.42$ ,  $p=0.026$ ). When relating to the scores at the end of the treatment (L2), Group A ( $F=6.69$ ,  $p=0.023$ ) showed more improvement in the length of erector spinae muscle as compared to Group B ( $F=5.08$ ,  $p=0.04$ ).

Cross B: The antagonist muscles i.e. Gluteus Maximus and Abdominals showed significant increase (Graph 3 and 5) in strength with course of treatment in both the groups but Group A showed better improvement than Group B. For Gluteus Maximus in Group A after completion of Phase I- L1 ( $F=24.9$ ,  $p \leq 0.01$ ), at the end of the treatment L2 ( $F=28.95$ ,  $p \leq 0.01$ ) as compa-

-red to Group B, Phase I- L1 ( $F=10.99, p \leq 0.01$ ), L2 ( $F=17.75, p \leq 0.01$ ).

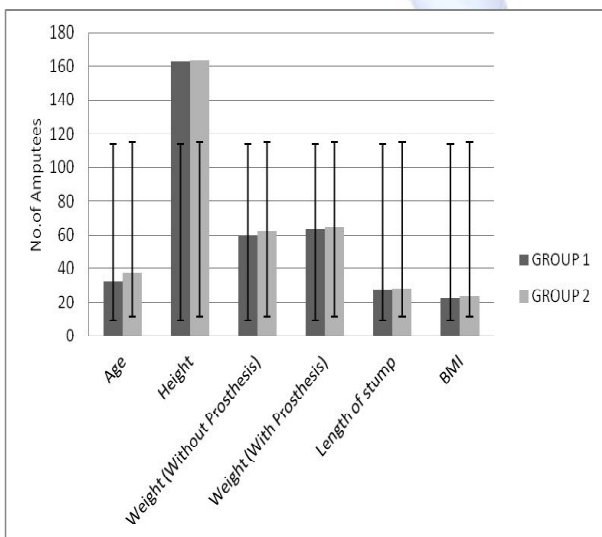
Functional Competence in Transfemoral Amputees was assessed by timed up and Go test which showed significant improvement (Graph 6) in both the groups, as reduction in the time required to complete a round of 3m distance. Group A (L2-  $F=19.82, p \leq 0.01$ ) proved greater improvement than Group B (L2-  $F=11.18, p \leq 0.01$ ) at the end of the treatment when compared with the baseline values.

Comparing Iliopsoas and Erector Spinae muscle length with Timed up and Go test, for both the groups by ANOVA showed that Group A showed greater significant co-relation (Graph 7) of muscle imbalance and functional competence than Group B. The Co-relation values in Table 4 for Group A Iliopsoas-TUG ( $F=13.99, p \leq 0.01$ ), Erector Spinae-TUG ( $F=9.23, p \leq 0.01$ ) as compared to Group B Iliopsoas-TUG ( $F= 11.01, p \leq 0.01$ ), Erector Spinae-TUG ( $F=5.72, p=0.03$ ).

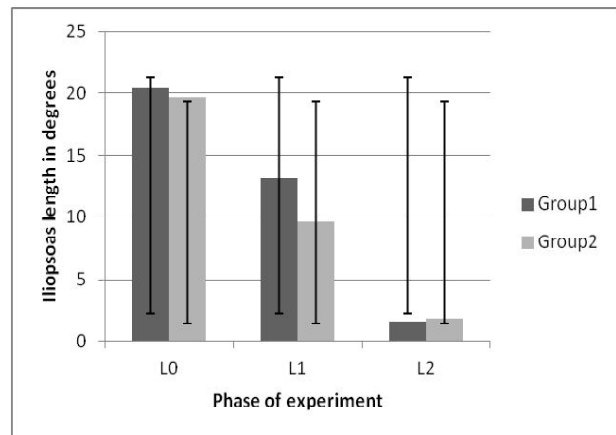
On comparing the co-relations using Pearson co-relation for Iliopsoas length and timed up-Go (TUG) test between the groups, Group A showed a significantly more co-relation with TUG than Group B with the t-values of 3.7408 and 3.3174. Similarly comparing the co-relations value of Erector Spinae length with timed up-go test (TUG) between the groups, Group A showed significantly more co-relation with TUG than Group B with t-values of 3.0395 and 2.3925.

The results of this study proved the alternative hypothesis to be true, thus null's hypothesis can be rejected.

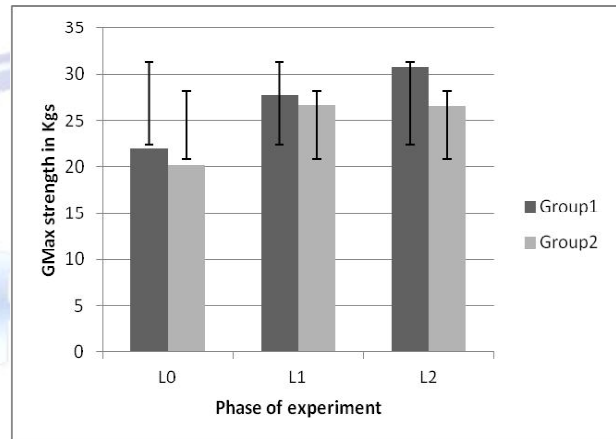
**Graph 1:** Demographic data.



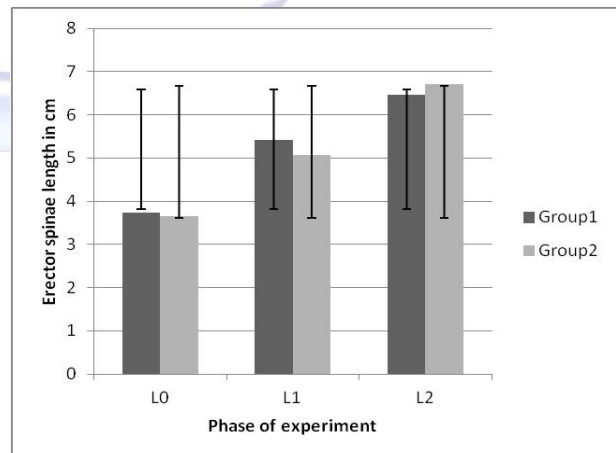
**Graph 2:** Change in Iliopsoas muscle length.



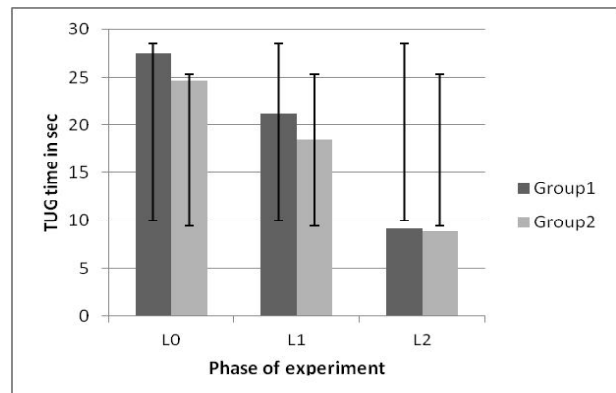
**Graph 3:** Change in Gluteus Maximus muscle strength.



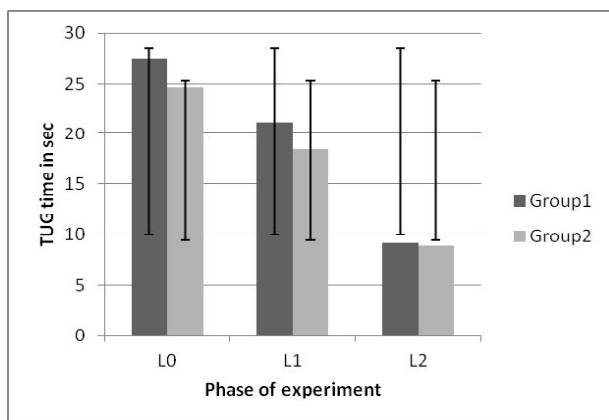
**Graph 4:** Change in Erector Spinae muscle length.



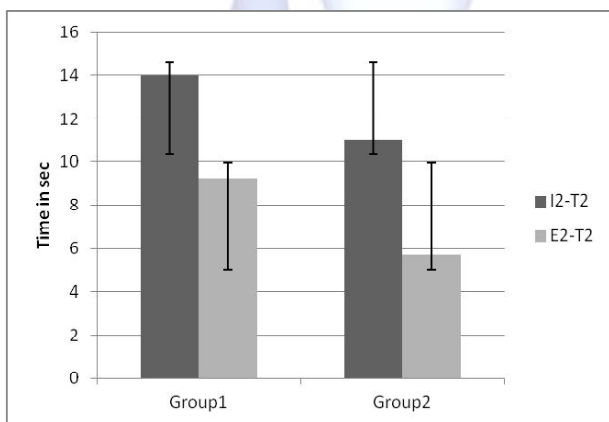
**Graph 5:** Change in Abdominal muscle endurance.



**Graph 6:** Change in the timed up-go test (TUG).



**Graph 7:** Represents correlation of timed up-go test (T2) with Iliopsoas (I2) and Erector Spinae (E2) muscle.



## DISCUSSION

In this study we aimed to find out the importance of treating Iliopsoas and Erector Spinae (Cross A only) in predicting the functional competence of transfemoral amputees.

The results of the study show the presence of Iliopsoas tightness in the range of 10° to 28° (by modified Thomas test) and that of Erector Spinae between 3 cm to 5cm (by modified Schober test) in all the amputees forming Cross A (tight). Gluteus Maximus strength (weak muscle) were ranging from 15kgs to 31kgs (Dynamometer) and that of Abdominals ranging from 0 to 22 repetitions /min (sit-ups) in all the amputees forming Cross B (weak). Friel K and Gaunard I also supported the presence of muscle imbalance in their study.<sup>4,8</sup> Kendall highlighted that Iliopsoas and Erector spinae that gets tight due to long sitting posture in the normal population.<sup>9</sup> Thus it can be concluded that prolonged sitting posture could be the reason to develop tight Iliopsoas and Erector spinae in amputees also.

## Tight Muscles (Cross A):

After completion of Phase I both the groups showed significant improvement in Iliopsoas and Erector Spinae muscle length but Group A showed more significant improvement for Iliopsoas muscle length ( $F=32.54$ ,  $p \leq 0.01$ ) as compared to Group B ( $F= 10.83$ ,  $p \leq 0.01$ ). The reason could be that MET stretching lengthened Iliopsoas and made it relaxed, eventually gave more available range for the Gluteus maximus to restore its normal tone. The change observed in the present study for ROM appear to be consistent with a viscoelastic tissue response within the elastic range, where the stretched tissue does not immediately return to its original length (Lederman 2005; Magee et al., 2007). However Ballantyne et al., (2003) suggested that increase in ROM following MET were due to changes in viscoelastic properties alone, allowing greater muscle extensibility, this would be achieved using a force of stretch or constant torque. But a more favoured explanation could be that an increase in stretch tolerance occurred as a result of Contract Relax (CR) procedures (Magnusson et al., 1996; Ballantyne et al., 2003) and inculcating good posture re-education. It was possible that an increase in stretch tolerance may have allowed for greater relaxation of muscle in the amputees.

Erector spinae muscle unlike Iliopsoas showed more significant improvement in Group B ( $F=10.42$ ,  $p \leq 0.01$ ) as compared to Group A ( $F=6.42$ ,  $p \leq 0.05$ ), the reason could be that endurance training of the abdominals (sit-ups) in Group B amputees lead to repetitive stretching of the erector spinae as compared to Group A in which only 5 times MET stretching was given in a single day.

## Weak Muscles (Cross B):

Gluteus Maximus forms one of the important components for the maintenance of pelvic stability in erect position. Iliopsoas and Erector spinae working alone pull the pelvis anteriorly leading to lordosis, whereas abdominals and Gluteus Maximus pull the pelvis posteriorly. Thus both groups of muscles work in a co-ordinate manner to maintain the pelvis in neutral position. And when iliopsoas becomes tight, the Gluteus Maximus due to reciprocal inhibition and disturbed length tension relation-

ship is unable to hold the pelvis physiologically leading to lordosis. Similarly with Erector spinae, hence the tight iliopsoas and lumbar erectors and weak abdominals and gluteals, unable to stabilize the pelvis, allow this aberrant swayback pattern to develop.<sup>5</sup> The result for strength of Gluteus maximus and Abdominals endurance shows that there was improvement in both the groups. But Group A (Gluteus Maximus  $F=24.9$ ,  $p \leq 0.0003$ , Abdominals  $F=26.66$ ,  $p \leq 0.0002$ ) has shown more improvement as compared to Group B (Gluteus Maximus  $F= 10.99$ ,  $p \leq 0.0062$ , Abdominals  $F= 16.82$ ,  $p \leq 0.0015$ ). Though Abdominals training was given for 3 weeks in Group B, the result was less significant than Group A. According to Liebensohn Sit-ups require the interplay between the Iliopsoas and Abdominals.<sup>10</sup> In Group B Iliopsoas muscle was tight, thus was unable to participate in effective contraction with Abdominals for Sit-ups training. Whereas in Group A as the effect of reciprocal inhibition was reduced and iliopsoas was relaxed using MET protocol, we can assume that performance of Abdominals gave better result. Similarly Gluteus maximus gave better result because of reduction of reciprocal inhibition.

At the end of the treatment (total 4 weeks) both iliopsoas and erector spinae muscle length improved significantly in both groups but more in Group A Iliopsoas ( $F=6.63$ ,  $p \leq 0.05$ ) and Erector Spinae ( $F=5.09$ ,  $p \leq 0.05$ ) as compared to Group B Iliopsoas ( $F= 4.87$ ,  $p \leq 0.05$ ) and Erector Spinae ( $F=5.092$ ,  $p \leq 0.05$ ). The reason could be that in Group B amputees stretching of Iliopsoas was not achieved in Phase I directly, so the effect of reciprocal inhibition was not completely reversed. Whereas in Group A both Iliopsoas and Erector Spinae was lengthened and relaxed Gluteus Maximus and Abdominals training was completed with less joint stress and easier isolation of the target muscles. Therefore it is being said that if a movement pattern is faulty, the general rule of thumb is to initiate by treating the tight muscles related to faulty pattern. We found the same in this study. The aim of using 3 weeks of strengthening program was not only aimed to regain the tone i.e. muscle property of length-tension relationship and force-velocity relationship but also giving stren-

gth to the weak muscles which is known to get altered because of reciprocal inhibition.

### **Functional mobility:**

Walking introduces phasic muscle activity. The amputees were made to walk a distance of 3m with their prosthesis on. Time (sec) was noted after completion of distance. Lesser the time required better the prognosis was considered. According to Perry, during walking lumbar and thoracic components of the erector spinae are acting synchronously. The abdominal muscles have two patterns of action. Activity of the external oblique muscles is an intermittent, low-intensity pattern throughout stance.<sup>11</sup> Movement of the pelvis is restrained by the hip muscles, while the back and abdominal musculature control the alignment of the trunk over the pelvis. Activity of the erector spinae and intrinsic muscles during limb loading and later action of the abdominal muscles decelerate the passive forces reflected to the trunk.<sup>11</sup> Thus, it requires the synchronous activity of Erector Spinae, abdominals, Iliopsoas, Gluteus maximus forming important muscle group among others during ambulation. Functional competence in Transfemoral amputees was judged by timed up and go test. It was correlated with the baseline (0 weeks) and values at the end of the treatment (4 weeks). Both groups showed reduction in time required to complete the test after the exercises. This could be explained on the basis of correlation (Pearson's correlation) results done between Iliopsoas – TUG test and Erector Spinae – TUG test for both the groups. The result showed that both groups had significant improvement but Group A ( $F=19.82$ ,  $p \leq 0.01$ ) showed more significant results as compared to Group B ( $F=11.18$ ,  $p \leq 0.01$ ). The reason could be the correct pattern of treatment in Group A which involved stretching followed by strengthening. This gave an equal resting tone of the agonist and antagonist muscles allowing the joint to take up a balanced position where the joint surfaces are equally loaded and the inert tissues of the joint are not excessively stressed. Whereas in Group B strengthening was followed by stretching, in which the inhibited muscles was made to work under restriction of tightness with greater joint stress and therefore the outcome though signi-

-ficant (strengthening antagonist stretched the agonist), the result was not satisfactory as seen by the greater time required to complete 3 m distance as compared to Group A.

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**Conflicts of interest:** None

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