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Multi-Subject Assessment of Human Performance Using the DYFORMON

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ABSTRACT

The DYFORMON is an accommodating-resistance exercise machine which was used to measure human momentum generation. This quantity was calculated by integrating the user force output over time. Momentum was determined to be a better measure of effort in this study rather than work since the exercise bar moves at the same constant speed regardless of applied force. The goal of this study was to consider momentum increases or decreases with respect to recovery time with multiple subjects. Four subjects completed the exercise protocols to the end of the experiment. The subjects were divided into two groups. Each workout session consisted of three sets of ten repetitions of bench press. The exercises were preformed with one set at a rep every four seconds, the second set at a rep every eight seconds, and the third also at a rep every eight seconds but with the subjects pushing one and resting one and so on until they pushed for ten repetitions. Results showed that working out once a week typically increased momentum generation from one week to the next. Working out twice a week showed mixed results.

Keywords: *Isometric, accommodating weight resistance, isokinetic, concentric, eccentric, recovery time*

INTRODUCTION

People have been constantly trying to develop better ways to exercise. There have been different methods of exercise developed and tested over the years, many which give a fine workout and results, but people still want improvements. They do not want to spend so much time working out, they want greater efficiency, and they want to see feedback on their workout.

Thus far the typical mode of strengthening has been with the utilization of free weights or weight resistant devices (WRD). Another mode of strength training that can be used is accommodating resistance devices (ARD). A study comparing ARD and WRD was done, which showed that both were effective at increasing strength and muscle size (O'Hagan *et al*. 1995).

The DYFORMON is an ARD that can be described as a moving isometric. The idea of a moving isometric may sound contradictory, but in this case it is not. It has the elements of an isometric in that no matter how much force is applied it does not effect the movement of the bar. The bar is moving cyclically up and down at a set speed. Using this idea, the DYFORMON is suggested to be a superior workout system for strength building compared to any other workout system existing.

The DYFORMON is currently being improved to make it commercially available. There are some issues such as safety and aesthetics that are being refined. The new models will have instant computer feedback for the user. It will have sensors that can tell how much force each arm or leg is exerting, as well as a suite of physiological parameter outputs.

There are many aspects that make this machine superior to free weights. One is the fact that there is no need to waste time putting weights on a bar and taking them off again. Also a great benefit of this machine is that if someone were to pull a muscle while working out he or she could simply stop and be done, with free weights stopping would cause the bar to drop on the person and lead to further injury. The aspect that really separates this machine from others is that this machine can be, by far, the most intense. The intensity of the workout using this machine is directly related to the effort the person is exerting. With this machine a person can be giving all they have through the entire cycle. This is different from free weights because with free weights the user can only put as much weight on the bar as they can get through their weakest point. Therefore, they are not giving 100 percent of their possible effort at the other points. This is the reason the DYFORMON is so intense, and due to this intensity, workout time is greatly decreased making it a much more efficient workout.

The DYFORMON machine can measure work done per cycle, average power per cycle, instantaneous power, momentum per cycle, and more (Hoffman 2005). This study looks for increases in momentum generation over a given time. Momentum is being used because it is thought to be the best indicator of effort. This claim is due to the fact that momentum is the product of force and time, and does not involve distance. One can be exerting a lot of force but not moving something at all. This does not mean he or she is giving zero effort though. The purpose of this study is to show that statistically significant increases in strength can be gained with a short amount of workout time, which would support that idea that the DYFORMON is a better and more

efficient system than any current system. Also, this study will look at recovery time of the subjects using the DYFORMON.

MATERIALS AND METHODS

Six college students, all males not involved in any fall college athletics, volunteered to participate in this study. Each subject signed a consent form prior to any participation. The subjects were instructed to maintain their typical lifestyle during this project. They were simply asked to keep track of eating, sleeping, and any extra exercise in a journal provided for them. The subjects were divided into two groups. The first group was assigned to workout twice a week for the first four weeks, then once a week for an additional four weeks. The second group was assigned the opposite, once a week for first four weeks, then twice a week for an additional four weeks. Of the six subjects, four continued to the completion of the project. The main reason for having the subjects' workout both once a week and twice a week was to consider recovery time.

The DYFORMON combined with a computer using DataStudio™ Software comprised the data collection equipment. The DYFORMON was created by Dr. Kent Noffsinger and Dr. William Kraemer. It has a five horsepower motor which moves an Olympic style bar (Herrara 2000). A newer version of this machine has been produced and is known as ABLE II. This newer version is much less crude looking, and is much more sensitive to pressure on the bar. It also has improved safety. There were hopes of having this newer machine available for this study, but it simply was not ready in time. However, it could be the basis for future research, including research on vibration analysis.

The DYFORMON can be considered a "moving isometric". Isometric means the muscles contract without causing a change in length of the muscle. In this case the muscles are changing their length, but not due to the contractions. The machine is moving the bar at a given speed, which causes the change in length of the muscles. In other words, no matter how hard someone pushes (up to 2000 lbs.) the bar moves the same speed.

The data that was taken included time, position of bar, and sensor voltage. The sensor voltage is what is converted to force to determine how hard someone is pressing on the bar. This raw data was transferred into EXCEL™ spreadsheets. From here the data was converted to momentum, cycles and sets. This allowed for comparison between sets of data. Momentum was the key aspect used to consider effort and increase or decrease in effort exerted. This momentum was graphed and the slope from week to week was examined for each subject and between subjects. Increases and/or decreases were observed and recorded.

All the subjects were familiarized with the machine during the week prior to the start of data collection. Each workout session consisted of three sets of bench press. The first set included ten repetitions done at a fast speed. The second set included ten repetitions at a slow speed. The third set was done at the same slow speed with the subject pressing a total of ten repetitions, but only pressing during every other cycle. All workout sessions were under direct supervision of the author and advisor. Two of the workout sessions had to be cancelled, one in the first four weeks and one in the second four weeks.

RESULTS

Calibration of the senor converting output voltage into pounds gave a polynomial equation with an R^2 value of .9953 which is near 1 and therefore a good fit. This conversion allowed for the instantaneous force to be figured. The instantaneous force was then integrated over the time the subject was pushing. This gave the momentum generated.

Plots of position of the bar vs. pounds exerted were generated to consider which positions allowed for greatest forces and which positions were "sticking points" or points where the least force could be generated. Figure 1 shows such a plot for a single rep. This figure shows that the maximum force on the eccentric was near 225 lbs. However, the maximum force for the concentric half peaked at around 175 lbs. The "sticking points" can be seen to occur as the bar is about halfway down and again as the bar is about halfway back up. In this example both sticking points are near 120 lbs., with the concentric being slightly lower than the eccentric.

It was found that working out on the DYFORMON once a week showed a gradual but significant increase in momentum generation from the first week to the fourth. This can be seen in the example used in Figure 2. This was observed for every subject with each of the three sets with one exception. One of the subjects increased his momentum generation on the first two sets, but showed little change during his third set. This third set can be seen in Figure 3. This could mean that he exerted so much energy on the first two sets each time that he didn't have as much energy left for the last set.

Working out twice a week showed mixed results. The group that started the experiment working out twice a week showed an initial decrease in momentum but soon leveled off. This can be seen in Figure 4. This would suggest that their muscles needed more time to recover. This is not surprising since this group went from previously not being involved in any type of weight training or conditioning to an intense twice a week routine. The group that first worked out once a week, then switched to twice a week did not show this same initial decrease in momentum. In fact, they showed a general trend toward increasing momentum, as can be seen in Figure 5. This change in outcome could be due to

the fact that this group was able to first train and condition their muscles to use the machine once a week in the first half of the study. For more on this see the discussion section.

These results were strictly for the bench press regiment that the subjects were assigned to. This same procedure could be done with any lift exercise desired in any future analysis.

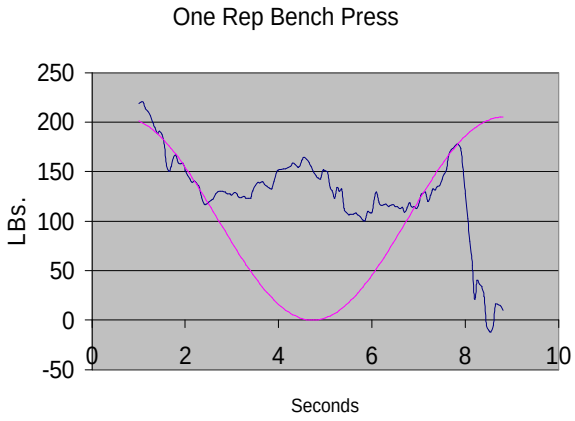

Fig. 1

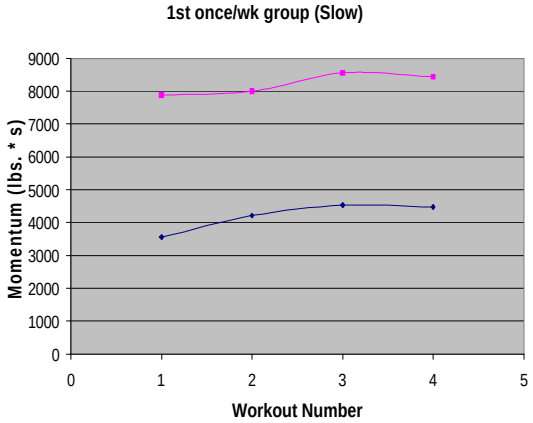

Fig. 2

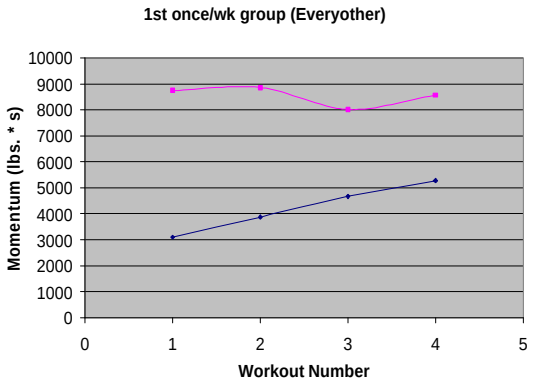

Fig. 3

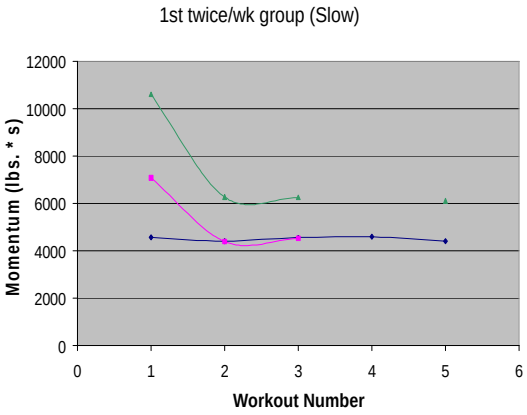

Fig. 4

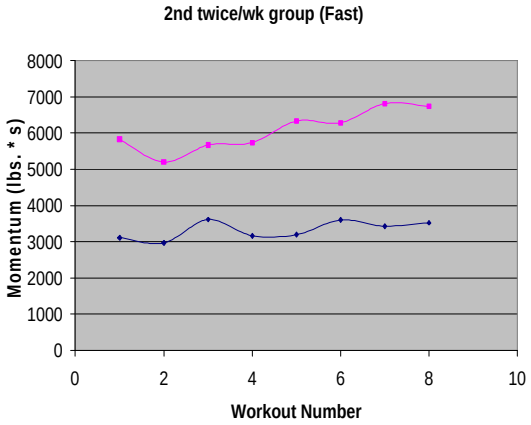

Fig. 5

DISCUSSION

The goal of this study was to monitor changes in subject's ability to generate momentum. Momentum was used to indicate effort because momentum is force multiplied by time. This is considered a better indication of effort than work because work is force multiplied by distance. This machine moves up and down at the same speed no matter how much force the subject is applying, therefore distance is less related to the effort of the subject.

The subjects that continued to the end of the study were very good about keeping to the set routine and showing up on time for each workout. There was a problem with one of the subjects having an overactive gag-reflex. This subject was not able to complete every set due to gagging. Any set that was not completed was thrown out when graphing total momentum generation over the entire ten reps. This can be seen in figure 4 with the top momentum generator not showing a point during the fourth workout session. In this same figure the subject that shows only points for the first three workouts is one of the two that did not complete the study.

When given proper recovery time the DYFORMON

allowed all the subjects to increase their momentum generation. Using a paired T-test, it was found that the overall increase in momentum for all three sets of the once a week routine were statistically significant to the 95% confidence level. The slow set was statistically significant to the 99% confidence level (Moore 2004).

Recovery time seems to play an important role. It also seems to be dependant on the each individual subject ranging from four to seven days. One of the subjects showed an interesting trend during his twice a week routine. He would increase momentum generation every other workout. This can be seen in figure 5. This tells us that three days was not quite enough recovery time for him, but four days was. One factor effecting recovery time seems be previous conditioning of the muscles, as mentioned in the results section of this paper.

There are many factors that could account for the variation in recovery time which is directly related to momentum gains between subjects. Variables such as attitude about the project, lifestyle, past workout history, genetic predisposition to increase strength, and group placement could all account for some of this variation. Group placement describes whether the subject worked out once a week first then two times a week or visa versa. Although the effect of attitude is difficult to measure or determine, it seemed subjectively that the two subjects that believed the machine would really make them stronger increased momentum generation more than the other two.

All this data was taken over the bench press only leaving room for further study of the machine's capabilities of doing other exercises. Key findings in this study were that momentum was increased for all subjects working out once a week. This is evidence that the machine does what it is suppose to. The fact that this machine does not involve taking off and putting on weights, gives it an advantage over free weights. Also the machine has the capability of being more intense because the subject can press as hard as they can possibly push at all times.

ACKNOWLEDGEMENTS

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