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The Relationship Between Carbohydrate Supplementation and Muscular Power in High School Varsity Athletes: The Future of Athletic Development

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ABSTRACT

This quantitative research study examines an unprecedented relationship between the use of carbohydrate supplementation and muscular power. The goal of the research is to decipher whether carbohydrate supplementation will have a positive, negative, or neutral effect on the muscular power of highschool varsity athletes. An experiment was done proportionate with the research goal that included the exercises: barbell bench press, barbell squat, and 40-yard dash. The high school athletes were given 20 fluid ounces of orange juice as the source of carbohydrates in order to test the differences in weight with, and without carbohydrate administration.

Introduction

The Need for Improvement; A Necessity for Carbohydrates

The jump from highschool to college is one of the biggest changes a person can have, especially for athletes. The immense competition in these sports make it that much more challenging for athletes to adapt and compete with upcoming athletes. On a competitive level, all athletes are trying to improve in their sport, whether more physically demanding sports like wrestling and football, or sports that focus more on an athlete's developmental skills like golf and bowling. In such competitiveness, just getting that small edge on other athletes could be the difference maker for athletes competing at the next level. The pressure put on high school varsity athletes to compete at the next level in their sports shows just how much talent is needed in nearly every sport for a competitive college experience. Unfortunately for many athletes, they are deterred away from an athletic college experience due to a lack of strength: more formally known as muscular power. It seems too good to be true that the answers to these problems for athletes may have been more simpler than one would think. The thought of carbohydrates being the possible solution to increasing muscular power in athletes would be derided by a large group of people that have a stigma against carbohydrate consumption. These people tend to see carbohydrates as just another label for sugar in their food, yet, they couldn't be farther from the truth. Carbohydrates may be the key that varsity athletes have needed to fully unleash their potential and compete at the next level by maximizing muscular power growth. Just how helpful could these simple nutrients (carbohydrates) be to varsity athletes trying to maximize muscular power growth, to further improve their athletic potential?

Literature Review

Carbohydrates: Help or Hinder?

Obtaining muscular power is a long, convoluted process that can take many years to build up for various athletes. Unlike many adults, this can be especially hard for adolescents who do not have the experience. Theories on accelerating this process using carbohydrates can date back as early as the year 1925 (Baker et al. ;Gordon et al.). The ingestion of candy by runners during a marathon prevented hypoglycemia, and was actually found to improve race times in the athletes. (Baker et al.). When compared with results where no candy was given, the runners that had ingested the candy had better race times than the runners who did not consume candy before races (Baker et al.). Almost 100 years of research has been available for scientists to make new connections, and further explore the relations between exercise and carbohydrates for athletic performance (Gordon et al.,). However, the ideas put forth of using carbohydrates to benefit athletic performance regarding muscular power have been disregarded, and in return, has become a stigma for many athletes to not consume carbohydrates due to diet-related risk factors for chronic disease (Marinangeli et al.). Hopefully, my research is able to better identify whether carbohydrates are rightfully scorned by athletes, or if they are a key piece in building muscular power that has been ignored. For this to be done effectively, determining whether or not carbohydrate supplementation consistently leads to a positive impact on muscular power is important, which is what my research will be based on.

The Gap in Knowledge

A large number of studies have been done in this general area of research such as: performance in team sports after carbohydrate ingestion, the effect of glycogen storage on physical strength, and even studies claiming that carbohydrate availability in athletes is "Too much of a good thing" for athletic training (Bartlett et al.). It is important to be aware of the fact that glycogen is the body's conversion of carbohydrates that lead to the various effects described in anatomical literature. Despite much of the research in the general area of carbohydrates relating to athletic performance, academic sources of research relating to muscular power are scarce; further research should be conducted when it comes to muscular-power training (Baker et al.), especially in adolescents. More specifically, high school varsity athletes ranging from ages fourteen to eighteen (as will be used in my research). This specific area of people should be more widely considered due to the competition involved at this level of sports and involvement in athletics at such a young age. Studying different varsity athletes will allow for a variety of people in different sports, further allowing for better analysis to determine if there is a strong relationship between carbohydrate intake and muscular power.

Not only does my research focus on adolescents, but it also differs in the type of training usually seen such as endurance training or even hypertrophy; the focus will instead be on the raw muscular power of varsity athletes. As best described by Sapega and Drillings, "...power is equivalent to energy output per unit of time, or the rate of doing work". In my research, "power" will be examined through an orthopedic perspective, even though views of muscular power tend to differ. It's also important to look at the differences between the 2 different types of muscle fibers: slow-twitch fibers and fast-twitch fibers (Plotkin et al.). The difference between the 2 muscles is so important to this area of focus on muscular power due to the nature of how the different muscle types affect one's body. Athletes with slow-twitch muscles like cyclists and long-distance runners are known to be better for endurance training and take less time to fatigue unlike power athletes (Plotkin et al.). On the other hand, fast twitch muscle fibers are abundant in elite power athletes, such as weightlifters and sprinters (Plotkin et al.). Such differences may be important in my research due to the variation in athletes with different types of training as well as muscle fibers. Another important piece of my research to keep in mind is best displayed by Nutritional scientists Clyde Williams and Ian Rollo. They have stated that, "Prolonged periods of multiple sprints drain muscle glycogen stores, leading to a decrease in power output and a reduction in general work rate during training and competition.". Similarly, McKay and their colleagues agree that glycogen stores from carbohydrates need to be restored routinely. This may also be necessary due to restrictions in energy intake and excessive energy expenditure, which is thought to impair key physiological processes that underpin health and performance. These glycogen stores are restored from the consumption of carbohydrates and are key to

improving performance and are commonly relied on in high-intensity exercise (Murray and Rosenbloom); this includes training involving muscular power.

Taking the Next Step

The possibility of carbohydrates playing an important role for many young athletes makes way for a breakthrough in research within the realm of developing muscular power. These sources show great promise for the expansion and publicization of carbohydrates, and the effects they have on adolescents' raw muscular power. As previously stated, further expansion in this topic of research is a necessary component that can make all the difference in the competitive world of athletics. With this in mind, the question that presents itself is: to what extent does the consumption of supplemental carbohydrates prior to exercise have an effect on the muscular power of high school varsity athletes?

Methodology

Research Explanation

To best aid my research, I will be conducting an experiment in which the muscular power of varsity athletes (ages 14-18) is tested before and after carbohydrate ingestion. This experiment takes inspiration from information concerning studies involving carbohydrates and exercise found in (Baker et al.) and (Henselmans et al.). These scholarly articles go on to explain that most studies in this field of research rely on high-intensity exercise. As well as this, the use of short-term study categories rather than long-term diet and training intervention is described, which is nearly identical to the type of experimentation I will be performing (Baker et al; Henselmans et al.). These studies align perfectly with what I wish to test; which is the relationship between carbohydrate consumption, and high school varsity athletes' muscular power. Many of the studies commonly feature exercises involving sprinting, jumping, high-intensity strength training, and sports performance. These scientists from specialized schools of sports sciences recommend subjects consume carbohydrates in volumes of 30-60 g/h before/during exercise (Baker et al.; Jeukendrup). These carbohydrates used for experimentation will typically consist of sucrose, glucose, fructose, or maltodextrin, which are commonly found in many carbohydrate-rich foods. Unfortunately for my research, access to such a variety of different carbohydrates was not an option due to safety concerns and school regulations from the district's board of approval. Compromises such as changing the product of carbohydrates given and the performed exercises done by subjects had to be made to comply with the board’s approval. Even with the changes to the ideal experimentation, the methods that will be used are still effective and contain the necessary nutrients needed to effectively test the carbohydrates effects.

Breakdown of Experimentation

Similarly to the recommendations from sports scientists, the research I will be conducting will feature varsity athletes consuming approx. 66 grams of carbohydrates, 15 minutes before exercises will be conducted. 15 minutes before exercise was the chosen time due to the body needing time to process the carbohydrates (turning them into the sugar, glycogen), but also the time window of 30-90 minutes in duration that the carbohydrates will affect (McKay et al.). These exercises will feature the athletes using their maximum power output in 3 exercises: barbell bench press, barbell squat, and the 40-yard dash. The consumption of 2, 10 FL OZ bottles of Tropicana 100% Orange juice 15 minutes prior to exercise (as recommended by sourcing) should allow enough time for the carbohydrates to be processed, broken down into glycogen, and circulated throughout the body. These orange juice bottles feature 33 grams of carbohydrates per 1 bottle (Per Nutrition Facts label) and contain a minimal 3 ingredients: filtered water, concentrated orange juice, and natural flavors. These orange juice bottles are perfect for experimentation as they have the right

amount of carbohydrates, are sealed for safety, and they are readily available to access unlike other sources such as carbohydrate powders or even carbohydrate-rich foods.

Figure 1. Tropicana Orange Juice Nutrition Facts and Ingredients, Amazon.

Over the course of 5 days, the research will be conducted inside the centereach high school weight room and the centereach high school turf field. In the weight room, the maximum barbell bench press and barbell squat will be tested and the field will be used to test the athletes' 40-yard dash times. These exercises are perfect for testing as they are easy to compare numerically and test the subject's maximum power output, which is ideal for my research purposes. Each exercise will be tested 2 times per subject which will help to gauge their maximum output of energy in each exercise. The first day will be a preliminary run to go through the experiment with the subjects and figure out what their maximum weights are for the lifts to ensure safety in my research. The 2nd day will feature the 1st group with a sample size of 8 varsity athletes; their muscular power will be tested as they attempt to lift their maximum amount of weight for barbell bench press, and barbell squat that was previously noted. After that, their 40-yard dash times will be tested and all results will be documented. Day 3 will feature the 2nd group with a sample size of 8 varsity athletes. Similarly to day 2, day 3 will include the same steps and precautions taken to ensure reliability in my research and to have the most accurate results possible. On day 4, experimentation will be nearly identical to that performed on day 2, including: the same group number, same sample size, and same exercises. However, the main difference between day 2 and day 4 is the administration of orange juice to the athletes. On day 4, each athlete will consume 2 10 fl OZ bottles of Tropicana orange juice to represent a carbohydrate solution in my experiment. After 15 minutes, athletes will begin exercise and start either at, or higher than their previously lifted amount. Again, results will be recorded and then compared to the previous results of group 1. Lastly, on day 5, group 2 will be given the same 2 bottles of orange juice and asked to perform the exercises in the same fashion as they did on day 3. To make participation for the athletes as easy as possible, I will stay after school to work with the athletes, allowing me to get as many participants as possible.

My research is backed by sports and exercise scientists such as Jeukendrup, as well as Bartlett, Hawley, and Morton. These scientists all agree that carbohydrate availability is important during exercise and would also agree on the amount of carbohydrates given being 30-60 g/h for the type of exercises I will be testing. Even with these similar

ideas and thoughts, differentiations in scientific opinions do exist; this includes carbohydrate targets for individual athletes based on things like weight and gender, or even administration of carbohydrates through methods like mouth rinses and carbohydrate supplements that can increase muscular power. With this in mind, it is important to reference the limitations of my experimentation in accordance with the differentiation of scientific opinions and uncontrollable factors while conducting my research.

Results

Data Overview

Taking pieces of experimentation from sports scientists like: (Baker et al.), (Henselmans et al.), (Jeukendrup), and (McKay et al.), I was able to construct my experimental data with the help of my fellow athletes. My research experiment analyzed a relationship between supplemental carbohydrate consumption and its effects on muscular power in high school varsity athletes. Based on my experimental data of the 16 subjects, unproven generalizations such as saying: that carbohydrate consumption directly correlates to increased muscular power, or that athletes will have increased athletic performance after consuming carbohydrates cannot be made. However, possible relationships and connections can be made after careful analysis, as well as an even better understanding of how an athlete's muscular power can connect to the basic consumption of certain nutrients.

It is already widely known that carbohydrates are the main source of energy in humans (Jéquier). Furthermore, they lead to direct oxidation– glycogen synthesis– in various tissues (more specifically the liver and muscular tissue) (Jéquier). While this is great, my experiment analyzed a more complex form of carbohydrate relation between their supplementation before exercise, and their effects on a high school athlete's muscular power. With the idea of the experiment in mind, visualization of the data collected is important for a better understanding of what occurred in the experiment. The creation of charts better allows for a visual analysis as well as shows off the data in a direct comparison with each other.

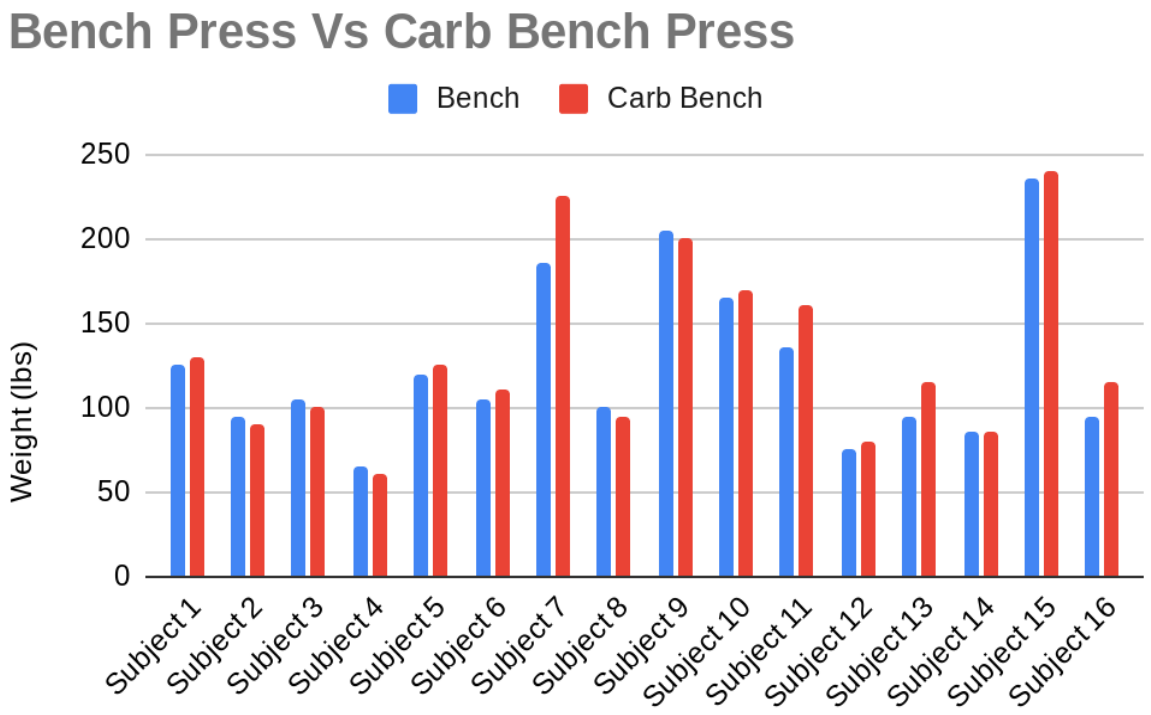

Figure 2. Bench Press Vs Carb Bench Press

Barbell Bench Press Analysis

As seen in the above chart, the bench press results are compared with, and without the administration of carbohydrates in the form of orange juice. The data ranges quite a lot in weight ranging from 60 lbs, all the way to 240 lbs. This however, is likely due to the differentiation in the types of athletes used. As for how many people increased their muscular power; 11/16 participants had a heavier bench press weight after consuming carbohydrates. On average, this equates to around a 7 lb average increase across the board when comparing the different data sets. Furthermore, it is likely that carbohydrates did play a role in increasing the muscular power of these athletes, even if the margins of increase are not super large. It is possible that even after waiting the previously mentioned recommended time–15 minutes– the carbohydrates may have taken longer to turn into glycogen for some people. This is dependent on a person's metabolic rate which can increase/decrease the rate at which nutrients are metabolized in the body. What can be drawn from this data is that the athletes' consumption of carbohydrates before exercise is likely related to increases in muscular power. Nevertheless, more conclusions can be drawn from this data when compared with the other exercises leading to even more fascinating possible discoveries.

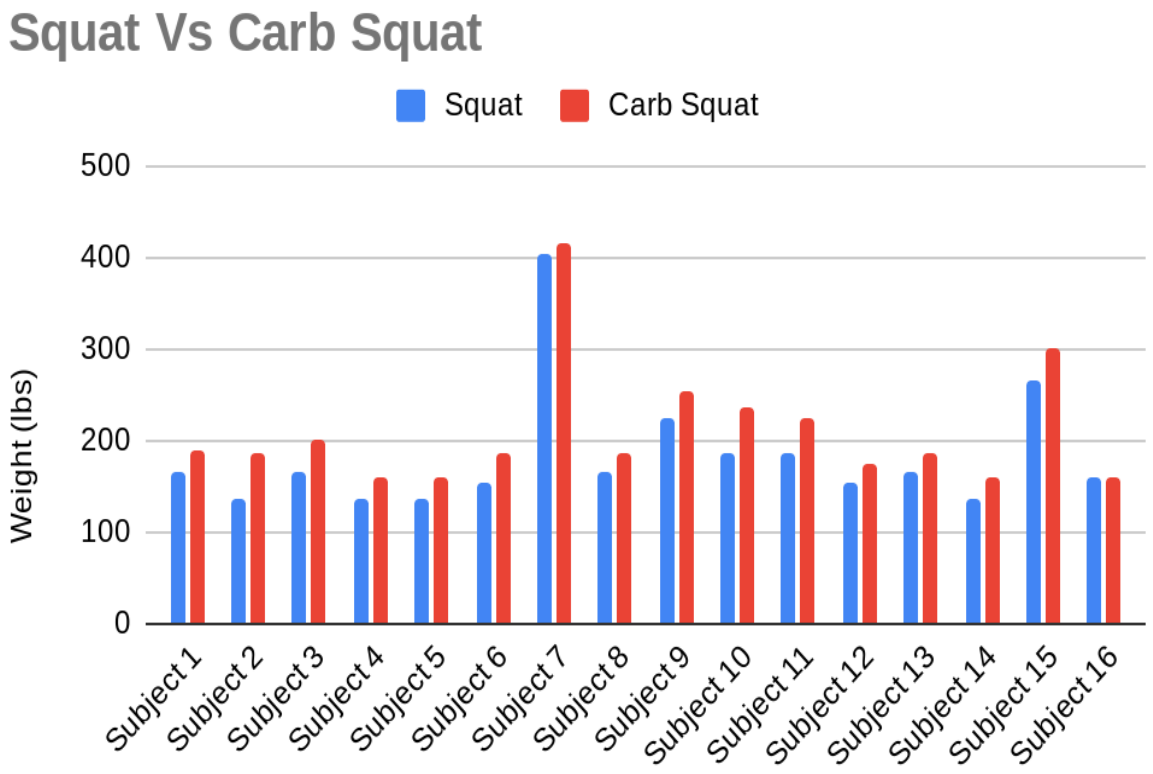

Figure 3. Squat Vs Carb Squat

Barbell Squat Analysis

Looking at the bar graph, a clear trend is seen among nearly all subjects where their squat after carbohydrate supplementation is noticeably higher than their regular squat. Incredibly, 15/16 participants had larger weights when squatting after carbohydrate consumption showing a high likelihood of the carbohydrates helping. Subject 16 was the only subject without increase, yet, they were still able to match their previous weight. These results were rather surprising to see; the mean average increase in lbs was a vast 27.5 lbs across the data. Such a large average increase may be attributed to previously explained limitations that could have inflated the amount of weight for some people. Despite this, it seems narrowly clear that relations between carbohydrate supplementation–pre-workout–are present.

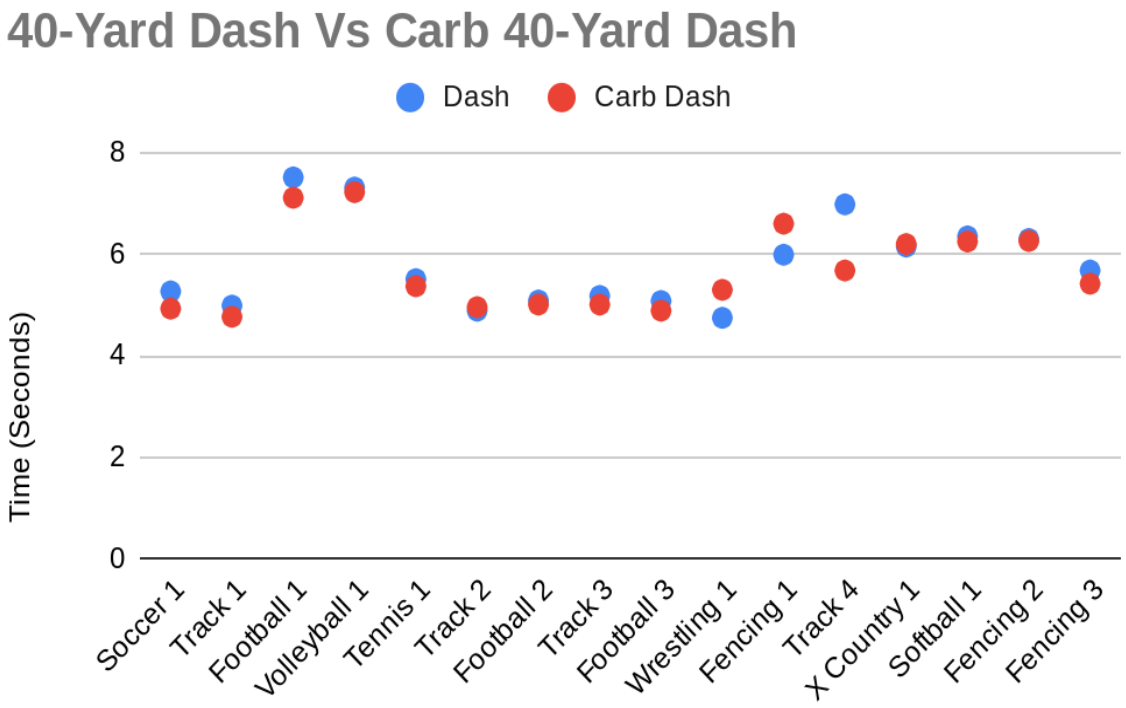

Figure 4. 40-Yard Dash Vs Carb 40-Yard Dash

40-Yard Dash Analysis

The above scatterplot shows the 40-yard dashes in order of subjects 1-16 respectively that everyone performed, including the raw results (in blue), and the results after carbohydrate supplementation (in red). As seen in the data, 12/16 subjects had decreased running times in the sprints after drinking the orange juice. It's also important to take note of the various different athletes listed in the scatterplot from subjects 1-16, and how their results differ by quite a large margin depending on the athlete. These differences stem mainly from the athletes having one of the two main types of muscle fibers including fast-twitch, and slow-twitch muscles. In combination with my results from the barbell bench press and squat, the 40-yard dash results better allowed for conclusions to be drawn based on my evidence, which engaged a full body analysis of muscular power in the athletes.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Name:	Bench 1:	Bench 2:	Carb Bench 1:	Carb Bench 2:	Squat 1:	Squat 2:	Carb Squat 1:	Carb Squat 2:	Dash 1:	Dash 2:	Carb Dash 1:	Carb Dash 2:
2	Subject 1	135x	125	135x	130	145	165	185	190	5.45	5.27	5.07	4.93
3	Subject 2	115x	95	95x	100x	115	135	155	185	5.05	4.99	4.81	4.77
4	Subject 3	95	105	115x	110x	145	165	185	200	7.51	7.61	7.34	7.11
5	Subject 4	95x	65	75x	70x	95	135	160	175x	7.31	7.85	7.22	7.31
6	Subject 5	105	120	130x	125	135	135	160	165x	5.62	5.51	5.65	5.37
7	Subject 6	115x	105	110	120x	155	185x	185	175x	4.99	4.89	4.96	5.06
8	Subject 7	185	225x	215	225	405	435x	410	415	5.09	5.3	5.28	5.01
9	Subject 8	80	100	115x	105x	135	165	165	185	5.27	5.18	5.05	5.01
10	Subject 9	205	205	215x	210x	185	225	245	255	5.08	5.11	4.96	4.89
11	Subject 10	165	175x	175x	170	225x	185	225	235	4.75	5.12	5.3	5.53
12	Subject 11	135	165x	155	160	185	215x	205	225	6.03	5.99	7.05	6.6
13	Subject 12	65	75	85x	80	135	155	175	185x	7.04	6.98	5.68	5.83
14	Subject 13	115x	95	100	115	155	165	175	185	6.18	6.15	6.2	6.65
15	Subject 14	65	85	100x	90x	135	155x	145	160	6.35	6.42	6.38	6.25
16	Subject 15	225	235	240	245x	245	265	295	300	6.3	6.38	6.28	6.26
17	Subject 16	75	95	105	115	155	160	165x	160	5.68	5.89	5.5	5.42

Figure 5. Complete Data Set

Data Comparison

By themselves, each data set of the different exercises doesn't hold much value when analyzed without comparing them. The comparison of data is necessary to make connections and support what I aimed to find in my research. When comparing results from barbell squat and barbell bench press, it is clear that results seemed to vary greatly among these lifts. In addition to this, bench press had a weight increase of about 7 lbs as opposed to the much greater 27.5 lb increase from the squat results. Disparities between how many participants increased their weights after carbohydrate supplementation are also seen here; as the squat results showed no decrease in weight and had a staggering 15/16 participants increase their maximum weight after carbohydrate supplementation. The bench press results yielded 11/16 subjects having increased muscular power after carbohydrate supplementation showing significant differences between the lifts. Not to say that the bench press results were insignificant to my research, rather that important differences do arise when looking at the results in combination with each other that further point to new conclusions being made. When comparing the 40-yard dash results to bench press and squat, the idea that different types of athletes are affected differently by carbohydrates seems to really shine in terms of being an important factor that varies results. As well as this, the 40-yard dash results show similar results as the bench press and squat that seemingly point in the same direction. This brings me to my conclusions regarding the effects that supplemental carbohydrates can have on varsity athletes.

Conclusion

Explanation of Limitations and Restrictions

Along with most experiments, limitations and restrictions can have an affect on the given results; these limiting factors are important components to consider within my research. To better aid future development in my topic of research, explaining the limitations that come with experimentation is important and will be addressed to keep the validity of my research and methods. Likely my biggest and most impactful of these limitations includes the sample size in my experiment. Due to the availability of students and resources, I am limited in the number of people I can use for experimentation and will only be accessing varsity athletes from Centereach High School. This limits the amount and variation of people which may hurt the accuracy of my results and the comparability needed to compare them. Another big limitation of my experiment is the inadequate neutrality that may be present. Factors such as a lack of motivation in the subjects and types of athletes may further hinder the results of the experiment and oppose a neutral background to my research. Other important factors to consider include: environment (people included and place of experimentation), time restraints (students will have to stay after school to participate in experimentation), resources (money and personnel will be needed to fund and aid my research), and personnel factors (sleep, diet, the placebo effect, and daily activity). These factors might seem small, but can add up to have a large impact on the overall results and trajectory that my research follows. It is important to reference such limiting qualities of my research, and further emphasize the need for more research to be conducted in the future to better minimize these limiting factors. By doing so, the opportunity for a conclusion to the pertinent analysis of the relations between carbohydrates and muscular power in high school varsity athletes may be possible.

What New Information has been Gathered?

Based on the results of my experimentation, along with other scholarly works, I found multiple conclusions that help to answer my research question. Originally, my project goal was to find if carbohydrate supplementation prior to

working out had a positive, negative, or neutral effect on the muscular power of high school varsity athletes: and while I did find that, I was also able to gather information from my own research that further extends our knowledge in this topic and is valuable information pertaining to what I aimed to answer. As for my main conclusion, my results would agree that carbohydrate supplementation pre-workout overall can lead to an increase in muscular power for high school varsity athletes. While some may find these methods to be more effective than others, it seems that the majority of varsity athletes can benefit from carbohydrate supplementation pre-workout to help increase muscular power.

In addition to this valuable knowledge, an explanation as to why certain athletes found carbohydrates to be more effective than others in my study was also discovered. The reason behind this happening appears to stem from differences between fast-twitch and slow-twitch muscles. Slow-twitch muscle fibers are geared towards elite endurance athletes such as long-distance runners and cyclists (Plotkin et al.). Alternatively, fast-twitch muscle fibers are most commonly found in elite power athletes like weightlifters and sprinters (Plotkin et al.). Although I was not able to test the muscle fiber types of the athletes, speculation of the types of muscle fibers that the athletes have is possible when looking at the type of athlete they are. What I found was that the most significant increase in muscular power occurred in athletes with fast-twitch muscle fibers. Athletes that participated in sports like wrestling, football, and track showed the most growth compared to the more endurance focused athletes in sports like volleyball and cross country. This makes sense considering fast-twitch muscle fibers are meant to excerpt a lot of power at one time; and when carbohydrates are administered, these muscles are better able to do this as compared to the slow-twitch muscle fibers.

The final conclusion was made in relation to my squat results as compared to the other exercises. It is important to note that a majority of the glycogen from carbohydrates are found in muscle stores and the liver, with the skeletal muscles containing ~80% of it (Jensen et al.). With this in mind, my results suggest that the most glycogen would be found in the leg muscles. This is because of the overwhelmingly large mass muscles like quadriceps and hamstrings have as compared to other muscles in the body. Due to the staggering results that the carbohydrates had on the squat exercise, I have come to the conclusion that: when glycogen is made in the body after carbohydrate consumption, the most glycogen will go to the most muscular mass in the body, which happens to be the leg muscles. This means that leg exercises will see the most improvement in muscular power for varsity athletes when supplementing carbohydrates.

Future Development of my Findings

There is certainly a long road ahead when looking at the future of this topic, as a lot more research needs to be done to better understand the relationships that carbohydrate supplementation can have on the muscular power of varsity athletes. As for what to look for in the future, the possibility of a new market aimed towards increasing muscular power using carbohydrate supplements may arise. This also comes with the normalization of carbohydrate supplementation pre-workout rather than the standard of consuming them post-workout. Along with these, leaving behind the common stigma towards carbohydrates would help to publicize the great uses of carbohydrates for varsity athletes. It is crucial that varsity athletes are given these opportunities to improve in their sports, and taking advantage of carbohydrate supplementation for increased muscular power allows these athletes to explore their true potential.

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