

HARD TRAINING

October, 2000

EDITORIAL COMMENT:

By Dr. Ken E. Leistner

This issue of the Hard Training Newsletter marks a departure from past issues for a number of reasons. The most important will be the absence of Dr. Ted Lambrinides. When Pete Brown, Kim Wood, and Gary Jones formed Hammer Strength in 1988, they also envisioned a newsletter that would provide truthful training information. The philosophy of these men and the Hammer Strength company, was that effective weight training was both science and art, an often delicate amalgam of the two. Their goal was to provide training programs, training information, and training history that was supported by science, long term experience, or both. Ted was the one chosen to carry the torch and actually put the newsletter together, an often thankless and difficult task. If nothing else, since its inception, the HIT Newsletter, and later with the name change to the current Hard Training Newsletter, has provided what it purported to. There are few publications that have consistently given the interested strength coach, athlete, trainee, exercise physiologist and student, usable and exacting information on such a consistent basis. Dr. Ted is to be given credit for this and his precise standards have allowed the HT Newsletter to garner a very loyal and enthusiastic following. While my name has been posted on the past number of issues as the Editor In Chief, the truth is that Ted's hand has been on each issue. His talents and abilities related to exercise physiology and equipment design brought him a new position with a different company in the strength training field, a position where his many strengths could be fully utilized. He graciously continued to have a profound influence upon the HT Newsletter, and continued to help put each issue together. This is the first issue, since its inception, that does not have his mark. He is a very difficult act to follow.

I have been involved in the weight and strength training game for approximately forty years. I have competed as an untalented Olympic lifter, a mediocre powerlifter, and a middle of the road athlete whose presence graced the football field, track lanes, rugby pitch, and judo dojo, making none of my coaches or teammates forget those who came before me and who were almost to a man (and woman in the case of judo),

much better than I was! However, I learned that many approaches to training can work, can be effective, and are followed in the gyms, weight rooms, and basements of the world. Hammer Strength Corporation and Life Fitness, the owners and publishers of the Hard Training Newsletter, also understand that a variety of approaches to training have brought excellent results to many programs. While my personal training philosophy and history is based in what has generally been teamed "High Intensity Training", it is my responsibility to present a diversity of training opinion and specific procedure within the pages of this newsletter. This I will attempt to do with each issue. Because my enthusiasm for training, even after decades of involvement, remains unbridled and I have a deep respect for all of those who actually roll up their sleeves and "do it", either on the training or coaching ends of the activity, expect to see new authors, a variety of opinion expressed in a respectful and positive manner, and an opportunity for strength coaches to find a common ground to heal the differences between the various factions. This newsletter will definitely reflect the old adage to "lead, follow, or get out of the way". This is a new age of strength training, one where experience can be blended with legitimate scientific information, where commercial hype and drugs can be left for those too disinterested to find out the proper way to get themselves or their athletes stronger.

The Hard Training Newsletter expects to lead in this instance, providing the information that every athlete and coach will find immediately useful and thought provoking. We will look forward to the input and support of each subscriber and reader. We will expect each reader to become a subscriber. We will give you every reason to look forward to each issue, and believe you should then keep it for future reference.

Dr. Lambrinides has left a wonderful legacy, one that I will strive to match. I am hopeful that the changes, as well as the precedents he has established, will allow the Hard Training Newsletter to grow and prosper, allowing for the dissemination of even more usable and authentic information. I thank everyone for their support.

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FLAWS IN RESEARCH DESIGN AND INTERPRETATION - Part III

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The studies that have been cited as evidence for multiple-set training and/or periodization contain design flaws and researcher bias that are so blatant and widespread that they would be amusing if they weren't so alarming.

THE KRAEMER STORY

What follows is a closer examination of the "series" of studies by Kraemer (1997) that have investigated various programming aspects of strength training.

"Multiple Sets and Various Periodized Training Programs (are) Superior to Single-Set Programs"?

In this report by Kraemer (1997), the researcher stated that the "series of (five) studies" or "experiments" represented "a data base (he) accumulated over many years as a football coach and strength coach" that investigated "the physiological basis for strength training in American football." Since the researcher was not employed in either of those two professions after July 1989, the "data base" was "accumulated" before the summer of that year. It does not appear as if any of the five studies had ever been published in a scientific, peer-reviewed journal prior to 1997. It is puzzling as to why the data were suddenly published in 1997 after having been "accumulated" nearly a decade or more beforehand.

The researcher cited a total of 61 references for his five studies including 19 in which his name appears as an author or co-author, representing 31.1% of the reference. If this article is truly a comprehensive overview of strength training for American football, this implies that the researcher had been involved in roughly 31.1% of all relevant investigations in this area. No less than nine of the references that were cited (14.75%) had been published in various periodicals that historically have waged a long and bitter crusade against any type of approach or method that differs from party-line thinking (such as low-volume training). Two other references were published in Moscow (1981) and Budapest (1976). These two references are especially intriguing since the purpose of this report was -- in the words of the researcher -- to "gain insight on resistance training in American football" and, unfortunately, Russia and Hungary are not known for their understanding of or expertise in American football.

Finally, it is especially odd that more than half of the references that were cited were published in the 1990s -- after this series of studies was actually conducted. Frequently, some of these references were cited as support for what the researcher stated or did during the study. In one of the studies, for example, the researcher noted that the methods for a certain test procedure were "published in detail elsewhere" and cited a reference that was published at least six years after the test procedure was performed. At any rate, what follows is a closer examination of these five "experiments."

Experiment 1

In this study, 20 Division I football players (average age 21) "volunteered" for testing. A 10-RM was determined for the bench press (with free weights) and leg press (with a selectorized machine). The movements were tested on separate days. The subjects did three sets with their same 10-Rm weight with three minutes of rest between sets. On later dates, the subjects did three sets with their same 10-RM weight with one minute of rest between sets. The researcher found that all 20 subjects were able to perform three sets of 10-RM for both the bench press and leg press when taking three minutes of rest between sets. In other words, all subjects managed three sets of 10, 10 and 10 repetitions when they rested three minutes between sets. When the rest interval was reduced to one minute, all subjects did significantly fewer repetitions with the same 10-RM weight ($p < 0.05$). With one minute of rest between sets, their repetitions -- on the average -- were 10, 8 and 7.1.

Some comments about the design and administration of this study:

- This study appears to be a thinly veiled attempt to discredit any type of training in which a minimal amount of rest is taken between sets.
- The subjects were more accustomed to three-minute rest intervals, having trained with "2-3 minute rest periods for at least 2 years" and "never used short rest periods in their training." Over time, it is likely that the groups would have adapted to the shorter rest between sets and improved their performance.
- The researcher seemed overly concerned with being able "to reproduce a 10-RM set" or, stated differently, "to perform more than one set to failure with the same load." Given enough recovery, a person should be able to do another set with the same resistance for the same number of repetitions. But the question is "Why would it be necessary to perform more than one set with the same resistance?"

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Some comments about the test results and conclusions:

- The author concluded that "maximal effort can be reproduced if adequate rest is allowed." There is no question that a greater amount of rest between sets and exercises will allow for greater recovery and should permit a person to be able to do more repetitions and/or use more resistance. However, the term "maximal effort" can be interpreted as "working as hard as possible" which does not necessarily have anything to do with the amount of repetitions that can be done or the amount of resistance that can be lifted. Therefore, a better conclusion would be that "resistance and repetitions can be reproduced if adequate rest is allowed."
- The researcher was unable to replicate these results in a later study that he co-authored with Volek and his colleagues (1997). In brief, that study involved 14 "healthy resistance-trained men" who were matched and randomly assigned into either a placebo group or a creatine group. Both groups did 5 x 10-RM with two minutes of rest between each set. In the pre-test for the bench press, the placebo group averaged about 11, 6 and 4 repetitions for their first three sets; in the same pre-test, the creatine group averaged about 10, 7 and 5 repetitions for their first three sets. Recall that the group in the study by Kraemer averaged 10, 8 and 7.1 repetitions when given a one-minute rest interval between sets. So despite receiving an additional minute or rest, neither the placebo group nor the creatine group in the study by Volek and his colleagues was able to do as many repetitions in their second and third sets as the group in the study reported by Kraemer. The fact that subjects who received a one-minute rest performed more repetitions in their second and third sets than subjects who received a two-minute rest indicates that the data in the Kraemer study is questionable and, therefore, raises uncertainty as to the reliability of the test.

Experiment 2

This 10-week study involved 40 Division I football players (average age 20). The subjects were matched for position, starting strength, training background, age and body size. They were randomly assigned into one of two training groups referred to as a "single-set circuit group" and a "multiple-set circuit group" with 20 in each group. The groups trained three times per week for ten weeks. Both groups did the same "circuit" which consisted of ten exercises with selectorized machines: leg press, bench press, chest fly, lateral raise, military press,

knee extension, leg curl, bicep curl, calf raise and lat pullover. The single-set group did 1 x 8 - 12-RM to fatigue "with forced reps at the end." (The number of forced repetitions was not specified by the researcher.) The single-set group was given a one-minute rest interval between exercises. Their resistance was increased when they were able to do more than 12 repetitions. The multiple-set group did 3 x 8 - 12-RM with "no forced reps." The multiple-set group was given a one-minute rest interval between sets and exercises. The researcher did not mention how the multiple-set group was directed to increase their resistance.

The groups were tested in their 1-RM bench press and 1-RM leg press. They were also tested in their muscular endurance using 80% of their 1-RM bench press and 85% of their 1-RM leg press. Testing was done with selectorized machines and occurred at the beginning and the end of the ten weeks.

Some comments about the design and administration of this study:

- There was no indication as to how the researcher provided adequate supervision of the 40 subjects so as to make certain that they used their assigned training protocol over the course of 10 weeks to assure the scientific purity of the study.
- There was no indication that the speed of movement was controlled during the tests of muscular endurance. So, one subject may have done more repetitions than another but -- because of a faster speed of movement -- had the same (or possibly lower) time under load (TUL). This controlled variable could have had a major influence on the results of the research.
- There was no indication that the seat position used in leg press was adjusted for the subjects based upon their leg lengths. Nor was there any indication that the subjects used the same seat position in the post-testing that they used in the pre-testing. The position of the seat affects the distance that the resistance travels and, ultimately, the amount of resistance that can be lifted. This uncontrolled variable could have had a tremendous impact on the results of the research.
- The data given in Table 1 for the 1-RM bench press appear to be horribly inaccurate. For example, the post-test 1-RM strength for the multiple-set group is given as 161 kilograms with a standard deviation of 96 kilograms. (Keep in mind that the testing was done with a selectorized machine, not with a barbell.) Assuming a normal distribution, these data indi-

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cate that 68% of the subjects had a 1-RM bench press between 65 and 257 kilograms and 95% of the subjects had a 1-RM bench press between -31 and 353 kilograms. Obviously, it is literally impossible for anyone to bench press 31 kilograms less than nothing. In all likelihood, the standard deviation of 96 kilograms was actually 9.6 kilograms. Regardless, the data for the other performances in the 1-RM bench press also appear to be erroneous; the data for the 1-RM squat are somewhat believable but are probably incorrect as well.

Some comments about the test results and conclusions:

- In terms of 1-RM strength, both groups showed significant increases in the bench press and leg press ($p < 0.05$). The multiple-set group demonstrated a greater increase in 1-RM strength than the single-set group but it was not statistically significant.
- In effect, the multiple-set group performed three times as many sets (or 200% more) than the single-set group without obtaining a significantly greater increase in their 1-RM strength in the bench press or leg press.
- In the 1-RM leg press, the single-set group showed an average increase of 5 kilograms (11 pounds) in ten weeks -- or a little more than one pound per week. Such an increase in 1-RM strength is so ridiculously small that it makes the data suspect.
- In terms of muscular endurance, the multiple-set group showed significant increases in the bench press and leg press. Though not statistically significant, the single-set group showed an increase in their muscular endurance in both movements.
- The researcher reported that the "[single-set group] demonstrated an increase in 1-RM strength but not in local muscular endurance" and that the single-set group showed increases that "acted like a maintenance program for local muscular endurance" which contradicts his own findings. Both statements imply that the muscular endurance of the single-set group was maintained when, in fact, the data clearly show that it was improved. Specifically, the single-set group increased their repetitions from an average of 11.1 to 12.2 with 80% of their 1-RM in the bench press and from 12.1 to 13.6 with 85% of their 1-RM in the leg press. In light of these data, reporting that the single-set group did not increase their muscular endurance suggests probable research bias.
- The researcher stated that "These data agree with those of J.B. Kramer et al. [1997] on the

magnitude of strength gain with multiple set or multiple periodized set resistance training." The design flaws and probable researcher bias of that study have been discussed earlier.

- The researcher noted that "distinct superiority has been demonstrated repeatedly for multiple-set systems." In support of this statement, the research referenced four studies -- two of which were Kramer and his co-workers (1997) and Stowers and his co-workers (1983). The design flaws and probable researcher bias in these two studies have been discussed previously. Moreover, the Stowers study did not show -- as the researcher claims -- the "distinct superiority" of "multiple-set systems." In truth, the Stowers study showed no significant differences between the one-set group and the three-set group in body weight, 1-RM bench press, 1-RM squat, vertical jump and leg and hip power after seven weeks of training. The Kramer study showed no significant differences in body mass and body composition between the single-set group and the multiple-set groups after 14 weeks of training. Additionally, the single-set group increased their lean body mass while the varied multiple-set group did not show any changes.
- The results of this study demonstrated that relatively brief but intense training -- that is, doing as little as ten exercises for one set to fatigue (with forced reps) done three times per week with one minute of rest between exercises -- can be effective in improving 1-RM strength and muscular endurance in the bench press and leg press. The study also showed that the aforementioned qualities can be improved when using selectorized machines.

Experiment 3

This 14-week study involved 34 Division III football players (average age 20). The subjects were matched for position, starting strength, training background, age and body size. They were randomly assigned into one of two training groups referred to as a "single-set group" and a "multiple-set strength/power training group" with 17 in each group. The groups trained three times per week for 14 weeks. The single-set group did 1 x 8 - 10-RM to fatigue "with forced reps" for each exercise. (The number of forced repetitions was not specified by the researcher.) The workouts of the single-set group consisted of the following ten exercises with selectorized machines: knee extension, leg curl, bench press, military press, arm curl, sit-up, calf raise, leg press and lat pulldown. The single-set group was given a two-minute rest interval between exercises. Their resistance was increased when they were able to do more than ten repetitions. On Mon-

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days and Fridays, the multiple-set group did the following "structural exercise with free weights: squat, push press, hang clean or power clean and bench press (using a selectorized machine); on Wednesdays, the multiple-set group did the following "structural exercises: with free weights: pull from the mid-thigh and lunge (with dumbbells). During each of the three weekly workouts, the multiple-set group also performed "small-muscle-group assistance exercise" consisting of the arm curl, hamstring curl (using a selectorized machine), rotator cuff exercises, tricep pushdown and sit-up. The multiple-set group did two seven-week "cycles" using varying sets and repetitions (2 - 3 x 8 - 10 with 50-70% 1-RM in weeks 1 - 3 - 4 x 6 with 70-80% 1-RM in weeks 4 - 5 and 3 - 5 x 1 - 4 with 85-95% 1-RM in weeks 6 - 7). The multiple-set group was given 1 - 2 minutes between sets and exercises for assistance movements and 2 - 4 minutes between sets and exercises that involved loads greater than 70% of their 1-RM. The multiple-set group did 2 - 3 x 8 - 10-RM for the "assistance exercises." The researcher did not indicate how the multiple-set group was directed to increase their resistance in those exercises.

The groups were tested in their body composition, vertical jump, 1-RM bench press (with a selectorized machine) and 1-RM hang clean (from the knees) and power output (using a Wingate test). Testing occurred three times during the study: at 0, 7 and 14 weeks.

Some comments about the design and administration of this study:

- It is uncanny that researcher was able to match two groups of 17 subjects each so evenly in five different test measurements. On average, the two groups only differed in their pre-test measures by 0.5 centimeters in their vertical jump (less than 0.2 inches), 1 kilogram in their 1-RM bench press, 0.6 kilograms in their 1-RM hang clean, 1 watt in their power output and 0.5% in their body-fat percentage.
- Interestingly, the researcher referred to one exercise by two different names in that the single-set group did the "leg curl" and the multiple-set group did the "hamstring curl."
- There was no indication as to how the researcher provided adequate supervision of the 34 subjects so as to make certain that they used their assigned training protocol over the course of 14 weeks to assure the scientific purity of the study.
- The two groups were assigned different repetition ranges, frequency of training, equipment choices, exercises, volume of exercises, number of sets and rest between sets. The large number of independent variables makes it difficult -- if not impossible -- to compare the results of the two groups and draw conclusions.
- The testing included the hang clean -- an exercise that was included in the training program of the multiple-set group but not the single-set group. In effect, the multiple-set group practiced this movement two times per week for 14 weeks (as well as a highly related movement -- the pull from mid-thigh -- one time per week) while the single-set group had no practice whatsoever. This gave the multiple-set group much greater familiarity with the hang clean and, as a result, placed the single-set group at a distinct disadvantage when it came to being tested in that movement. It is difficult to believe that such an enormous design flaw can be attributed to anything other than researcher bias.
- The researcher stated that "The maximal 1-RM strength tests were performed for related training lifts during the training protocol each week or when needed." This uncontrolled variable renders the results of the 1-RM testing (for the bench press and hang clean) highly suspect. Since the loads used by the subjects in the multiple-set group for their "structural exercises" were based upon percentages of their 1-RMs, it is assumed that they are the ones who performed 1-RM tests "each week or when needed." It is unclear as to how often the 1-RM testing was "needed." Nevertheless, any amount of 1-RM testing done by the multiple-set group "each week or when needed" gave those subjects much greater familiarity with the 1-RM tests and, consequently, an unfair advantage over their counterparts in the single-set group. Once again, this unbelievable design flaw suggests researcher bias.
- The single-set group did sets of 8 - 10 repetitions throughout the entire study while the multiple-set group did sets with 1 - 4 repetitions during the last two weeks of each seven-week cycle (with 85-95% of their 1-RM) -- just prior to the 1-RM tests. The fact that the multiple-set group did eight weeks of training using lower repetitions -- 57.14% of the total training period doing sets of 6 repetitions or less -- certainly favored them when it came to tests of 1-RM strength and, in all probability, was also a factor in the tests of vertical jump and power. This is yet another design flaw that unfairly favored the multiple-set group and undoubtedly influenced the results of the research.
- Some of the data given in Table 2 for the 1-RM bench press appear to be terribly inaccurate.

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For example, the pre-test 1-RM strength for the single-set group is given as 117 kilograms with a standard deviation of 59 kilograms. (Keep in mind that the testing was done with a selectorized machine, not with a barbell.) Assuming a normal distribution, these numbers indicate that 68% of the subjects had a 1-RM bench press between 58 and 176 kilograms and 95% of the subjects had a 1-RM bench press between -1 and 235 kilograms. Naturally, it is literally impossible for anyone to lift 1 kilogram less than nothing. It is likely that the standard deviation of 59 kilograms was actually 5.9 kilograms. Regardless, the data for the other performances in the 1-RM bench press are slightly more believable but appear to be incorrect as well; the standard deviations for the 1-RM hang clean also appear to be erroneous.

Some comments about the test results and conclusions:

- The researcher found that both groups experienced significant decreases in their percentages of body fat ($p < 0.05$). The multiple-set group showed a significant increase in their body mass; though not statistically significant, the single-set group also showed an increase in their body mass. In both measures, the multiple-set group had significantly greater improvements than the single-set group. If changes in body mass and body fat are to be evaluated, the experimental groups should receive instruction in the area of caloric intake and expenditure. Ideally, these nutritional variables should be controlled. However, there was no indication that any of this was done.
- In the test of power output, the single-set group showed an average increase of 8 watts after 14 weeks of training (from 894 to 902). Such an increase in power output is so insignificant that it makes the data suspect. Incidentally, this very meager improvement was not replicated by the researcher in Experiment 4. In that study, the single-set group increased their power output by 42 watts after 14 weeks of training (from 898 to 940).
- The researcher noted "At best the [single-set protocol] acted as a type of maintenance program." This statement implies that the physical characteristics of the single-set group were maintained when, in fact, the data show that most were improved. In 14 weeks, the single-set group -- on average -- showed (1) a statistically significant reduction in their percentage of body fat from 17.6% to 16.1%; (2) an increase in body mass from 104.2 kilograms to 105.6

kilograms; (3) an improvement in vertical jump of 3.4%; (4) a statistically significant increase in their 1-RM bench press from 117 to 121 kilograms; and (5) a statistically significant increase in their 1-RM hang clean from 95.5 to 98.8 kilograms (despite not doing the exercise as part of their training protocol).

Experiment 4

This 24-week study involved 44 Division III football players (average age 19). The subjects were matched for position, starting strength, training background, age and body size. They were randomly assigned into one or two training groups who did a "high intensity single-set program" or a "periodized training program" with 22 in each group.

The single-set group trained three times per week for 24 weeks. They did 1 x 8 - 12-RM to fatigue "with forced reps" at the end of each set. (The number of forced repetitions was to be specified by the researcher.) The single-set group alternated between two different workouts designated as "A" and "B". Workout A consisted of the following exercises with selectorized machines: leg press, bench press, leg curl, seated row, calf raise, arm curl (with free weights), sit-up, pullover, military press and abduction/adduction exercises; Workout B consisted of the following exercises: knee extension, chest fly (with dumbbells), leg curl, lateral raise, calf raise (seated), triceps (sic) pushdown, back hyperextension, upright row, rotator cuff exercises (with dumbbells) and lat pulldown. The single-set group was given a rest interval of 1 - 2 minutes between exercises. The researcher did not indicate how the single-set group was directed to increase their resistance.

The periodized group trained four times per week for 24 weeks. On Mondays and Thursdays, the periodized group did a "strength/power" workout consisting of the following exercises: hang clean/power clean, squat, split squat, bench press, push press, rotator cuff exercises and sit-up; on Tuesdays and Fridays, they did a "hypertrophy" workout consisting of the following exercises (which were performed as five "supersets"): (1) leg press, upright row, military press; (2) arm curl, triceps (sic) pushdown; (3) lat pulldown (front), seated row; (4) sit-up, side bend, obliques; and (5) leg curl, calf raise, lunge. During the strength/power workout, the repetitions varied between 3 - 5-RM with "heavy" loads, 8 - 10-RM with "moderate" loads and 12 - 15-RM with "light" loads. The subjects did sets of 5 repetitions in the hang clean and power clean with different percentages of their 1-RMs: heavy (85-90%), moderate (65-70%) and light (40-60%). Each exercise involved 2 - 4 sets that were varied

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within a workout. Rest periods were 1 - 2 minutes for light and moderate loads and 3 - 4 minutes for heavier loads. During the hypertrophy workout, the subjects did 8 - 10-RM with 1 - 2 minutes rest between supersets. Finally, both groups also participated in the same running workouts and agility drills 2 - 3 days per week.

The groups were tested in their muscular endurance with 80% of their 1-RM in the bench press and 85% of their 1-RM leg press, power output (using a Wingate test), percent changes in vertical jump, body-fat percentage, body mass, 1-RM leg press, percent changes in their bench press and 1-RM hang clean (from the knees). Testing occurred four times during the study: at 0, 7, 14 and 24 weeks. Both groups were given a one-week "active rest period (no weight training), after 14 weeks. Training resumed with week 15.

Some comments about the design and administration of this study:

- There was no indication as to how the researcher provided adequate supervision of the 44 subjects so as to make certain that they used their assigned training protocol over the course of 24 weeks to assure the scientific purity of the study.
- The two groups were assigned different repetition ranges, frequency of training, equipment choices, exercises, volume of exercises, number of sets and rest between sets. The large number of independent variables makes it difficult -- if not impossible -- to compare the results of the two groups and draw conclusions.
- Multiple-joint movements involve a greater amount of muscle mass than single-joint movements and, therefore, are thought to be of greater value in stimulating increases in muscular size and strength. The multiple-set group averaged 22 multiple-joint movements per week while the single-set group averaged 9 per week. Over the course of the 24 weeks of training, the multiple-set group did 528 multiple-joint movements while the single-set group did 216. Stated differently, the multiple-set group performed more than twice as many multiple-joint movements (or 144% more) than the single-set group. This huge difference in multiple-joint movements may have had a major impact on the results of the research, especially in terms of changes in 1-RM strength, body fat and body mass.
- There was no indication that the seat position used in leg press was adjusted for the subjects based upon their leg lengths. Nor was there any indication that the subjects used the same seat position in the post-testing that they used in the pre-testing. The position of the seat affects the distance that the resistance travels and, ultimately, the amount of resistance that can be lifted. This uncontrolled variable could have had a tremendous impact on the results of the research.
- As in Experiment 3, the testing included the hang clean -- an exercise that was included in the training program of the multiple-set group but not the single-set group. In effect, the multiple-set group practiced this movement one time per week for 24 weeks (as well as a highly related movement - the power clean -- one time per week) while the single-set group had no practice whatsoever. This gave the multiple-set group much greater familiarity with the hang clean and, as a result, placed the single-set group at a distinct disadvantage when it came to being tested in that movement. Such an enormous design flaw can only be attributed to researcher bias.
- The data for the test measures recorded by both groups were compared in Table 3 with the exception of the 1-RM hang clean which -- for unknown reasons -- was presented separately a graph in Figure 1. This is indeed a curious comparison since the single-set group did not perform the hang clean in their training protocol. Singling out and highlighting this particular test measure is a clear indication of researcher bias.
- Four of the test measures involved the bench press and the leg press. During the 24-week training period, the single-set group did the bench press and leg press in 36 of their workouts while the multiple-set group did those two movements in 48 of their workouts. In effect, the multiple-set group had the opportunity to train the bench press and leg press in 33% more workouts than the single-set group.
- The 1-RM tests (in the bench press, leg press and hand clean) were largely influenced by the fact that the single-set group did sets of 8 - 12 repetitions throughout the entire study while the multiple-set group did some of their sets with 3 - 5 repetitions. It is likely that such low-repetition training by the multiple-set group was also a factor in the tests of vertical jump and power. Similarly, the muscular endurance tests (in the bench press and leg press) were undoubtedly affected by the fact that the multiple-set group did some of their sets with 12 - 15 repetitions. This inherent design flaw selectively favored the multiple-set group and surely influenced the results of the research.

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- At the end of a paragraph that details the exercise protocol of the multiple-set group, the researcher stated, "Individual responses in progression were monitored for the progression of all acute program variables (resistance used, rest periods, etc.) [As support for this statement, the researcher cited a reference that was -- as strange as it sound -- a book he had co-authored at least eight years after this study was conducted.] Thus the program represented a comprehensive interaction with the players." Since absolutely nothing was mentioned about monitoring, supervising or interacting with the single-set group, it is assumed that this "comprehensive interaction" was only done with the multiple-set group. This independent variable certainly gave the multiple-set group a clear advantage over the single-set group and is further evidence of researcher bias.

Some comments about the test results and conclusions:

- The single-set group experienced significant improvements ($p < 0.05$) in all nine test measures except for the 1-RM hang clean.
- It is interesting to compare the results achieved by the multiple-set groups in Experiments 2 and 4. For example, the multiple-set group in Experiment 2 who did not use periodization increased their 1-RM leg press from 175 kilograms to 208 kilograms -- 18.86% in 10 weeks; the multiple-set group in Experiment 4 who did use periodization increased their 1-RM leg press from 172.1 kilograms to 207.1 kilograms -- 20.33% in 24 weeks. Despite training for 14 fewer weeks, the group that did not do periodization nearly achieved the same percentage improvement as the group that did periodization. These data contradict the researcher's assertion in Experiment 3 that "a periodized training program [is] superior to other constant set/rep multiple-set programs."

Experiment 5

This "experiment" was actually a "survey questionnaire." It appears as if the survey was done when the researcher was employed as a football coach and strength coach who "[took] over programs that had used [single-set training] as the primary training method." The survey was given to 115 football players of which 102 (89%) "reported using other multiple-set programs at home, during breaks, over the summer, or during off hours at health clubs to supplement the single-set program prescribed by the strength coach."

Some comments about the design and administration of this study:

- It is unclear as to when the survey was taken but it was certainly at least eight years prior to it being published in 1997. This only deepens the mystery as to where the data for this "series of experiments" have been for all these years.
- Needless to say, when questioned by a new strength coach -- particularly one who also coaches football -- most players would naturally be quite unwilling to give credit to the previous coaching staff, including their strength training method.
- Surveys are often a far cry from being scientific. Information provided by the subjects rather than the researchers clouds the scientific purity of the data.
- The unfortunate truth of the matter is that the majority of athletes do not follow the programs given to them by their strength coaches when they are away from campus -- regardless of whether their programs call for single-set or multiple-set training. In fact, some athletes do not follow the programs given to them by their strength coaches even when they are on campus.

FACT OVER FICTION

Scientific studies can be valuable provided that they offer information that is of practical use and has been found to be of acceptable design without researcher bias. It is incredible to think that numerous studies with absolutely hideous and blatant design flaws go unnoticed during the peer-review process and end up being published in supposedly scientific journals.

Published studies that are used for the development of training programs should be peer-reviewed, not pal-reviewed. That way, the information will be based upon science fact, not science fiction.

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