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Correlation between Forefoot Varus and Passive Knee Extension

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CORRELATION BETWEEN FOREFOOT VARUS AND PASSIVE KNEE EXTENSION

by

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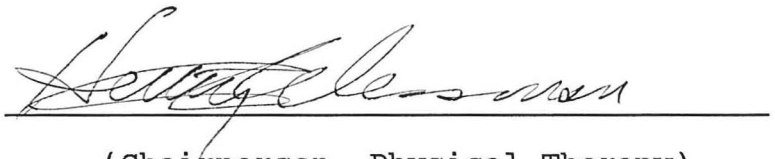
This Indepedent Study, sumitted by Scott B. Nice in partial fulfillment of the requirements for the Degree of Master of Phyiscal Therapy from the University of North Dakota, has been read by the Chairperson of Physical Therapy under whom the work has been done and is hereby approved.



(Chairperson, Physical Therapy)

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Title	Correlation Between Forefoot Varus and Passive Knee Extension
Department	Physical Therapy
Degree	Master of Physical Therapy

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Date March 25, 1993

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ABSTRACT

The purpose of this study was to examine if a relationship exists between the amount of passive knee extension measured along with the degree of forefoot varus. The intent was to demonstrate that a positive relationship does exist.

Twenty single limbs were tested and all met the criteria set. Forefoot measurements were taken in the prone position, the plane of the lesser metatarsal bones was measured in relation to the bisection of the posterior aspect of the heel. Passive knee extension was recorded by measuring the distance of the lift of the calcaneus from the table, with the thigh stabilized and traction employed through the great toe.

Direct positive results were generated when correlated mean values of knee and foot groups were compared. When classified as knee values with forefoot varus types compared to those with a forefoot valgus, highly significant results were generated.

It was concluded that the great toe traction technique may provide examiners with a valuable screening tool to predict certain generalities of their patients. Upon which physical therapy measures can be employed.

I. INTRODUCTION

The purpose of this study was to investigate the relationship between the degree of forefoot varus and the amount of passive knee extension present in any given individual. The topic originated as result the of four years of biomechanical lower extremity evaluation and gait assessment in the physical therapy clinical environment. As subsequent evaluations were performed, and more and more patients assessed, certain generalities became evident. To determine if such generalities do truly exist, a non-bias method to test the hypothesis had been designed. If true, the answer to the research question will be that a positive correlation does exist between the degree of forefoot varus and the degree of passive knee extension. This study may provide a simple screening procedure for those who are involved in gait analysis, to develop insight and guidance towards diagnosing the patient's problem, and in designing a proper treatment regime.

II. LITERATURE REVIEW

The foot performs many essential dynamic functions during gait that permits the body to progress forward in a normal walking pattern.[1] Rapid passive pronation of the foot occuring immediately after heel contact, with resultant supination in response to the ground reaction forces imposed, permits the foot to convert from a mobile adaptor to a rigid lever, allowing for normal propulsion at toe off.[1,2] This driving force is dependent on many factors, most important being the delicate balance of the subtalar joint motions of pronation and supination as they occur normally during their appropriate phases of gait. Subtalar joint neutral is that position at which the subtalar joint will function optimally, allowing maximum pronation and supination to occur.[2,3]

The subtalar joint has been described as a torque convertor that has direct functional correlation with the midtarsal joint, as well as the other joints of the entire lower extremity. When held in a subtalar neutral position, the midtarsal joint loses its ability to dorsiflex, evert, and abduct. The midtarsal joint is then considered to be locked."[2,3,4] This is accomplished in a open kinetic position by applying a dorsiflectory force to the fourth and

fifth metatarsal segments. This force is only taken until resistance is met.[2,3]

Pronation can be defined as a tri-plane motion involving elements of plantarflexion, eversion, and adduction.[1,2,3,4] Excessive pronation has been described as a common compensatory motion of gait. Pronation that continues beyond midstance prevents the conversion of the foot into a rigid lever for propulsion, and imposes functional limitations upon the joint structures of the lower limb as the foot prepares to leave the ground.[1] The resultant subtalar joint pronation and its compulsory triplane motion of calcaneal eversion and talar adduction with plantarflexion, continues in response to the flexion moment at the knee. Obligatory internal rotation of the tibia also occurs, placing stress on the knee joint.[1,2,3] In order to maintain talocrural joint congruency during the initial loading phase of gait prolonged, excessive subtalar joint pronation necessitates additional internal rotation and inclination of the tibia and flexion of the knee. Such forces occuring during midstance through terminal stance, result in delayed or reduced extension of the tibiofemoral joint. Torsional stress is created as the lower extremity attempts to extend while the tibia is prolonged in medial inclination.[1] Coplin[5] studied this phenomenon, and divided her subjects into two groups, a pronating group and a normal group. She tested all of her subjects for their total

available passive transverse rotatory motion at the knee at 90, 15 and five degrees of knee flexion. Coplin's[5] results manifested that tibial rotation was significantly greater in the pronatory group when compared to normals at five degrees of knee flexion. Although her studies were performed in a non-weightbearing position, it appears that as the knee moves towards terminal extension, an increase in transverse rotation at the knee is noted.

The anterior cruciate ligament is a key element in this study because of its relationship with knee extension. The anterior cruciate is the ligament that has been noted to prevent hyperextension (recurvatum) of the knee and anterior movement of the tibia on the femur.[6,7,8] The anterior cruciate also becomes taut in knee extension, and checks movement of the lateral condyle.[6,7] Combining the above two statements, the anterior cruciate ligament has a very important function with respect to terminal rotation and locking of the knee.[7]

The other key element is an appreciation for the amount of forefoot varus present. It should be noted that in conjunction with forefoot varus, it is common to also assess the position of the subtalar joint, but in this study, only the forefoot position will be addressed. When present, even a small degree of forefoot varus may influence total lower extremity joint motion in a weight bearing position.[2,3,4]

Most commonly, these compensatory motions are demonstrated by the lower extremity assuming a position of some degree of pronation.[2,3,4]

III. MATERIALS AND METHODS

The materials utilized in this study were basic and simple; a goniometer, metric ruler, plinth, and thigh stabilization belt. Twenty subjects were tested, none with any past orthopedic, neurological, or congenital abnormality that would influence the result of the test. Upon screening each subject, a single extremity from each was examined for the study. The first step of the procedure was to assess the forefoot in a subtalar joint neutral position with the subject in a prone position.

Upon establishing the subtalar joint neutral position, assessment of forefoot position was accomplished. Beginning by bisecting the calcaneus along its posterior aspect, all of the soft tissue structures, including the fat pad of the heel, were negated. Upon bisection, stabilization of the subtalar joint in its neutral position was achieved by applying a loading force to the fourth and fifth metatarsal heads to lock the forefoot. The angle at which the plane of the lesser metatarsal bones were inverted or everted in relationship to the bisection of the posterior aspect of the heel, was measured and recorded.

The thigh must be stabilized to adequately assess passive knee extension. With the subject positioned supine

on a plinth, a mobilization belt was placed just cephalad to the superior pole of the patella, and fastened around the thigh and the plinth to ensure proper stabilization.

The technique of great toe traction was employed to elicit the amount of passive knee extension present. Passive knee extension was then measured by having the examiner apply traction to the great toe and lift the calcaneus off of the table until a joint end feel is evident. The assessment was made by measuring, in millimeters, the height of the inferior part of the calcaneus from the plinth. A zero reading would indicate that no heel lift was demonstrated, and that no passive knee extension existed.

The results of each individual test were compiled and analyzed statistically using a two-tailed analysis of variance.

IV. RESULTS

Twenty subjects were tested, nine males and eleven females, whose ages ranged from 23 to 37 years (X = 28.3, S.D.= 3.9). All subjects were classified into three groups, those demonstrating a forefoot valgus (VL), forefoot varus (VR), and a neutral forefoot (N). Eleven were classified with a forefoot varus, six with a forefoot valgus, and three with a neutral forefoot. Forefoot measures were recorded in degrees, neutral being zero, valgus measures are denoted as negative to neutral, while varus types being positive to neutral.

Total forefoot measures are recorded in Table 1:

TABLE 1

	N	Mean	S.D.	Range(degrees)
All Subjects	20	2.25	6.32	-8 to 16
Forefoot Valgus	6	-5.17	2.14	-8 to -3
Forefoot Varus	11	6.90	3.91	2 - 16
Neutral	3	0.0	-	0

Total passive knee extension measures are recorded in Table 2:

TABLE 2

	N	Mean	S.D.	Range (m.m.)
All Subjects	20	23.55	12.91	7 - 55
Valgus Knee	6	15.67	2.80	13 - 20
Varus Knee	11	30.64	13.43	17 - 55
Neutral	3	13.33	6.51	7 - 20

Comparing means of all group knee values and foot values generated a t-statistic of 8.74 with 19 degrees of freedom. A correlation coefficient of 0.54 was generated. Spearman's Ranking-Difference for correlation coefficients for N=20; a .05 level of significance = .447, and the .01 level = .570. The results are significant.

A t-test performed to describe the correlation of the total knee and foot values generated a t-value of 3.21 with 18 degrees of freedom; a .05 level of significance = 2.10, and the .01 level = 2.88. The results are highly significant.

A t-test performed to describe the relationship between mean values generated a t-value of 8.74 with 19 degrees of freedom; a .05 level of significance = 2.09, and the .01 level = 2.86. The results are highly significant.

A t-test of means comparing knee values classified as those with a varus forefoot type and those with a valgus

forefoot type described a t-value of 3.45 with 10 degrees of freedom; a .05 level of significance = 2.23, and the .01 level = 3.17. The results are highly significant.

V. DISCUSSION

The results of this study indicated a significant relationship between the degree of forefoot varus measured and the amount of passive knee extension present. There appears to be a direct relationship between the two groups. Therefore the null hypothesis can be rejected. A significant difference was also demonstrated between the average means of the passive knee extension measurements when the measurements are classified as knee passive extension measures with an identified forefoot varus posture, and knee passive extension measurements with an identified forefoot valgus posture. The average mean of the forefoot varus' groups knee measurements was almost two times that of those of the forefoot valgus knee measurements.

Coplin[5] felt that she was not able to prove the theory that in a closed-chain weightbearing position, pronators have greater tendency to show a increase in passive knee rotation. She did find that however in a non-weightbearing position, increased passive knee internal rotation did occur at five degrees of knee flexion.[5] This study indicated that terminal passive knee extension was greater on the average

in those subjects who possessed a varus type of forefoot posture, than those in the valgus or neutral groups. The anterior cruciate ligament functions to check movement of the lateral condyle of the femur and becomes taut to limit the anterior translation of the tibia on the femur, i.e. knee extension. It also serves to prevent hyperextension of the knee and anterior movement of the tibia on the femur. Our study thus suggests that those persons who possess a varus forefoot type of posture may have the propensity to demonstrate increased recurvatum at the knee. Which could imply increased laxity in the anterior cruciate ligament, and the likelihood of pathologies that might exist or ensue.

Many researchers believe that chronic rotationally lax knees can lead to such conditions as early degenerative arthritis or increased risk of subluxation of the knee joint, and other chronic knee pathologies.[1,5] If our results prove to be valid, a simple screening evaluative tool such as the described great-toe traction technique may provide examiners the information to suggest that further conditions may exist, and thus to initiate preventative physical therapy measures.

APPENDIX A: SCREENING QUESTIONNAIRE

1. What is your age? _____

2. Do you have a history of any bone, nerve, or inherited problem with either of your lower extremities?

   Yes _____ No _____

   If yes, please describe the condition and indicate the side that is involved below:

3. Do you have a known allergy to the ink of a ball point pen or felt tip marker?

   Yes _____ No _____

If you qualify, would you be interested in being a participant in a study of the relationship between the position of your foot and the amount your knee extends?

   Yes _____ No _____

If you are willing to participate, please read further. If your answer is no, please return this form to Scott Nice, PT.

APPENDIX B: C O N S E N T F O R M

You are invited to participate in a study to determine if a relationship exists between the position of your foot and the amount your knee extends. This study is a requirement for a Master of Physical Therapy Degree at the University of North Dakota, the graduate program in which I am enrolled.

If you agree to participate, I will manipulate your foot and your knee. First, you will be tested lying on your back. A strap will be placed around the top of your thigh so that I stabilize your knee. I will grasp your great toe and lift your foot from the table. I will measure how high your heel clears the table in millimeters. Second, I will ask you to lie on your stomach. I will measure how far your foot turns inward from a neutral (midline) position in degrees. This will only be done on one of your extremities, your right side, unless a history of an injury exists, the left side will be used.

There is no known risk to you for participating. Your decision whether or not to participate will influence your current of future relationship with the examiner, Scott Nice, PT. If you agree to participate, you are free to discontinue participation at any time without prejudice. All information will be recorded in a codified form and all reports will be in group format so that you will not be able to be identified.

I am available to answer any questions you may have concerning the program now and in the future. You may contact me, Scott Nice, PT, at the Broadway health Centre Physical Therapy Department at (701)234-6735.

ALL OF MY QUESTIONS HAVE BEEN ANSWERED AND I AM ENCOURAGED TO ASK ANY QUESTIONS THAT I MAY HAVE CONCERNING THIS STUDY IN THE FUTURE. I ALSO WILL RECEIVE A COPY OF THIS SIGNED FORM UPON COMPLETION OF IT.

I have read all of the above and agree to participate.

_____ _____

Participant's Signature **Date**

REFERENCES

1. Mc Culloch M, Brunt D, Vander Linde D, The Effect of Foot Orthotics and Gait Velocity on Lower Limb Kinematics and Temporal Events of Stance, J Orhto Sport Phys Ther 1993; 17:2-10.

2. Gray G, Chain Reaction. A course presentation; October 6-8, 1989; San Diego, CA.

3. Gray G, Crayons and Computers. A course presentation; December 6-9,1990; Las Vegas, NV.

4. Gray G, Practical Locomotor Biomechanics: Evaluation and Treatment. A course presentation; September 16-18, 1988; Bismarck, ND.

5. Coplan J, Rotational Motion of the Knee: A Comparison of Normal and Pronating Subjects, J Ortho Sport Phys Ther 1989; 10:366-369.

6. Butler D, Noyes F, Grood E, Ligamentous Restraints to Anterior-Posterior Drawer in the Human Knee, J bone Joint Surg 1980; 62-A:259-269.

7. Erickson W, Mohr T, Muscle Function in Health and Disease. Publication for course notes of PT 412, 1986.

8. Grood E, Suntay W, Noyes F, Butler D, Biomechanics of the Knee-Extension Exercise, J Bone Joint Surg Am 1984; 66-A: 725-733.