# FLEXIBILITY AND HEIGHT AUGMENTATION: THE COMPARISON OF THE COUNTER MOVEMENT SQUAT JUMP AND SQUAT JUMP

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Thanks to Ms. Distante & Dr Gilbert Gleim, teacher and mentor

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6 women (age 25.6$\pm$3.6 years} and 15 men (27.13.7) performed the Squat Jump and Counter Movement Squat Jump while their motion was recorded by 5 infrared cameras (60 frames/sec) and a force place (Sampled at 1200 Hertz). This was followed by 11 flexibility tests based on a paper written by Gleim et al. in 1989. Two areas were being observed. One area of study was to determine if there was an augmentation in height from the squat jump to the counter movement squat jump and the second area was to determine whether flexibility effected the augmentation between these two maneuvers. It was determined that there was significant augmentation between these two maneuvers (P=.003} but flexibility did not seem to play a role in this augmentation (P=.769). There is need for further investigation into the relationship between flexibility, energy stored, elastic tissue, and/or stretch reflex.

## INTRODUCTION

Many rapid paced sports such as volleyball and basketball, increase the need to produce high muscle forces in a short period of time. The Squat Jump and the Counter Movement Squat Jump are similar to jumps that play an important role in these activities, where performances are dependent on muscle power more than muscle strength.(1) Some of the energy for these maneuvers is thought to have come from energy stored, elastic tissue and/or reflex activation. In 1990, Gleim et al. (2) published a paper on how measurements of trunk and lower limb flexibility relates to the economy of Oxygen uptake during treadmill walking and running. It was concluded that musculoskeletal tightness was associated with a decreased steady-state VO2 while performing these exercises. In 1994, Wilson et al.(3) discussed the relationship between musculotendinous stiffness and performance in eccentric, isometric, and concentric activities. They found that a stiffer musculotendious unit may facilitate such performances by improving the force production of muscles. Later, in 1995, McCarthy et al.(4) reported that isoinertial strength training resulted in significant increases in repetition maximum squat and vertical jump performance. The purpose of my study was to determined it there was an augmentation in height from the Squat Jump to the Counter Movement Squat jump, and also if flexibility affected the augmentation between the two maneuvers.

## Materials and Methods

Informed consent for exercise testing was obtained from all subjects following a medical history to exclude significant current orthopedic or medical pathology.

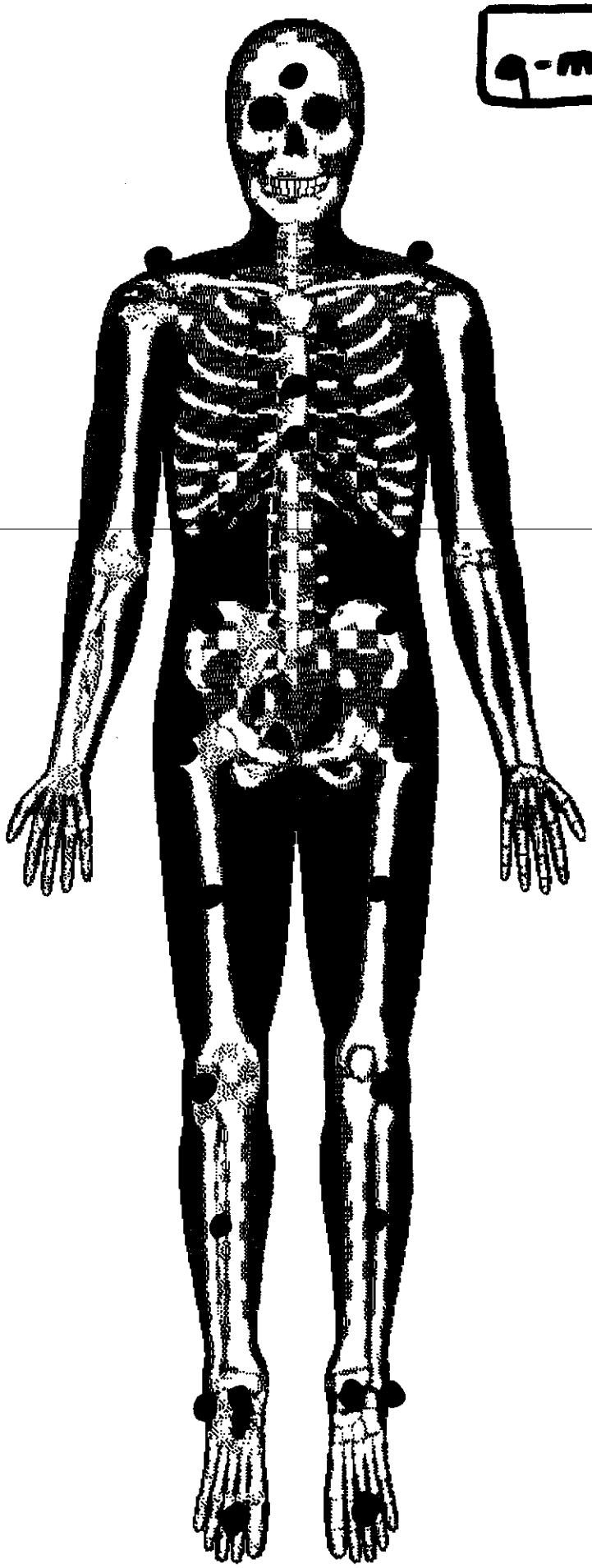
*Subjects:* 15 males (age 27.1±3.7 years) and 6 females (age 25.6±3.6 years) participated in the study. The average weight of the males was 180.9 lbs.(range from 142 lbs to 285 lbs) and the females was 131 lbs.(range from 104 lbs to 169 lbs.)

*Protocol:* First, the musculosketal flexibility of all 21 participants was obtained based on a paper written Gleim et al. All measurements were made by the same investigator. The subjects were asked to relax while the investigator moved the limbs through predetermined positions until mild discomfort was experienced. A total of 11 flexibility tests were used including Trunk Rotation, Toe Touch, Hip Adductors, Lotus Position, Toe Out, Knee to Chest, Ober Test, Ely Test, Straight Leg Raise, Ankle Dorsi-flexion, and the Thomas Test. Each test was then rated as loose, normal or tight using a arbitrary scale of (-1), (0), (1) respectively. The subject's test score for that individual flexibility test was then added to the other 10 tests to come up with a total flexibility score.

Following the flexibility testing, each subject then performed the Squat Jump and the Counter Movement Squat Jump. Two practice jumps were performed prior to testing to enable the subjects to familiarize themselves with each technique. The Squat Jump required the subjects to lower their body while keeping their back in an erect position, until their knees were flexed to a 90 degree angle. This position was then held for a count of two seconds where the subjects then performed an explosive vertical jump. The Counter Movement Squat Jump was then performed in a dynamic and continuous motion

as the subject squatted down to a 90 degree angle and then extended upwards in an explosive manner. Both techniques were performed on a force plate with four sensors, one on each corner of the perimeter.(1200Hz.) Simultaneously, five Qualisys motion analysis cameras (60Hz) recorded the individual's motion by reflecting infra-red light off 20 markers strategically placed on each subject. (As shown below) The height in the air for both movements was determined in two different manners. The first was by finding the delta (amount of time)from when there was no force on the force plate to when the force returned. The second method was based on the same five motion analysis cameras, where the delta (change in time) was from when the subjects foot left the ground to when it returned. Therefore, by both techniques, jump height was measured as time in the air with greater time representing higher jumps. Each subject's test was performed within a single day period.

q-markers



## RESULTS

The time in the air based on the force plate data for the Squat Jump had a mean time of .3978 $\pm$ 1.76*-02 seconds while the Counter Movement Squat Jump had a mean time of .4211 $\pm$ 1.75*-02 sec. (shown in figure #1). The time in the air based on the motion analysis cameras for the Squat Jump had a mean time of .3978 $\pm$ 1.77*-02 while the mean time for the Counter Movement Squat Jump was .4403 $\pm$ 2.36*-02 sec. (shown in figure #2).

The total flexibility scores for each individual ranged from -10 to 11. Once again, the individual that was most flexible received the score of -10 and the least flexible person received 11. The least possible score that one could receive was a -11 and the greatest was 11. The mean flexibility for all subjects was -1.1428.

A paired sample t-test was used and it was determined that both the force plate ($p=.003$) and the motion analysis cameras ($p=.050$) show that there was a significant augmentation in height from the Squat Jump to the Counter Movement Squat Jump. Finally, the correlation between flexibility and the augmentation between the two maneuvers was determined. Based on the force plate($r=.-.068$)[figure #3] and the motion analysis cameras($r=.092$)[figure #4], the correlation was determined to not be significant.

**FIGURE #1**

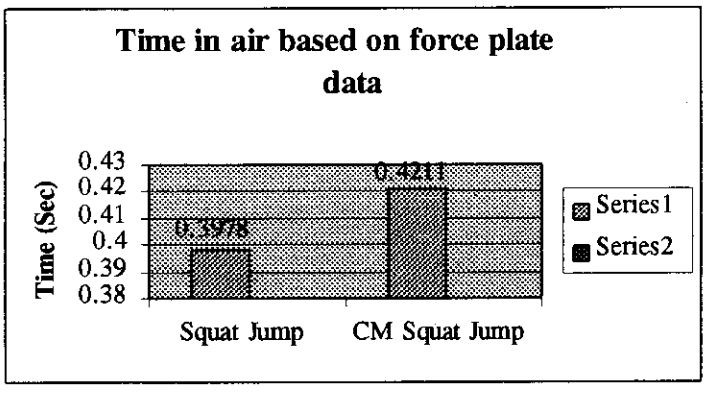
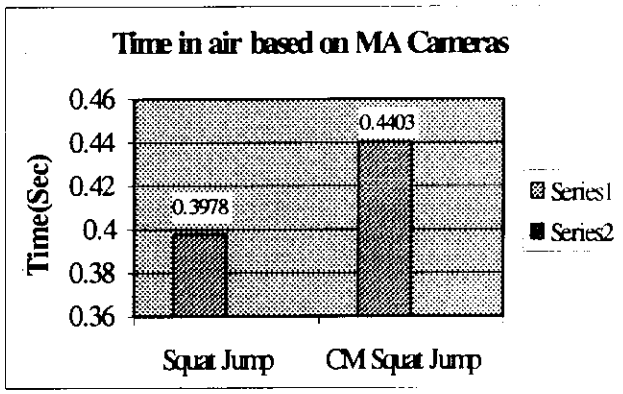
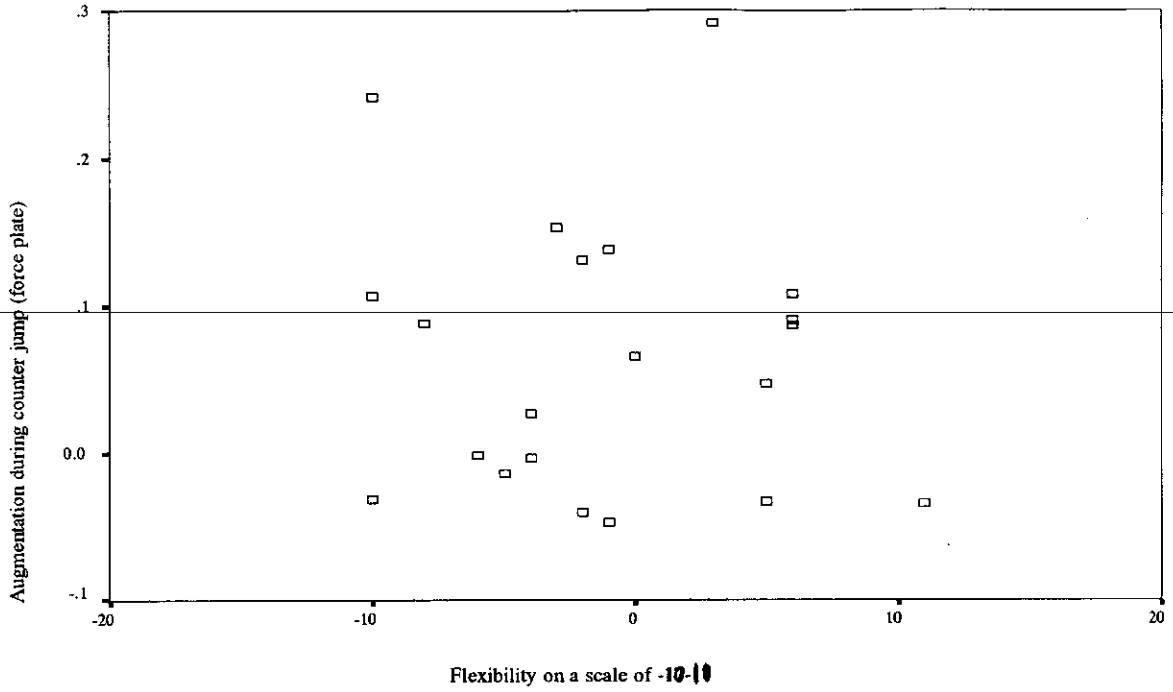


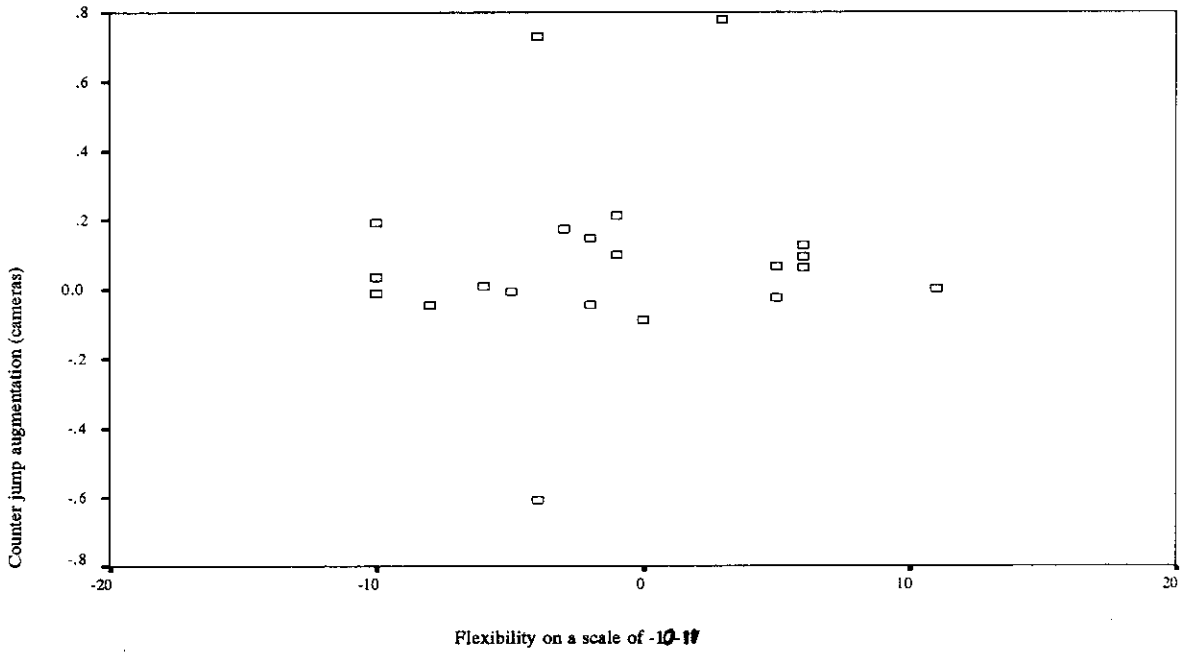

**FIGURE #2**



## FIGURE #3




## FIGURE #4



## CONCLUSION

Overall, there was a definite augmentation in height from the Squat Jump to the Counter Movement Squat Jump. Also, flexibility did not play a role in this augmentation between these two maneuvers.

There seems to be two main reasons for these results. The flexibility test measured overall body flexibility rather than the flexibility of individual muscles in the lower extremities. The best hypothesis of why the augmentation occurred is thought to be related to neurological reasons. It seems to be evident that the augmentation between the two maneuvers is related to reflex activation. During a reflex movement, many muscle fibers are activated, causing a quick, powerful movement to take place. A common known example of this is a doctor tapping a patient on the knee and the patient responding by quickly extending his/her leg out in a powerful way. A similar phenomenon is thought to have taken place with the Squat Jump and the Counter Movement Squat Jump. Other reasons for the augmentation could be due to elastic tissue and/or energy stored in muscles.

Further studies need to investigate the neurological intervention of the mind in the augmentation between the Squat Jump and Counter Movement Squat Jump.

## REFERENCES


1. Thesis from NISMAT @ Lenox Hill Hospital, NYC-pending publication

2. Gleim GW, Stachenfeld NS, Nicholas JA (1990) **The Influence of Flexiblity on the Economy of Walking and Jogging.** *Journal of Orthopaedic Research* 8:814-823

3.Wilson GJ, Murphy AJ, Pryor JF (1994) **Musculotendinous stiffness: its relationship to eccentric, isometric and concentric performance.** *J Appl. Physiol.* 76(6):2714-2719

4. McCarthy JP, Agre JC, Graf BK, Pozniak MA, Vailas AC (1995) **Compatibility of adaptive responses with combining strength and endurance training**. *Med Sci Sports Exercise* 27:429-436.