Examining a Novel Physical Rehabilitation Technique: A comparison to conventional therapy methods

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Abstract:

This study compared the functional benefits acquired from two different approaches to physical therapy. A common neuromuscularly weak position was identified by a licensed MPT in which one's leg is abducted. Participants were tested as to how much force was produced in this position among others (figure 1). They were then assigned a specific intervention to do for 6 days and they were tested again. Group A was assigned to lie down for 3 minutes a day. Group B was assigned to perform a specific exercise on the weak leg. Group C performed the same exercise but on the stronger leg. After 6 days of exercise we were most interested in the strength increase in the weaker abducted leg. Group C had a mean 26.4% increase in strength, Group B had a mean 10.7% increase in strength, and Group A had a mean 9.56% increase in strength. These values were determined to be statistically significant which suggests Rekinetics™, represented in Group C, could serve as a novel method to be considered in the field of physical rehabilitation. Further insight is needed to explain the neuroscience that supports it.

Introduction

The majority of traditional approaches to physical therapy and physical rehabilitation in Western medicine focus on treating and strengthening an injury or weakness directly. A new alternative approach, Rekinetics, takes advantage of certain neural systems and circuits that allow training of one limb to yield functional improvements in performance of the opposite limb. Often when someone experiences an injury but physically heals, they develop a different neuromuscular patterning from that prior to the injury. For example, an average health insurance plan will permit, at most, several hours of therapy a week. For the rest of the week, a patient's hamstring injury would likely cause pain if they attempt to use it at a pre-injury level—thus aggravating the injury. The brain changes its neuromuscular control of the hamstring so that the body moves in such a way as to not incur pain from the hamstring—limping, for example. Thus, despite a full physical recovery from the hamstring injury, it is possible that dysfunctional neurological conditioning lingers. It has been reported that unilateral strength training results in strength increases in ipsilateral limbs[7]. This possibility suggests that a therapy like Rekinetics could be viable in restoring proper neuromuscular conditioning to the affected area.

The corticospinal tract is the pyramidal tract that controls motor function. Brain control of motor function is contralateral, which means that one hemisphere controls a specific part on the opposite side of the body. The neural impulse for movement begins in the primary motor cortex, descends along the tract, then desiccates—or crosses over—to the opposite side of the tract at the level of the medulla. The tract continues to descend along the spinal cord, and branches off to control different levels of motor function.

Two general hypotheses attempt to explain how these contralateral benefits occur from a neurological standpoint: The Bilateral Access hypothesis and The Cross Activation hypothesis. These contralateral gains were observed as early as 1892.[1]

The Cross Activation (CA) model suggests that during unilateral movements of a limb, activation of the contralateral homologous corticospinal tract occurs such that the neuromuscular network is able to develop bilateral adaptations that improve function of the opposite limb.

This model has been supported in several studies. Transcranial Magnetic Stimulation (TMS) was used to detect bilateral excitability of corticospinal projections during unilateral movements.[2] This suggests that moving one side of your body, the left arm, for example, results in neurological activation of the projections to move the right arm in the same manner. While we would expect that the neural impulse begins in the primary motor cortex in one hemisphere, Tsuboi finds that the crossed activation occurs from a common impulse to both motor cortices. [3] Specifically, it seems that the actual crossing over of information does not occur in the primary motor cortex, but in other, currently unidentified brain centers.[4] Furthermore, the level of cross activation was shown to positively correlate to the amount of force generated by the opposite limb.[5] This would suggest that if one utilizes more force in one limb, there would be a greater level of corticospinal projection to the other limb.

Essentially, when training one side of the body, not only is the contralateral side of the brain activated, but the ipsilateral side of the brain is activated well. Despite the fact that it only results in a unilateral movement, the body undergoes adaptations that improve the function of the untrained limb

The Bilateral Access Model (BA) proposes the idea that when a unilateral motor movement is done, the brain develops engrams, or blueprints for a specific movement. These engrams are located in a specific region of the brain that is accessible to both hemispheres. A corollary to this model suggests that the adaptations gained by one hemisphere are transferred to the opposite via the corpus callosum and it is this transfer of adaptations that yield improved function of the untrained limb. Studies that support this on a structural basis are not particularly advanced at this point in time; however, certain fMRI studies do suggest that this could be a substantial model.[6]

This study seeks to compare the outcomes of participants who undergo "traditional therapy" with outcomes of participants who undergo Rekinetics therapy, testing force one can create with the leg either in a straight position or abducted position. 93.5% percent of the participants exhibited a weakness in the abducted position compared to the straight leg position for both legs pre-treatment. Of these participants, the average force in the abducted position on the strong side was 83.58% of that in the straight position. For the weak side, force in the abducted position was 77.67% of that in the straight position. That the abducted position is almost universally weaker than the straight position suggests the source of the discrepancy is neuromuscular activation rather than a weakness in the position's contractile potential.

In order to examine the potential benefits of Rekinetics over a traditional therapy approach, we analyzed a population of 77 individuals, 49 of whom identified as male and 28 of whom identified as female. The median age was 21 years old, with a range of 18-51 years old. On a scale of 1-5, the average activity level of the participants was a 3.9, with 51 of the 77 participants playing a varsity college sport at the time. We also noted any past or current injuries that were relevant to this study, such as: back or lower extremity injury, back or lower extremity pain, and back or lower extremity surgery. Combining this information with data provides a more informative vision as to how and whom Rekinetics may have the most significant benefit for.

We hypothesized that the Rekinetics treatment group would see the greatest gains in force production, and that several members of the Rekinetics group would have much higher gains than any participant in either of the other two groups. We thought there would likely be a few participants who would see much higher force gains in the first session after 3 minutes of a Rekinetics exercise. We expected that the conventional training regimen would incur greater gains than in the control group, but that due to learning effects all three groups would see overall improvements.

Rekinetics has therapeutic potential across several patient populations: individuals with diminished unilateral motor function—caused by traumatic brain injury, a vascular injury, or strictly musculoskeletal injury. Previous studies have demonstrated that high intensity strength training of a non-paretic muscle group can improve activation and strength in a highly paretic muscle group in stroke victims, suggesting a role for the plasticity of the brain allowing even damaged brain tissue to regain function.[8]

Rekinetics, however, has potential to produce greater benefit than traditional cross educational training (CEE). One of the key differences between CEE and Rekinetics is that Rekinetics focuses on identifying a pre-existing functional difference between two sides of the body, whereas CEE targets the strength of two limbs that have relatively equal levels of muscle activation. Furthermore, Rekinetics focuses on testing and improving function in positions that require the recruitment and communication of multiple muscle groups rather than isolating a single muscle group. Prior, unpublished Rekinetics results have found that the strength of an individual muscle group can be normal, but when asked to work together with other groups it can show an abnormal weakness. For example, it has been observed that the gluteus maximus muscle can suddenly become inhibited when asked to fire in conjunction with the ipsalateral latissimus dorsi.

Rekinetics has been practiced clinically on elite athletes, dancers, weekend warriors, children with developmental disabilities and has reduced pain and improved function. While the exact underpinnings of this novel technique are still not fully understood from a neurological or muscular standpoint, the unique benefits it has shown call for increased study to pursue this as a therapy for those with vascular injuries, neurological disease, or musculoskeletal disease/injury.

Materials and Methods:

General Method:

We tested the force production of each participant in four different positions. The participant was asked to lie on their back with one leg bent such that the bottom of the foot was on the ground, and the other leg out straight. The bent leg was positioned such that there was approximately a 90-degree angle between the femur and the midline of the tibia and fibula. The participant was then instructed, “When you are ready, please push as hard as you can into the force plate.” The participant would then proceed to press the heel of their bent leg into a plate containing a dynamometer. After the first baseline measurement, the bent leg was abducted 45 degrees from the midline of the torso. The force measurement was retested. This procedure was practiced identically for each position for both legs (figure 1).

We then identified which leg was weaker in the abducted position. After this point, the participant was then asked to do a specific exercise/intervention for 3 minutes, take a 30 second rest, and then have the weaker abducted leg tested again. These exercises were designed by Rekinetics therapist Jeremy Baber, MSPT, CSCS.

The patient was then asked to perform the same exercise for 3 minutes a day for 6 days, and then revisit the lab to have all 4 baseline positions tested once again.

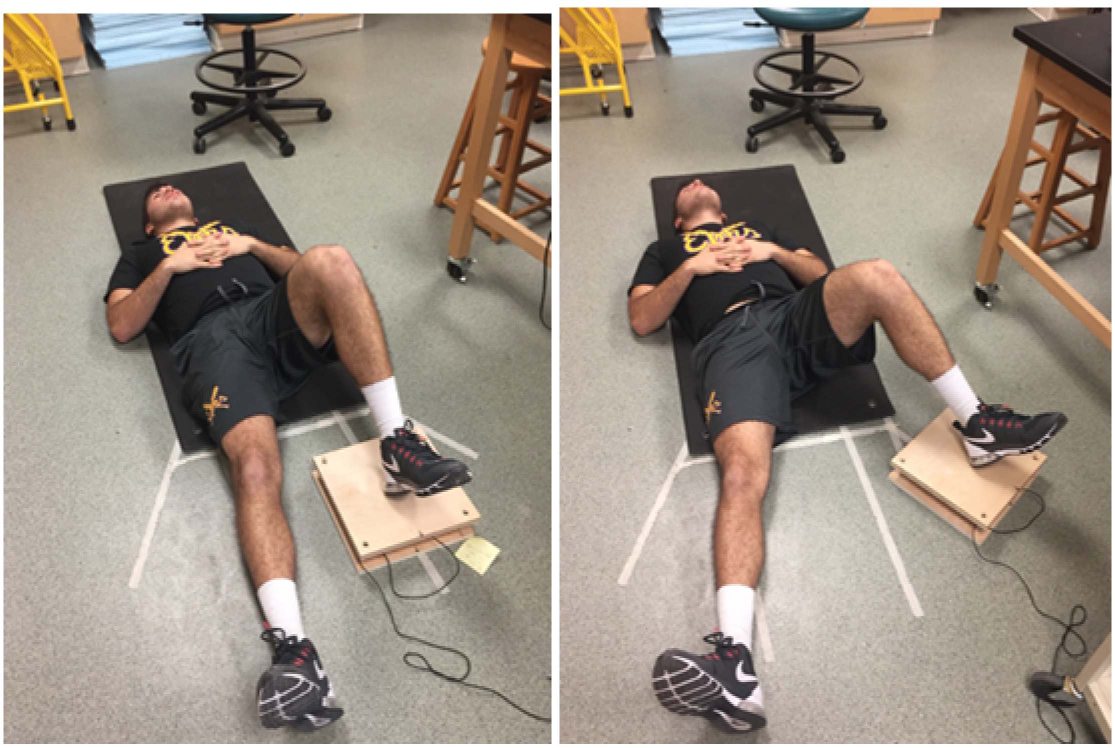

Figure 1: Tested Positions for the left leg.
These are images that show the tested positions for only the left leg. The left leg straight position is the picture on the left. The left leg abducted position is the picture on the right. The participant was asked to do these (on both legs) prior to the intervention, and after 6 days of exercise.

Group Designation:

We designed three groups to be studied in this experiment. They were designated groups A, B, and C. These groups were differentiated only by the intervention/exercise the individuals were asked to perform. Group A was asked to perform their exercise of lying down with both legs straight for 3 minutes a day. Group B was asked to practice an exercise on the weaker abducted leg. The specific exercise was to assume the same position as the test, with only the weaker abducted leg bent. They were asked to press into the ground using the heel of the bent leg for 20 seconds and then rest for 10 seconds for 6 total repetitions of the cycle. Group C was asked to perform the identical exercise, on the stronger abducted leg. Once the participant returned a week later, the same measurements were taken.

Force Measurement:

A MLT004/ST isometric dynamometer was utilized to measure force output in millivolts. The dynamometer was placed into a wooden device to easily measure force from the participant's heel (figure 2).

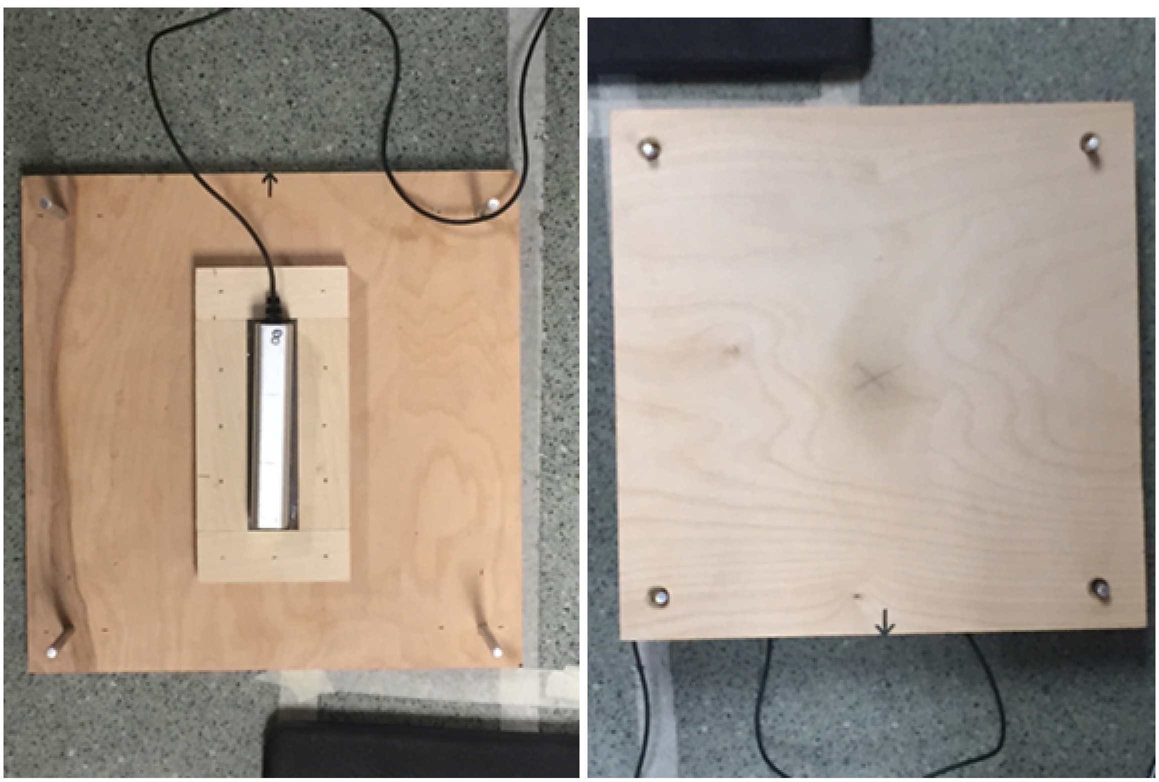

Figure 2: Dynamometer Device

This is the device, which was utilized for participants to put their heel upon such that we could easily measure their force output. The wooden slab was placed on top of the dynamometer—on the X.

Results:

	Average % Increase	Median % Increase	Maximum % Increase	Minimum % increase
Group C	14.19%	9.05%	94.46%	-9.75%
Group A	5.05%	3.25%	21.22%	-7.77%
Group B	7.29%	5.99%	28.65%	-14.95%

Table 1: Percentage increase in force production in the weak leg in the abducted position after one 3-minute intervention the first day the participant is tested.

Group C was the Rekinetics group in which the strong leg was trained before re-testing the weak leg in the abducted position. Group A is the control group in which the participant was asked to lie down for three minutes before re-testing the weak leg in the abducted position. Group B is the conventional training group in which the weak leg was trained before re-testing the weak leg.

	Average % Increase	Median % Increase	Maximum % Increase	Minimum % increase
Group C	26.36%	15.51%	119.53%	-15.26%
Group A	9.56%	10.39%	36.17%	-7.38%
Group B	10.74%	10.31%	33.33%	-7.44%

Table 2: Percentage increase in force production in the weak leg in the abducted position after a week of doing the group's intervention for three minutes each day.
*Only includes participants who completed the exercises 4 or more times

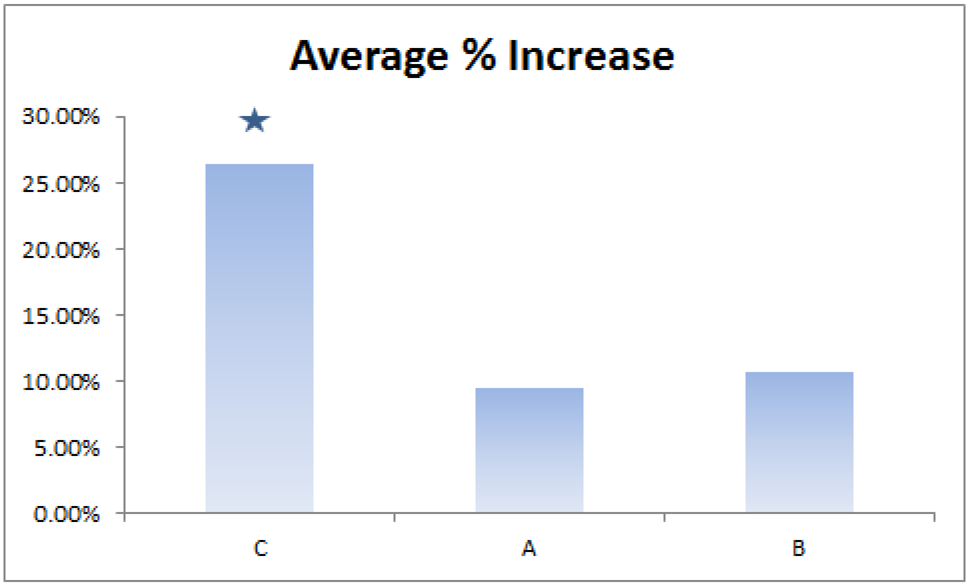

Figure 3: Graph of average percentage increase in force production after one week of exercises.
*Statistically significant difference from the other groups

Tables 1 and 2 show that Group C had the largest strength increases in average, median and maximum strength produced. The maximum percent increase refers to the largest strength increase observed in an individual while the minimum percent increase refers to the lowest strength change observed in an individual for each group. Group C had an average strength increase of 26.36%, whereas the traditional approach to physical therapy yielded only a 10.74% increase in strength; the significance of this data was supported by a z-score of 2.11 and a P-value of 0.017. This result indicates a significant difference in the participants' outcomes between treatment C and treatment B, suggesting that Rekinetics therapy could offer a greater benefit in rehabilitative medicine than the current approach. Furthermore, Treatment C induced a 86.2% greater maximum increase in an individual than Treatment B.

Discussion:

The results support our hypothesis that Group C, the Rekinetics group, would have greater increase in force strength than either of the other groups. A p-value of .012 shows that the C treatment was statistically different than the control. Again, a p-value of .017 shows that treatment B and treatment C are indeed different from one another.

A more rigorous statistical analysis using a linear mixed-effects model fit by maximum likelihood returned greater evidence of statistical significance. Only participants who completed the exercises 4 or more times were included, and in this set the number of times one did the exercise did not return any significant differences. Only complete cases -- those who came in twice for testing -- were included: 17 participants in Group C, 23 in Group A, and 21 in Group B.

Group C participants, controlling for the random effect (how each individual deviates from the expectation for the group) and random error (error in the intercept for each individual controlling for different strength levels), saw an increase of 7.9lbs of force due to being in the Rekinetics group (p-value of 0.0061). Group C's difference from Group A was statistically significant. Group B and Group A were not different in a statistically significant manner, and further analysis would potentially show a statistically significant difference between Group C and Group B. Current analysis showed the two groups to be about two standard deviations apart, on the border for statistical significance. These results support Rekinetics as a superior treatment method.

Interesting to note is the magnitude of force gains in two members of Group C. After just one performance of 3 minutes of the Rekinetics corrective exercise, two participants saw a 53.9% increase in force production and 94.5% increase. These were increases by 19.5lbs and 29.6lbs respectively. Similarly, the same two subjects saw increases of 104.2% and 119.5% respectively after a week of doing the exercise, gains of 36.9lbs and 37.3lbs over the initial testing. As shown in Table 1 and Table 2, these gains are far greater than that of the other two groups. The increase we see in Group A likely accounts for natural motor learning simply from having performed the tested movement at least once. Thus, the statistical significance between Group A and Group C support the fact that Group C did indeed increase participants' strength in the tested position more than Group B. Upon observation of the aforementioned participants with extreme strength gains, we also observe a medical/injury history of hip or back pain. This would support the idea that while past physical injury may have healed, faulty neurological wiring may still exist and utilizing neuromuscular-based therapies such as Rekinetics are particularly efficient at remedying these issues.

In determining where these results fit with the theoretical models on cross-training, we came to mixed conclusions. On the BA model, this study would say that, rather than having bilateral access to one engram for a particular movement, each hemisphere might have its own engram. Maybe the right side has a better blueprint for a particular movement, and that blueprint can be transmitted to the left. We would see immediate strength gains because the requisite muscle strength was previously there, and now the left side "knows" how to use the muscle. Our results would more likely support the CA model, as using the strong side could induce similar activation of the contralateral homologous corticospinal tract. If such activation in the strong side leads to greater force output and could be called more efficient or effective, then the weak side would then be gaining greater efficiency or activation and as a result increase force output. However, this is simply speculation, and more research on this matter is necessary.

Comparing this study to similar research that examines cross-education training, one might question how our experiment saw percentage increases in force output far higher than increases in other experiments. The abducted position creates mild lumbar side bending, thus testing integration between the hip abductor muscles (gluteus minimus, tensor fascia lata, gluteus maximus and gluteus minimus) as well as certain lumbar muscles and obliques. This co-functioning is both necessary and applicable to everything from walking to elite athletics. If someone is injured or has pain while walking or in sport, then integrated movement may be where the faulty neurological firing might exist. According to the BA model, creating proper neurological blueprints could improve function. Or with the CA model, experiencing proper bilateral corticospinal movements via practicing unilateral movements could also improve function. As a result -- and a hypothesis underlying Rekinetics -- correcting that integrated movement between different muscle groups and the efferent nerve fibers that project to them would expedite improved movement.

Our results in which holding a posture can lead to such significant benefits for the body prompt an inquiry into the converse: can holding certain postures lead to chronic pain and weakness? Although the neurological underpinnings remain uncertain, there would likely be some correlate to the use of mirror therapy in phantom limb pain. Perhaps a posture, like the mirror, serves as a signal to the brain that the body is either well or injured, and the brain responds with the appropriate pain level as a result. If this were the case, the interaction between physical postures and chronic pain could serve to explain the epidemic of back pain associated with a sedentary lifestyle.

Conclusion:

We should also note that the full Rekinetics treatment was not used in this experiment, as it involves a retraining component that would have interfered with parsing out effects from training the strong limb and the weaker limb. Jeremy Baber, the developer of Rekinetics, includes a minute of the appropriate exercise on the weak side following those on the strong side to "myelinate the new connections," as he puts it, so that improvements are maintained indefinitely. Based on our results, this extra minute of exercise would either improve performance from that of only doing our Rekinetics treatment or leave it unchanged. Similarly, Rekinetics attempts to find an individual's unique neuromuscular weaknesses, so it is possible that the near-100% gains of the two individuals in our study would be replicated in different movements for a much larger populace. We chose to test in the positions we used because this weakness was deemed by Baber as relatively common, so a treatment catered to an individual's weakness could yield results near the top of what we saw in this experiment.

Utilizing contralateral training, but more specifically Rekinetics, is an exciting development in the world of rehabilitative medicine and therapy as it has many applications. It could potentially treat anything from patients who have suffered a traumatic brain injury, a stroke, spinal cord injury, or musculoskeletal injuries. The fact that it is minimally invasive and easily translated into clinic makes Rekinetics all the more attractive as a therapy to pursue in further research.

Supplementary Figures:

Supplementary Table 1. Comparing means for follow-up testing

	Standard Error	Z-score	P-value
Comparing C and A	7.44%	2.26	0.012**
Comparing C and B	7.41%	2.11	0.017**
Comparing B and A	3.24%	0.36	0.359

* Only includes participants who completed the exercises 4 or more times
** Significant at $p < 0.05$
Supplementary Table 1: Z-scores and P-values comparing force production increases for each pairing of treatment groups after one week of doing the assigned group's intervention for three minutes each day. Only includes participants who completed the exercises four or more times.

Supplementary Table 2. Linear Mixed-Effects Model*
Fixed effects: Weak Abducted ~ Group * Visit

	Value	Std.Error	DF	t-value	p-value
(Intercept)	211.44042	14.300922	55	14.785089	0.0000
GroupB	-17.40842	21.211696	55	-0.820699	0.4154
GroupC	-1.19042	23.560898	55	-0.050525	0.9599
Visit	13.62542	9.536372	55	1.428784	0.1587
GroupB:Visit	7.33758	14.144726	55	0.518750	0.6060
GroupC:Visit	44.84387	15.711258	55	2.854251	0.0061**

*N.B. values are in millivolts, which convert to lbs by the translation Weight = 0.1595(mvolt) + 0.7918. Thus the increased value for the Group C visit is 7.94 lbs.
**Denotes statistical significance

Conflict of Interest: Alex Beschloss declares no conflict of interest. Brian Astrachan declares a conflict of interest as the Director of Business Development for Rekinetics. His experience with and resulting belief in Rekinetics led him to propose this research in the hopes of getting scientific backing for the technique to help in further expansion of Rekinetics.

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