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Effect of Hip Abductors and Lateral Rotators Strengthening Exercises on Knee Valgus Alignment among Adolescents: A Prospective Study

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Abstract:

Title: *Effect of hip abductors and lateral rotators strengthening exercises on knee valgus alignment among adolescents: A prospective study.* ***Objective:*** *The objective is to study the effect of hip abductors and lateral rotators strengthening exercises on improving the knee valgus alignment among adolescents.* ***Background:*** *In accordance to the well known fact that knee dysfunction condition among growing adolescents contributes to a wider segment of entire orthopedic practice, it is therefore essential to aware of the effect of strengthening the hip muscles on correcting functional knee valgus problem. So, we conducted this study to find out the effect of strengthening hip abductors and lateral rotators exercises on functional knee valgus among healthy adolescents.* ***Subjects:*** *30 subjects (25 females and 5 males) aged between 18 to 20 years old.* ***Method:*** *The subjects were assigned to hip abductor and lateral rotator strengthening exercises 3 times per week for 6 weeks. Knee valgus alignment was assessed at baseline and post-intervention.*

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Result: *Paired t-test and Microsoft Excel 2010 were used for data analysis. The mean difference for the pretest group is 161.071±5.106 while the posttest group is 166.867±5.106. There is a difference in variance between pre and post intervention with a difference of 5.6977. Paired sample test value shows a t value of -29.446119 and a p value of p<0.00001. The result is significant at p ≤ 0.01.* ***Conclusion and discussion:*** *The hip abductors and lateral rotators strengthening exercises are effective in reducing the dynamic knee valgus alignment among the adolescents.*

Key words: Hip Abductors, Lateral Rotators, Strengthening Exercises, Knee Valgus Alignment, Adolescents

1. Introduction

Of all other joints in the human body, the knee joint sustains the most frequent number of orthopaedic injuries.[1,2] Adolescents are noted to be actively involving in sports and games over the last few decades. Recent study shows that 40% of all paediatric injuries are caused by sports activities which contribute to about 4.4 million numbers of injuries every year.[3] A retrospective study done by Sariff, Ramlan A. in 2009 found that about 58.8% of all musculoskeletal injuries reported in Malaysia were sustained by adolescent children aged less than 20 years and lower extremities are mostly affected (63.1%), primarily the knee joint (37.1%) and the major incidence occurs during practice and game sessions.[4]

In a previous retrospective study, an individual's recollection of having had "childhood knock-knees or bow-knees" was related with a 5-fold rise in the risk of knee osteoarthritis development in future.[5] The continuous involvement of the adolescent children in recreational or amateur sports with presenting knee mal-alignment will further increase the risk of various knee pathologies in future.

Awareness of the structural and muscular consequences of postural faults re-inforces the belief that beginning in childhood, all individuals should be monitored on a yearly basis to assess acquired skeletal mal-alignment and monitor structural deviations. According to the outcome of examination, therapist can suggest exercise programs and postural training.[6]

1.1 Background of Study

There are many longitudinal studies provide ample amount of evidence that knee injury is associated with hip muscle weakness.[7,8] Willson et al[9], studying single-leg squats in athletes, reported that reduced hip external-rotation strength was correlated with increased knee valgus. Ireland et al[10] reported that women with patellofemoral pain had reduced hip-abduction and external-rotation strength. Niemuth et al[11] reported that runners with overuse injuries had reduced hip-abduction strength compared with uninjured limbs and with healthy subjects. The authors postulated that inadequate hip strength might have results to lower extremity injury and mal-alignment.[6,10,11]

In accordance to the well known fact that knee dysfunction condition among growing adolescents contributes to a wider segment of entire orthopaedic practice, it is therefore essential to aware of the effect of strengthening the hip muscles on correcting functional knee valgus problem. However, there is no such related study has been done to date. So, I would like to conduct this study to find out the effect of strengthening hip abductors and lateral rotators exercises on functional knee valgus among healthy adolescents.

1.2 Statement of the Problem

As the prevalence of knee valgus deformity increases, its anatomical, physiological and pathological implications are becoming more evident. Knee valgus is associated with muscle weakness in adolescents and is an early risk factor of knee

disease development in future. Hence, study discussing the effect of strengthening hip muscles turn out to be very helpful on correcting knee valgus alignment.

1.3 Hypotheses

Null hypothesis: Hip abductors and lateral rotators strengthening exercises may not have a significant difference on knee valgus alignment among adolescents.

Alternate hypothesis: Hip abductors and lateral rotators strengthening exercises may have a significant difference on knee valgus alignment among adolescents.

2. Review of Literature

According to John H. Hollman et al[1], during step-down tasks, lateral rotation strength might have lesser association with decreased knee valgus in females than does gluteus maximus. Increased knee valgus might be related with gluteus medius.

Christopher M. Powers et al[2], stated that even though excessive tibia and femur movement in the transverse and frontal planes can influence patellofemoral joint mechanics and PFP, existing research suggests that such abnormalities are not a universal finding in this population. Hence, treatments aimed at controlling lower limb motion may be warranted in a subpopulation of persons with PFP.

Khalil Khayambashi et al[16], concluded that isolated strengthening programme of hip external rotator and abductor muscles were efficient in improving health and pain status in women with patellofemoral pain compared to a non exercise control group. Whenever designing a rehabilitation program for females suffering from patellofemoaral pain, consider incorporate hip strengthening exercises.

According to Kyung Mi Park et al[17], the rating of movement quality during the forward step-down test in

asymptomatic women received good agreement among researcher in predicting musculoskeletal conditions.

Last but not the least, Balsalobre-Fernández C et al[18] in his study of reliability and validity of HSC-Kinovea video motion analysis method for calculating the jump height and flight time concluded that the results showed a ideal correlation agreement (ICC=1, $p<0.0001$). This clearly shows that the HSC-Kinovea technology does not only require known experience of application but also can be used to provide highly reliable and valid flight time and vertical jump height measurements as similar to a costly equipment.

3. Methods and Procedures

3.1 Study design: One group pretest, posttest design

3.2 Sampling method: Simple random sampling

3.3 Study location: This study was conducted in physiotherapy lab, Asia Metropolitan University at Jalan Kemacahaya, Batu 9, Cheras.

3.4 Sample size: 30 subjects (25 females & 5 males)

3.5 Study sample: Adolescents aged 18 to 20

3.6 Duration of study: 4 Months

3.7 Inclusion Criteria

- Individuals with normal BMI
- Both genders (females & males)
- Aged between 18-20 years
- Has functional knee valgus
- Capable to climb up & down a flight of stairs without assistive devices
-

3.8 Exclusion Criteria

- Has any orthopedic, neurology, or any other pathology that impaired motor function.
- Has antalgic gait.

3.9 Data Selection and Study Methodology

A single-leg step-down was performed on randomly picked students aged 18-20 years from a college to assess for eligibility. Potential participants were evaluated for specific inclusion/inclusion criteria. 30 eligible subjects were recruited on the basis of random sampling for the study.

Three dimensional (3D) frontal plane projection of knee valgus alignment was measured during a single-leg step-down test performed from a 15cm step using Kinovea 0.8.15 Video Motion Analysis Software on the selected subjects prior to intervention. Average frontal knee plane angles during the stance phase of step descent were analyzed for data analysis. A digital video camera was placed 3m anterior to the subject, at the subject's knee height and aligned perpendicular to the frontal plane projection angle of knee.

The frontal-plane projection angle of knee valgus/varus was defined by the angle formed from a linear line that joins the ASIS with the midpoint of the tibiofemoral joint and a second line connecting the midpoint of the tibiofemoral joint and the talocrural joint. 2cm diameter markers were placed on subjects' ASISs bilaterally in order to facilitate digitization of bony landmarks with the motion-analysis software.

We analyzed joint alignments at 2 distinct points during the task. First, we measured static alignment in double-limb stance to provide an estimate of baseline knee alignments (figure 1.1). Next, when the frontal-plane knee angle was maximally departed from the baseline position, we measured knee valgus during the eccentric phase of the step-down (figure 1.2).

The subjects were assigned to hip abductor and lateral rotator strengthening exercises 3 times per week for 6 weeks. Knee valgus alignment was assessed at baseline and post-intervention. Prior to participation, all the subjects were provided written informed consent. The subjects were educated

regarding their condition and the intended treatment approach and realistic goal setting were discussed.

Each session consisted of warm-up segment for 5 minutes (brisk walking), 20 minutes of hip-strengthening exercises, and cool-down segment for 5 minutes (brisk walking). All strengthening exercises were completed unilaterally. Strengthening exercises were progressed according to FITT principle at 2-week intervals (table 1.1). Subjects were given strengthening exercises according to the muscle group and type of exercises (table 1.2). After successful completion of 6 weeks intervention, three dimensional frontal plane projection of knee valgus alignment was calculated again for post-test analysis.

Method of measuring the 3-D frontal plane projection of knee valgus alignment

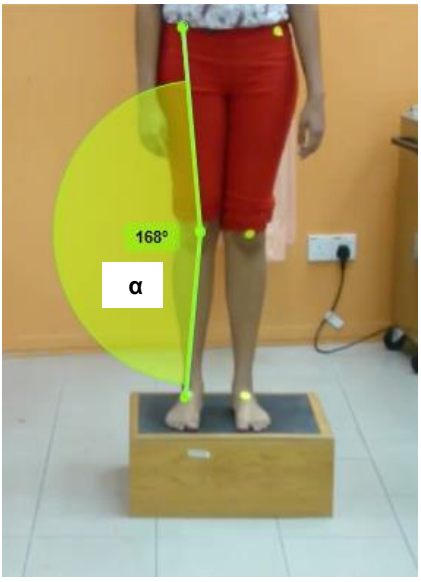


Figure 1.1: Static phase

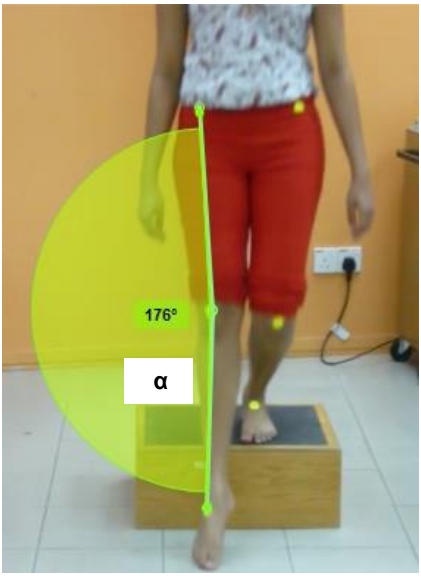


Figure 1.2: Eccentric phase

Table 1.1: Strength training protocol according to FITT principle

FREQUENCY	3 days/week for (1-2weeks)	3 days/week for (3-4weeks)	3 days/week for (5-6weeks)
INTENSITY	50% of 1 RM	75% of 1 RM	100% of 1 RM
TIME	3 sets of 10 repetitions each set	3 sets of 10 repetitions each set	3 sets of 10 repetitions each set
TYPE	Isometric	Concentric-using theraband	Eccentric-using theraband

Table 1.2: Strengthening exercise procedures for hip abductors and lateral rotators

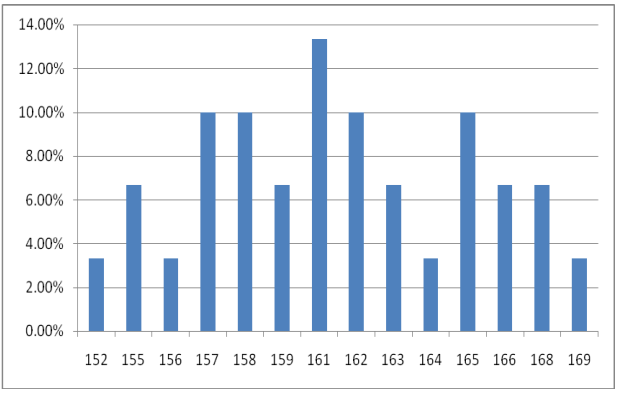
MUSCLES	**ISOMETRIC EXERCISE (1-2 weeks)**	**CONCENCTRIC EXERCISE (3-4weeks)**	**ECCENTRIC EXERCISE (5-6 weeks)**
Hip abductors	Stand against wall and try to abduct leg against wall.	Abduct the leg away in standing using theraband.	Using theraband, maintain the abducted leg in position.
Hip external rotators	Stand against wall and try to rotate leg externally.	Externally rotate the leg in sitting using theraband.	Using theraband, maintain the externally rotated leg in position.

4 Analysis of Data

4.1 Statistical analysis

Paired t-test was used to compare the results of pre and post intervention of the hip abductors and lateral rotators strengthening exercises on knee valgus alignment using Microsoft Excel 2010.

4.2 Data analysis for pretest intervention

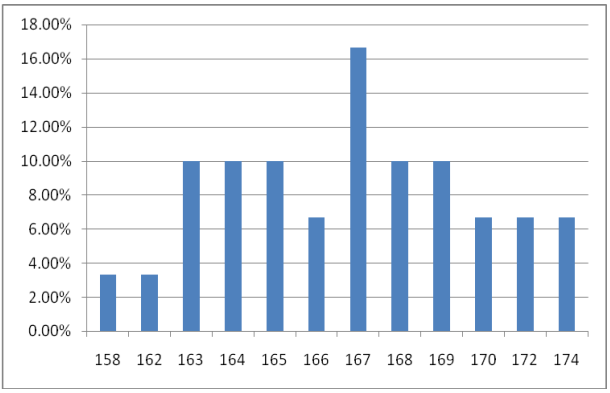


Graph 1.1: Pretest

Interpretation:

Graph 1 shows the data analysis for pretest group. The graph shows a normal distribution. The mean value is 161.071with the standard deviation of 5.106.

4.3 Data analysis for posttest intervention



Graph 1.2: Posttest

Interpretation:

Graph 2 shows the data analysis for posttest group. The graph shows a normal distribution. The mean value is 166.667 with the standard deviation of 5.106.

4.4 Data analysis for pre and post intervention

	PRE-TEST	***POST-TEST***
Mean	161.071	166.867
Variance	18.64482759	12.94712644
Standard deviation	5.106	5.106
Observations	30	30
Pearson Correlation	0.979644378	
Hypothesized Mean Difference	0	
Df	29	
t Stat	-29.44611903	
P(T<=t) two-tail	0.00	
t Critical two-tail	2.045229642	

Table 1.4: Data analysis of pre and post intervention group

Interpretation:

Table 1 shows the data analysis for pre and post intervention group. The mean difference for the pretest group is 161.071±5.106 while the posttest group is 166.867±5.106. There is a difference in variance of 5.6977 between pre and post intervention. On the other hand, the Pearson correlation shows the value of 0.979644378 (close to the value of 1). Paired sample test value shows a t value of -29.446119 and a p value <0.00001. The result is significant at $p \leq 0.01$. Hence, the null hypothesis is rejected and the alternate hypothesis is accepted. This shows a high significant difference between pre and post intervention group. Thus, we conclude that hip abductors and lateral rotators strengthening exercises are effective in reducing the dynamic knee valgus alignment among the adolescents.

5. Discussion and Conclusion

5.1 Discussion

The primary finding was to study the effectiveness of strengthening hip abductors and lateral rotators in improving

the knee valgus alignment among adolescents. Alternate hypothesis was accepted which shows that there is a significant result in this study with a P< 0.01(0.00). Results showed the subjects had noteworthy improvement in knee valgus range of motion in pre and post intervention.

According to many related studies done before, researchers found that increased knee valgus alignment was associated with reduced hip lateral rotation and abduction strength. Willson et al[9] in his study of single-leg squats among athletes, reported that decreased strength of hip lateral rotation was related with elevated knee valgus. On the other hand, Ireland et al[10] found that women with patellofemoral pain syndrome had shared common medical history of reduced hip abduction and lateral rotation strength compared with age matched healthy subjects. Besides that, Niemuth et al[11] concluded that runners with overuse injuries had reduced hip-abduction strength. In spite of several limitations of the aforementioned studies, these researchers collectively agreed that lower extremity mal-alignments, especially the knee valgus was correlated with hip muscle weakness.

According to Power et.al[2], the kinematics of the entire lower extremity has the potential to get affected by excessive hip medial rotation and adduction during weight bearing. Dynamic knock-knee happens because of knee's inferior rotational movement which makes the shin bone to abduct from midline and the ankle to pronate.

Till today, only researcher Mascal et al[13] have studied the link between strength of hip musculature and lower limb joint motion. According to his case report, the subject who had been assessed in terms of showed increased hip strength and kinematics (eg, less hip adduction and medial rotation) which ranged from 32% to 56% during a step-down task following 14 weeks of core muscles strengthening programmes. Succeeding studies by Earl and Hoch, Boling et al, and Tyler et al[19] collectively suggested that hip strengthening exercise programs

resulted in pain reduction and improved functional outcomes among women with patellofemoral pain syndrome. These valuable data supported the speculation concerning hip muscles weakness and altered kinematics of lower extremity.

5.2 Conclusion

In conclusion, we found that hip abductors and lateral rotators strengthening exercises proved to be effective in improving knee valgus alignment among adolescents aged between 18 to 20 years.

5.3 Limitation of study

This study had several draw backs. Foremost limitation was neither the therapist nor subjects was not blinded. Secondly, only two types of hip muscle groups were tested. Besides that, we had a relatively small number of subjects in this study and the intervention session was only for 6 six weeks.

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