Cantaurus, Vol. 21, 13-15, May 2013 © McPherson College Division of Science and Technology

Correlation between Lower Limb Muscle Strength, Reflex Reaction Times of the Patellar Tendon and Lower Limb Dominance

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ABSTRACT

In this experiment, lower limb dominance was defined through consideration of muscle strength and reflex reactions of the patellar tendon. To test this question, a group of 18 college students from McPherson College were selected. Fourteen of the subjects were able to complete the testing for their lower limb muscle strength using leg extension and curl lifts and reflex reaction times using the IWorks equipment. Dominance was then determined by comparing results from their self-reported dominant leg to the data acquired from the testing. A chi squared test conducted showed that there was a significant correlation between the reported dominant leg and reflex reaction times (C.I. 95%, p=0.033). However, there was no significant correlation between the reported dominant leg and muscle strength (C.I. 95%, p=0.109). In further studies, if a larger sample size would be used, it is possible that significance could be found in both studies.
Keywords: *lower limb dominance, muscle strength, reflex reaction,*

INTRODUCTION

Typically when the matter of dominance of extremities of the human body is discussed, the focus is on the upper extremities. People normally define themselves as right/left handed which indicates which arm and hand arm dominant. Generally speaking, someone's dominant arm/hand is the one that they use more often, is stronger and they are also more coordinated with it than the other one. The dominant hand is used more frequently in daily activities such as writing, picking up objects, and throwing objects. This is common in our everyday life and even more so with sports. People generally use a specific arm to throw, swing a racket or bat or use a specific hand to shoot with. In most cases, it is clear to individuals as to which upper extremity is their dominant one, but it seems a bit more difficult to determine which lower extremity is dominant. When asking someone which leg is their dominant leg, they aren't always sure what it is that makes one leg dominant over the other.

There are several tests that can be taken to determine someone's hand dominance. A common test pertaining to dominance would be grip strength using a dynamometer (Peterson et al. 1989). Similar to the dynamometer for grip strength, there are also test that can be used to measure the muscle strength in the lower limbs as well. Such test would include lifting weights to maximum effort and also using isokinetic dynamometers at different angular velocities in both concentric and eccentric modes (Rahnama et al 2005). But aside from muscular strength few studies have been conducted that test for other attribute that correlate with lower limb dominance.

Since the lower limbs are used almost equally, especially compared to the upper body, is dominance something of concern or of importance? There have been studies that try to relate leg dominance and physiological events. One study published in July 2007 in Clinical Biomechanics was able to claim that their studies expressed a significant difference in the single leg hop distance and hip extension angle between the two lower limbs (van der Harst et al 2007). Several other studies have been done that have tried relating injuries to dominance of lower limbs, specifically with ACL injuries. In a previous piece of literature it was questioned on whether or not soccer players with ACL injuries showed a correlation between the side of the injury and the dominant leg (Negrete et al 2007). In that specific study there was no significance although there were trends leading to gender factors. In more recent studies, there was significance found in ACL injuires occurring more often in men in their dominant leg and ACL injuries occurring more often in women in their non-dominant leg (Brophy et al 2010). It has also been stated strength of the hamstrings in the dominant legs of soccer athletes were significantly weaker in the dominant legs, which could result in muscular imbalance which is an injury risk factor.

Thus being said, being able to properly identify which lower limb is dominant at an early stage could possibly aid in injury prevention. By correctly identifying which leg is a person dominant one, that person could then take the necessary action to protect themselves from injury through preventative training techniques.

MATERIALS AND METHODS

To answer the questions of whether someone's dominant leg is the strongest and/or fastest leg in terms of reflex reaction time in the patellar tendon, 18 different McPherson College students were selected to perform reflex reaction tests and leg strength tests. Each test subject will undergo the same routine in

testing in which they will each be tested and recorded in each tests with both legs. The first test the subjects will perform is the leg strength test. This test took place in the McPherson College weight room using the leg extension and leg curl machine. In order to record the leg muscle strength, we will find the maxes of the two largest muscles in the leg; the quadriceps and hamstrings. To find the individual leg max for the quadriceps, the subjects performed single leg extensions. To find the individual leg max for the hamstrings, the subjects performed single leg curls. The lifting routine was the same for both of the different lifts. The routine started with leg extensions using a single leg. Weight was added to the machine in five lb. increments until the subject felt that they were nearing their max, in which weight was then added in 2.5 lb. increments. Once the subject failed to complete a lift, the highest completed weight was then recorded as the max. In order for the lift to be counted as completed, the subject had to be able to lift their leg to the same height as the beginning of the test. Once the max was found in one leg, the same routine was repeated for the other leg for the leg extension lift. Following the completion of the leg extension lifts, the same routine was then used for the hamstrings using the leg curl lift. Finally, once both test have been completed for each individual leg, the total leg maxes are then calculated by adding the leg extension and leg curl maxes for their respective legs together.

The next series of tests that the subjects performed were the reflex reaction time tests of their patellar tendons. The subject will be hooked up to the IWorx equipment by attaching 3 electrodes on each leg. The first electrode is placed 12cm above the knee on the thigh. The second electrode is placed 10cm above that and then the third is place on the medial side of the knee to act as a ground. The black (-1) lead wire is then attached to the electrode directly above the knee, and the red (+1) lead wire is attached to the electrode above that. The green (C) lead wire is attached to the electrode on the knee to serve as the ground electrode. The IWorx equipment will have a pulsimeter taped to a mallet to record the exact time at that the mallet strikes the subjects patellar tendon. At the same time it will be recording an EMG (electromyograph) of the reflexive muscular twitch in that same leg. The difference in time between the strike of the mallet and the muscular twitch, which can be measured to the thousandth of a second, is the time it takes for the nervous impulse to make it through the reflex arc, and the muscles to respond. The measurement of their reaction time will be recorded five different times for each leg. Once the test is completed for one leg the same process is repeated to test the other leg. In order to determine which leg is the faster leg in terms of reaction time, the averages of the five recordings for each leg are compared against one another to determine the faster leg.

For the data that was collected to be able to be analyzed to determine whether or not those two factors had any relation to dominance, the subjects were also given a survey asking them which leg was there dominant leg. Final analysis compared the subjects' answers to their data. Two separate chi square tests were used; one for each data set (strength and speed) to analyze the whether or not there was a significant correlation between the dominant leg and the recorded data.

RESULTS

Once the data was collected, two separate comparisons were made. The first comparison was between the strongest leg and the dominant leg and the second comparison was between the faster leg and the dominant leg. In order to analyze the data for significance, a chi squared test was chosen to process the data. The first test that was analyzed was the strength test. If the dominant leg was the same as the strongest leg then it was recorded as agreeing with the hypothesis. If it didn't it was recorded as agreeing with the null hypothesis. Since there were 14 total subjects, the expected range was seven, since there was a 50/50 chance that either leg was stronger. In the strength data, ten subjects agreed with the hypothesis and four agreed with the null hypothesis. After finding the chi squared value of 2.571, I then used that value to calculate the probability of the data agreeing with the hypothesis using a 95% confidence interval (α=0.05). In this test I found the probability to be insignificant (p=0.109). According to the data, the hypothesis was rejected and the null hypothesis was accepted, stating that leg strength is not a significant factor in leg dominance. However, there was a trend in the data leading towards the hypothesis, but not enough to deem it significant. The same analytical process was then used to compare the reflex reaction time data to the dominant leg. In this section of the data, 11 subjects agreed with the hypothesis and three did not. Again the expected value was set at seven and after completing the chi squared test a value of 4.571 was found. This value was then used to find the probability again using a 95% confidence interval (α=0.05). In this comparison I did find significance (p=0.033). The hypothesis that the leg with the faster reflex time is also the dominant leg is supported with the data found in this experiment.

DISCUSSION

After completing this experiment I found that there are many things that could have been improved upon such as; the leg muscle test, the electrode attachment sites, and the number of subjects. When testing for the leg muscle strength I realized that it

wasn't quite the same effect as the grip strength test for the upper body using a dynamometer. With the dynamometer, subjects would squeeze it as hard as they could, giving maximum effort the every time. Fatigue is not an issue when trying to find the maximum potential with this style of testing. However with the leg muscle strength used in this experiment, fatigue became an issue as the weight was added progressively rather than being able to have a maximum effort lift all at once. Also, the weight could only be narrowed to the nearest two and a half pounds since that was the smallest weight available. Had we had smaller increments of weight, a greater margin of difference between the two legs might have been able to be obtained. When it came to the reflex test, it's seemed that the subjects with short or no hair at all on their thighs seems to get better readings from the electrodes rather than the subjects with hairier legs. The final results would also have a chance of showing great significance, or any significance at all in terms of the muscle strength comparison, if there was a larger sample size of subjects. It would be interesting to see this test conducted on a much larger scale to see whether or not the trend seen in the muscle strength comparison would lead to any form of significance or not. Even though there could be several changes to the experiment, the experiment as a whole seemed rather successful. The hypothesis of the leg with the faster reaction time would also be the dominant leg was accepted with significant data. The other comparison rejected the hypothesis of the stronger leg would also be the dominant leg but with the data that was collected, we were able to see a trend that lead towards the hypothesis but was not able to significantly support it.

ACKNOWLEDGEMENTS

I would first off like to thank my subjects that were willing to assist me in my experiment. I would also like to thank the natural science faculty, especially Dr. Ayella, Dr. Frye, and Dr. Wilgers, in assisting me with my research and data analysis.

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