Multiple Sets Elicit Greater Strength Increases Than Single Sets In Trained Individuals

B. Alver, M. Rhea, S. Ball, and L. Barkett. Exercise and Wellness Research Lab, Arizona State University, Tempe, AZ.

The purpose of this study was to compare single and multiple sets of weight-training for strength gains in recreationally trained individuals. Sixteen males (age = 21 ± 2.0) were randomly assigned to one set (5 = 1; n = 8) or three set (5 = 3; n = 8) groups and trained three days per week for 12 weeks. 1RM was recorded for bench press and leg press as a pre, mid, and posttest. Subjects trained according to Daily Undulating Periodization (DUP) and included the bench press and leg press exercises between 4RM and 8RM. Training intensity was equated for both groups. ANOVA with repeated measures revealed statistically significant differences favoring 3 sets in the leg press (p < 0.05, ES = 6.5) and differences approaching significance in the bench press (p = 0.07, ES = 2.3). The results demonstrate that for recreationally trained individuals using DUP training, three sets of training are superior to one set for eliciting maximal strength gains.

The Effects of an Herbal Thermogenic Supplement on Weight Loss in Nonlean Subjects

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This study was conducted to determine if Xenadrine® has an effect on weight loss and body composition in nonlean subjects with no dietary restriction. Following human subject committee approval, twenty-nine male (n = 16) and female (n = 13) subjects (age 18–33 y; height 172.7 ± 8.8 cm; weight 206.7 ± 41.7 lb; %fat 31.9 ± 8.4%) were asked to participate in the double blind, placebo controlled study. Subjects’ body weight and body composition were assessed utilizing body plethysmography (BOD POD) and bioelectrical impedance analysis (BIA) prior to and after six weeks of supplementation. Subjects ingested their supplements (1.75 g Xenadrine® or placebo, cellulose (n = 14)) two times a day. During the study, subjects were required to exercise a minimum of twenty minutes, 3 days per week, at an intensity of 60% maximum heart rate. Differences in body weight and body composition between pre and post for each group were compared using a 2 (pre, post) × 2 (group) mixed ANOVA with repeated measures. Subjects’ results suggest a significant (p < 0.05) decrease in body mass for the Xenadrine® group from pre to post (98.28 ± 19.5 to 96.54 ± 20.3 kg), while the placebo group gained mass pre to post (88.56 ± 17.4 to 89.79 ± 18.2 kg). Body composition analysis showed both groups significantly decreased body fat as measured with the BOD POD, while BIA resulted in a trend (p = 0.06) of greater %fat loss in the Xenadrine® group compared to placebo. These data suggest that Xenadrine® supplementation may result in significant weight and fat loss within six weeks in subjects with no dietary restrictions. This research project was partially funded by a grant from CytoMed Technologies.

An Analysis of Various Physical Fitness Components Recommended for Law Enforcement Personnel

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The fitness levels of law enforcement personnel are directly related to their ability to perform the essential physical functions of a very demanding profession. Adequate fitness levels may minimize the risk of exercise stress and known health risks associated with the occupation. Therefore, the purpose of this investigation was to examine the effectiveness of the proposed fitness recommendations established by The Cooper Institute for Aerobics Research for law enforcement personnel. Forty-two males ages 22–58 (32.2 ± 9.9) enrolled in a select law enforcement-training academy volunteered to participate in the study. After pretest measures were collected (body composition, body weight, bench press, flexibillity, push-ups, sit-ups, and the 1.5 mile run), a twelve-week training program consisted of a designed resistance training program twice a week and running the 1.5-mile twice a week. All subjects were tested on each of the previously mentioned fitness components at six weeks and during posttest procedures at 12 weeks. Analysis of data included paired samples t-tests to determine if significant changes occurred between pretest and posttest observations. An alpha of 0.05 was used for determining significance. Results indicated significant increases in strength (bench press), (41) = 8.0, p < 0.001, muscular endurance (pushups), (41) = 8.2, p < 0.001, (sit-ups), (41) = 6.8, p < 0.001, cardio-respiratory performance (1.5 mi. run), (41) = 7.9, p < 0.001, and flexibility (sit-and-reach), (41) = 21.7, p < 0.001. In addition, significant decreases in body fat (BIA), (41) = 6.09, p < 0.001, were observed. It was concluded that the physical fitness components recommended by The Cooper Institute appear to be effective in improving overall health-related fitness of law enforcement officers. However, further investigation into comparisons of other specialized specific conditioning programs for law enforcement officers is warranted.

The Effects of Elk Velvet Antler Supplementation on Hormonal Levels after Combined Strength and Endurance Training

G.J. Bell, K. MacFaraday, V. Harber, and D. Syrotuik. Exercise Physiology Lab, University of Alberta, Edmonton, Alberta.

The purpose of this study was to examine the effects of elk velvet antler supplementation (EVA) and combined resistance (3d/wk) and endurance (3d/wk) training on serum hormone levels in 45 male and female rowers (age = 21.5 y). Serum testosterone (total and free), cortisol and growth hormone concentrations were measured at rest and at 5 and 60 minutes after a simulated 2000 m race on a Concept II rowing machine and these measurements were taken before and after 5 and 10 weeks of combined training. Other measurements included body mass, VO2max, 2000m rowing time, leg and bench press strength. Subjects were randomly assigned by gender to a EVA group that ingested 560 mg/day of elk velvet antler (n = 20) or to placebo group (P) that ingested a similar looking gelatin capsule (n = 25). There was no significant effect of EVA supplementation on resting or post-exercise hormone concentrations. There was a significant elevation in all hormones after rowing exercise in both groups. Similar improvements (P < 0.05) occurred in both groups for VO2max, leg and bench press strength and 2000m rowing performance. No significant changes in body mass were observed for either group. It appears that 10 weeks of EVA ingestion at a dose of 560 mg/day does not significantly influence serum hormone levels or exercise performance greater than training alone. The practical application of our findings suggest that EVA supplementation does not produce an ergogenic effect during combined strength and endurance training. This research was supported by the Alberta Elk Velvet Antler Association and Royal Elk Products, Sangudo, Alberta.

The Correlation Between Maximal Leg Strength and Single Limb Balance in Old and Young Females

J. Bellieu, B. Grubenstein, J. Watson, and R. Baker. Department of Physical Therapy, Louisiana State University Health Sciences Center, Shreveport, LA.

Much data are available which suggest that age-related loss of leg strength leads to an increased risk of falling and decreased function in older adults. Within the last two decades, the use of strength training in older adults has increased and an abundance of data can be found supporting the use of strength training as a means of preventing age-related loss of strength and function. However, the relationship between maximal leg strength and control of balance in healthy adults remains unclear. Therefore, this study examined the relationship between maximal leg strength and control of balance in twenty females 60–80 years of age (mean 68.4 ± 7.5 years) and twenty females 20–30 years of age (mean 23.3 ± 5.3 years), all healthy and without history of falling. Leg strength was measured during a 1-repetition maximum leg press and control of balance was measured during single limb stance with eyes closed. The duration (seconds) a subject was able to maintain postural stability within a 18° × 20° rectangular frame reflected control of balance. Variable relationships were assessed across all subjects, within age groups, and between age groups using a bivariate correlation analysis yielding Pearson product-moment correlation coefficients. The results revealed a significant but low, positive correlation between maximal leg strength and control of balance across all forty subjects. r = 0.340 (p = 0.032). In contrast, the within-group comparisons failed to reveal significant correlations in either group with r = 0.075 in the older females and 0.066 in the young. These data do not provide convincing evidence to suggest that maximal leg strength and control of single limb balance are related in these healthy females. For the strength professional, the use of strength training for balance may not be indicated in healthy adults, but what benefits are offered to older adults with a previous history of falling needs to be considered.

Reliability of Force Measures During Load-Spectrum Squats


Force output is important in many physical activities. Today, inexpensive computer-interfaced dynamometers are available to measure external mechanical force in situations in which the load is known, constant, and moved linearly. PURPOSE To determine the stability reliability of force and force-dependent data obtained from a multiple joint lift using one of the aforementioned dynamometers. METHODS Maximum-acceleration, concentric-only parallel back squats were performed at 30, 60, and 90% 1RM in a random sequence by 31 men who had been weight training no less than the previous 3 months. Data were obtained using a Fidotomy® device that was tethered to an Olym- pic barbell. External force was evaluated at 50, 100, 200, 300, and 400 lb, at its peak, as the rate of dynamic force development (RDFD), and as impulse (IMP). At each
This was calculated via intraclass correlation coefficients (ICC). RESULTS: (See Table 1.) Across the load spectrum, ICCs were 0.96 for peak force, ranged between 0.27 and 0.96 for measurements taken between 50 and 400 ms, ranged between −0.25 to 0.48 for RFD, and ranged between −0.07 and 0.74 for IMP. CONCLUSIONS: It appears that the Fitrodyne® dynamometer may be used to obtain reliable measures of external force generated within the non-countermovement load-spectrum area for up to 200 ms and for peak. Force measurements obtained at 300 and 400 ms, as well as RFD and IMP as operationally defined in this study were not very reliable. Also, even though the calculated squatting system force would be greater than the reported external force, its use in the study would not be expected to alter the reliability of the various force variables. PRACTICAL APPLICATIONS: The hardware and software existing at the time of data collection provided reliable measures of specific aspects of external mechanical force. Although other force-related variables were unreliable, their reliability coefficients were relatively low. Therefore, it appears that additional hardware and/or software enhancements to this dynamometer are needed in order for a wider array of force variables to be useful.

Table 1. Intraclass correlation coefficients for squatting force and related variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>30% 1RM</th>
<th>60% 1RM</th>
<th>90% 1RM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Force</td>
<td>0.96**</td>
<td>0.96**</td>
<td>0.96**</td>
</tr>
<tr>
<td>Force @ 50 ms</td>
<td>0.96**</td>
<td>0.95**</td>
<td>0.94**</td>
</tr>
<tr>
<td>Force @ 100 ms</td>
<td>0.93**</td>
<td>0.90**</td>
<td>0.93**</td>
</tr>
<tr>
<td>Force @ 200 ms</td>
<td>0.80**</td>
<td>0.78**</td>
<td>0.78**</td>
</tr>
<tr>
<td>Force @ 300 ms</td>
<td>0.46**</td>
<td>0.27**</td>
<td>0.39**</td>
</tr>
<tr>
<td>Force @ 400 ms</td>
<td>0.65**</td>
<td>0.65**</td>
<td>0.38**</td>
</tr>
<tr>
<td>RFD (Pl Force/Time)</td>
<td>0.48*</td>
<td>0.11</td>
<td>−0.25</td>
</tr>
<tr>
<td>Impulse (Pl Force/Time)</td>
<td>0.74*</td>
<td>0.49*</td>
<td>−0.07</td>
</tr>
</tbody>
</table>

* p < 0.05, ** p < 0.01

Vertical Jump As a Predictor of Force in Power Football Players
M. Bird, K. Fletcher, B. Buford, A. Koch, M.L. Cole, and J.L. Mayhew. Human Performance Laboratory, Truman State University, Kirksville, MO.

The purpose of this study was to examine the vertical jump as a predictor of force in power football players. Forty-one NCAA Division II college football players (height: 184 ± 6.7 cm; mass: 103 ± 18.8 kg; percent fat: 12.8 ± 5.4%) completed a vertical jump on a portable Kistler force plate (sampling rate: 200 Hz). Power (2390 ± 756 W) and jump height (45.9 ± 6.7 cm) were determined from force plate measures. Step-wise regression produced prediction equations for peak and average power: Peak Power (W) = 31.08 Weight (kg) + 84.93 VJ (cm) 3055 (R = 0.80, SEE = 463 W) Ave Power (W) = 19.27 Weight (kg) + 57.88 VJ (cm) 25255 (R = 0.75, SEE = 369 W). Previously developed prediction equations generally did not cross-validate well on this group, with moderate correlations (r = 0.59 to 0.74) but significant over-and under-estimates of peak power. Specific power equation may be required for this population due to their size and jumping capabilities.

Effects of Volume and Exercise Complexity on Strength Gains and Lean Body Mass in Untrained Men and Women
J.B. Blaak, T. Triplett-McBride, and J.M. McBride. Musculoskeletal Research Center, University of Wisconsin-La Crosse, La Crosse, WI.

This study was designed to examine the effects of a 12-week resistance-training program using single vs. multiple sets of a complex vs. simple exercise. Twenty-eight men (n = 13) and women (n = 13) (mean age 21.6 ± 2.5) performed six sets of the resistance exercise and two groups (n = 6, n = 9) performed six sets of the resistance exercises. Group three (control, n = 10) was pre-tested and post-tested. One repetition maxima were measured in the LP and BC, pre-, mid-, and post-testing. Lean body mass of the legs and arms were measured pre- and post-training by dual energy x-ray absorptiometry (DEXA). Results of the study indicated that both S = 1 and M = 6 significantly increased in percentage strength pre-post training in both the LP and BC exercises (S = 1 pre-post LP = 41.2 ± 23.7%, BC = 8.5% ± 6.71%), (M = 6 pre-post LP = 52.0%, BC = 22.8% ± 15.6%). However, compared to S = 1, M = 6 showed a significantly greater increase in percentage strength in both the LP (p = 0.075) and BC (p = 0.05) from pre- to post-testing. There were no significant differences found in lean muscle mass gains for either the legs or arms between groups S = 1 and M = 6 (p = 0.05). No significant changes were observed in the control group. The data from this study suggests that multiple sets produces greater increases in percentage strength gains for both complex and simple exercises in untrained men and women during a twelve week training period.

Comparison of the 4–6–RM Versus the 7–10–RM for Predicting 1–RM
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The purpose of this study was to compare the accuracy of the 4–6–RM and 7–10–RM for predicting the 1–RM bench press in moderately trained college men. After completing eight weeks of thrice weekly resistance training, 275 men were randomly assigned to a validation group (n = 220) or a cross-validation group (n = 55) and to either a 4–to-6 (n = 114) or 7-to-10 (n = 106) repetition group. Linear regression analysis on the validation group for each RM load produced prediction equations for the 1-RM which had high correlations (r = 0.96) but significantly overpredicted in the lower repetition range (p < 0.05) and underpredicted in the upper range (p < 0.05). A prediction equation developed on the full repetition range cross-validated well (r = 0.95, r = 1.16) and had the most subjects within ±4.5 kg of their actual 1-RM. It appears that the 1-RM can be predicted with reasonable accuracy using any RM load between the 4 and 10-RM in moderately trained college men.

Velocity Is Not Generic Across Asymmetric Limbs
L.E. Brown, T. Sjostrom, M. Comeau, M. Greenwood, K. Stahura, and B.W. Findley. Human Performance Laboratory, Arkansas State University, State University, AR.

Researchers have hypothesized that human movement velocity may be generic across limbs and thereby merely a product of neuro patterning and coordination. The purpose of this study was to investigate the kinematics of two intrinsically different limbs (lower leg and lower arm) across a velocity spectrum. Ten male subjects aged 23.0±2.1 years volunteered to participate. Each subject performed five repetitions of each movement at three different load (consisting of a sine extension and elbow flexion movements in random order) at 60, 120, 180, 240, 300, 360, 400, 450, and 500 d/s on a Biosys 3 isokinetic dynamometer. Data were collected from the middle three repetitions at 1000 Hz while the velocity ROM phase of acceleration (ACCR) was separated out for analysis. This procedure allows measurement of each individual subject’s ability to move a limb quickly. Repeated measures ANOVA and Pearson correlations were performed to analyze the data. All subjects were able to sustain velocity during knee extension up to a velocity of 450 d/s while during elbow flexion subjects only achieved a max velocity of 400 d/s. ANOVA resulted in a significant ACCROM main effect (p < 0.05) with less acceleration velocity evident during elbow flexion when compared to knee extension. Correlations between knee and elbow ACCROM demonstrated a significant Pearson r-value only at the velocity of 360 d/s (p = 0.06). Therefore, velocity was less in elbow than in knee movement (400 < 450 d/s) and only one test showed evidence of a limb velocity relationship. These results collectively point to limb velocity specificity and do not support a generally based neuromuscular system. This specificity may be explained as a result of biophysical differences between limb length and mass. Individuals involved resistance training program design utilizing arm and leg motions should be aware that neural patterns may be dissimilar between these two effectors.

The Effects of Long-Duration Concentric or Eccentric Contractions on Maximal Strength, Oxygen Consumption, and Rate of Perceived Exertion

Research has shown that circuit weight training increases V O2 max (8±10%) as well as the economy of the working muscle at the same absolute load. Anecdotal evidence suggests that contraction duration may be a key stimulus for these adaptations. We thus compared the physiological adaptations in response to training with long concentric or eccentric contractions. Twelve previously resistance trained males were randomly assigned to either a long-duration concentric (2 s eccentric, 1 s pause, 8 s concentric, N = 6) or eccentric group (8–1–2–N = 6) and performed in each of 16 sessions 2 sets of 8 reps with 70% of leg press 1-RM. Control subjects did not train (N = 5). All subjects (N = 11) were tested for 1-RM (pounds), oxygen consumption (L/min), and for both the concentric and eccentric contraction modes and for rate of perceived exertion (RPE). The Group by Time interactions were not significant for 1RM and oxygen consumption. There was a Group by Time interaction for RPE for both training bouts and 5 minutes into recovery for the concentric (p < 0.05) and eccentric (p < 0.05) group. Table 1 shows the significant time main effects. These preliminary data suggest that both contraction modes produce similar adaptations in muscle strength and muscle economy. Lengthening contraction duration could be an effective alternative to conventional resistance training in trained males.

Table 1. Time Main Effect (*, p < 0.05).

<table>
<thead>
<tr>
<th></th>
<th>Pre 1-RM</th>
<th>Post 1-RM</th>
<th>VO2 Pre-Con</th>
<th>VO2 Post-Con</th>
<th>VO2 Pre-Ecc</th>
<th>VO2 Post-ECC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>396.5</td>
<td>416.2*</td>
<td>13.9</td>
<td>11.3*</td>
<td>12.6</td>
<td>10.8*</td>
</tr>
<tr>
<td>STD</td>
<td>74.7</td>
<td>71.7</td>
<td>5.2</td>
<td>3.2</td>
<td>2.6</td>
<td>2.1</td>
</tr>
</tbody>
</table>
The Effects of ‘GAKIC’ (an Amino-Keto Acid Blend) on High-Intensity Anaerobic Performance

B.N. Buford and A.J. Koch. Human Performance Laboratory, Truman State University, Kirksville, MO.

Purpose: The purpose of this study was to determine the effects of an amino-keto acid (GAKIC) supplement on dynamic muscle performance, measured under the conditions of intense, exhaustive anaerobic exercise. Methods: Ten male subjects completed a randomized, double-blind sucrose placebo controlled protocol with sessions separated by at least three days. A diet analysis was performed with Nutritionist IV® each testing session to account for dietary amino acid levels. Blood collected 45 mins prior to exercise (REST) and 5 mins post exercise (POST) was analyzed for plasma lactate by spectrophotometry using a 2 x 2 repeated measures ANOVA. The subjects consumed either 11.2 g GAKIC or 9.5 g sucrose placebo in 355 ml of cranberry juice in three equal allotments during the 45 mins period between the resting blood sample and exercise. Mean power, peak power, and fatigue values were assessed from a 30 sec Wingate test and analyzed using a paired t-test. Results: There were no significant differences between placebo vs GAKIC treatments in mean power (649.9 ± 62.7 W vs 652.7 ± 110.6 W respectively), peak power (839.6 ± 73.5 W vs 825.0 ± 126.6 W), or fatigue index (40.0 ± 8.8% vs 39.5 ± 6.8%). POST lactate levels were significantly higher (p < 0.05) increased above REST, but there was no difference between treatments. Conclusion: Compared with the sucrose placebo, GAKIC treatment did not increase peak power, mean power, or fatigue index in dynamic anaerobic exercise. These results do not support an ergogenic effect of GAKIC in anaerobic, dynamic exercise. In the absence of power conditioning setting, this supplement does not appear to increase anaerobic performance.

The Effect of Strength and Balance Training Versus Strength Training Alone on Balance and Gait in the Elderly

R. Chelein, C. Mancinelli, J. Perko, and L. DeChristopher. West Virginia University, Morgantown, WV.

The purpose of this pilot study was to determine the effects of a combined low intensity resistive exercise and balance training program compared to a low intensity resistance training program alone on balance, strength and gait in older adults. Ten subjects (2 male, 8 female) were recruited from a local independent-living retirement community. Balance was assessed using the Berg Balance test. Isometric torque output was assessed for major muscle groups. Gait parameters were assessed using an instrumented walkway. Subjects were then randomized into one of two treatment groups: strength alone (n = 5) or strength and balance (n = 5). Control data were gathered in a group of 9 subjects prior to the start of the study. Both experimental groups performed resistance exercise training 5 times per week for 12 weeks using dumbbells and weighted vests. The strength and balance group performed various balance exercises in addition to resistance training exercises. All pre-tests were then repeated one week following the cessation of training. The control group showed no significant changes from pre to post tests for all variables. Berg scores increased in the majority of experimental subjects so that they were no longer categorized as high fall risk. Paired t-tests showed significant changes in Berg scores for both experimental groups (p = 0.03). The only statistically significant difference found in isometric torque output was for hip extensors in the strength group (p = 0.02). However, resistance used for training increased 2±3 times the baseline load used for all upper extremity exercises, and one fold for all lower extremity exercises in both experimental groups. Significant changes in gait were found for stance time in both experimental groups (p = 0.04 strength, p = 0.03 strength and balance) and cycle time for the strength and balance group (p = 0.02). Power analysis indicated a need to increase sample size in each group to 13 to attain an 80% probability of being able to detect a treatment effect. Preliminary data suggest that fall risk decreases whether training with resistance exercises alone or resistance exercises combined with balance exercises. No conclusions can be made as to whether one form of training is superior to the other because of the small sample size used in this study. Further work is needed with a larger sample size.

Constitution of a Low-Cost Biomechanical Measurement System


Commercially available resistance exercise biomechanical measurement systems have become increasingly popular. However, these systems are often expensive and suffer from methodological limitations. A key limitation is the calculation of force from displacement or velocity rather than from direct measures of force. This leads to variability in the estimation of force-dependent variables, such as rate of force development, work, and power. A biomechanical measurement system was constructed, specifically for measurement of weight lifting type actions. The system consists of a uniaxial force platform (FP) and a linear position transducer (LPT). The FP was built using 4 single-component load cells (SW/01K; Transducer Techniques, Temecula, CA) bolted to a 1/2 inch thick steel plate 1 inch square from the corners. A 3/4 inch steel plate was placed on top and bolted to the load cells. The steel plates were 36 inches wide and 24 inches long and coated with rust-proof paint. The load cells were channeled into signal conditioners (TMO-3; Transducer Techniques). Each signal conditioner had a 5volt output which was summed with a junction box (SUM-3; Transducer Techniques). The LPT (P510-80-NJC-004-TS, Unimeasure, Corvallis, OR) was attached to a 9vdc regulated power source. Both devices were connected via coaxial cables to an analog-to-digital board, which was hardware-interfaced with an IBM compatible computer. To assess the linearity of the FP output, known weights were placed on the FP. The incremental increase in output voltage was determined for each increase in weight. A similar protocol was used for the LPT, raising the tether to known heights and measuring the output voltage. Simple linear regression was performed to determine the relationship between weight or displacement and output voltage. From the equations (Equation 1: 4474.3v = 0.0160x; R² = 1.00) and (Equation 2: 37.975v = 0.0172b; R² = 0.91) the output voltages were estimated for the known weights and displacements and compared to the actual output voltages using paired t-tests. No significant differences were found between predicted and actual output voltages, indicating that the force platform (Equation 1: p = 0.54) had a linear response to force between 0N and 8200N and the LPT (p = 0.981) had a linear response to position between 0 cm and 190 cm. Further tests to assess the dynamic measurement capabilities of the force platform are still required. The cost of this measurement system was approximately $4000, comparable to the price of commercially available systems without force platforms, making it affordable for use in facilities with limited budgets.
uct lost significantly greater weight compared to the group receiving the prescription fat-blocking agent (~4.58 kg vs. ~1.63 kg, respectively; p = 0.0246). There was also an equally impressive time trend difference in weight loss each 6-weeks favoring the non-prescription ephedrine-based product (~2.21 vs. ~0.82, p = 0.0081). In addition, within the confines of the study parameters, we believe that the non-prescription ephedrine-based product is more effective as a weight loss agent than the tested prescription fat-blocking agent.

Sponsored in part by a grant from Cytodyne Technologies® Lakewood, New Jersey

Comparison of Olympic Versus Traditional Power Lifting Training Programs in Football Players


The purpose of this study was to compare Olympic lifting to the more traditional power-lifting program in football players, and determine whether either training style provides any advantage for strength and athletic performance improvements. Twenty members of a NCAA Division III collegiate football team were randomly assigned to either an Olympic lifting group (OL; mean ± SD 174.0 ± 5.8 cm; 90.3 ± 13.5 kg) or a power-lifting group (PL; 178.8 ± 8.6 cm; 91.3 ± 11.8 kg). Each group trained 4 days-wk⁻¹ for 15 weeks. All subjects were tested prior to and following the training program. Testing consisted of field tests common to athletic conditioning programs to evaluate strength (IRM squat and bench press), speed (40-yd sprint), agility (T-drill), vertical jump height (VJ), and vertical jump power performance (VJP). No significant pre to post differences (p = 0.05) were observed in 1-RM bench press, 40-yd sprint, T-squat (VJ) or either group. Significant effects were seen in VJ in both the OL (175.0 ± 31.5 kg to 197.5 ± 21.0 kg) and PL (148.0 ± 25.9 kg to 166.9 ± 33.1 kg) groups. In addition, a significant training effect was seen in VJP in the PL group only. However, no significant group differences were observed in any of the strength or athletic performance variables. Although an 18% greater improvement in 1-RM squat was noted (p = 0.005), and a 20% greater improvement in VJP (p = 0.05) across the 3 week time (0.07 s versus 0.35 s) by OL, analysis of D scores revealed no significant group differences. Although statistical analysis of the data suggests no advantage exists between OL and PL training programs, a practical interpretation of results does imply that OL may be more beneficial than PL for improving leg strength and speed in football players.

The Effects of Vitamin E Supplementation on Muscle Function in Middle-Aged Subjects: Preliminary Results

B.W. Craig, S. Wintenmacher, and E. Eiselstein. Human Performance Laboratory, Ball State University, Muncie, IN.

The purpose of this investigation was to determine if 3-weeks of Vitamin E supplementation could protect the muscle against the damaging effects of a single bout of resistance exercise in older subjects (50-65 yrs). After they signed an IRB approved consent form the subjects were separated into supplemental (VE) and placebo (PL) groups (N = 3 for each group). The small N can be contributed to the fact that this project is still in progress, therefore these results are preliminary in nature. After a 3- week wash out period (no Vitamin E intake) the subjects were pre-testing for body composition and for any contracted need for exercise. For the next 3 weeks subjects started a 3 week supplemental phase with the VE group taking 1200 IU Vitamin E per day and the PLC group taking an equal number of cellulose capsules each day. After supplementation they completed a second exercise session and repeated RMF tests at 24 hours post-exercise. All data was subjected to a repeated ANOVA analysis and post-hoc testing performed using a Fisher PLSD test. The peak torque/%BW from the RMF shows that the VE group was stronger after 3 weeks of Vitamin E intake. The peak torque/%BW (average of 24-48 hr post at 60 °/sec) was 82.3% for the VE group and 67.23% for the PLC group. The total work/%BW showed a similar pattern with the VE group being 93.5% and the PLC 61.1%. These differences were found at all speeds tested and suggest that vitamin E might improve muscle function. These results are based on only a few subjects but if additional subjects show the same trend Vitamin E should be helpful to these subjects when they start the training phase of this project.

The Acute Effects of Static Stretching on Peak Torque and Mean Power Output During Maximal, Concentric Isokinetic Muscle Actions

J.F. Cramer, T.J. Hough, G.O. Johnson, and J.M. Miller. Center of Youth Fitness and Sports Research, University of Nebraska-Lincoln, Lincoln, NE.

The purpose of this investigation was to examine the acute effects of static stretching on peak torque (peak PT) and mean power output (MP) of the stretched (dominant) and unstretched leg extensor muscles of males and females during maximal, concentric isokinetic muscle actions. Fourteen females (mean age ± SD = 22 ± 1 yr) and nine males (22 ± 1 yr) volunteered for this study. PT and MP of the dominant and nondominant leg extensors were measured for 10 contractions at 120°/s on a calibrated Cybex 6000 dynamometer. The dominant leg was stretched concentrically to 45° in the 0.5-0.7 seconds for 10 contractions. The peak and MP measurements, the dominant leg extensors were stretched for approximately 20 minutes using one active and three passive stretching exercises. After the stretching, the PT and MP measurements were repeated. For PT, there were no significant (p > 0.05)
interactions involving the pre- vs. post-stretch factor (STRETCH), but a significant main effect \( (p < 0.05) \) for STRETCH collapsed across limb, gender, and testing velocity. Thus, the pattern of decrease for PT as a result of the static stretching was the same in both limbs for the males and females at 60 and 240° s\(^{-1}\) (pre-stretch mean PT + SEM = 171.7 ± 9.0 Nm; post-stretch = 164.9 ± 8.0 Nm). MP, however, was not affected \( (p > 0.05) \) by the static stretching protocol. It is possible that the 4% mean decrease in strength in the stretched and unstretched limbs may have been due to a bilateral central nervous system inhibitory mechanism. Furthermore, the fact that this STRETCH protocol accounted for 60.4% of the variance associated with balance. This study was important to further illustrate the link between athletic performance and balance. Future research should focus on a battery of test, which may help to identify athletes. Further investigat-
generative focus on kinematic variables as well as the link between static and dynamic balance. Different statistical analysis of raw COP data may lead to additional findings. With this information in mind coaches may want to implement additional balance programs to further enhance athletic performance and coordination.

**Kinetic Measures of the Hang Snatch, Hang Clean, and Vertical Jump Performed by Female Collegiate Basketball Players**

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The purpose of this study was to compare power production during the hang snatch, the hang clean, and the vertical jump to determine whether there were kinetic similarities among these movements. The participants were eight Division II female basketball players who all had experience with the two lifts. Two trials each of the hang snatch (60%, 70%, 80%, and 90% of 1RM) and the hang clean were performed by each participant along with two trials of the standing vertical jump with counter-
movement. Two AMTI force plates were used to collect ground reaction force data for each activity and a forward solution method was used to determine velocity and power outputs. There were no significant differences between the two tests for intensity of the lift. Therefore, the data for each lift were pooled for each subject. A repeated measures design was used to determine if there were significant differences between the two activities. The power produced during the vertical jump (2.02 + 0.09 W/kg) was significantly less than that produced in either of the hang snatch or hang clean, 2.67 + 0.11 and 2.80 + 0.08 W/kg respectively, while there was no difference of force between the lifts. The relative power produced during the hang snatch (31.85 + 3.55 W/kg) and vertical jump (32.02 + 1.59 W/kg) were significantly greater than that produced in the hang snatch (27.18 + 1.36 W/kg), while the power produced during the hang snatch and vertical jump were not significantly different. The power production of the lifts and jump were influenced in different proportions by the force and velocity of each lift. Even though the vertical jump had the lower force output it had the highest vertical velocity (1.93 + 0.12 m/s), which was significantly greater than that of the hang snatch and hang clean, 1.57 + 0.04 and 1.32 + 0.05 m/s, respectively. The results of this study demonstrate that weightlifting style lifts can result in similar power outputs compared to the vertical jump but the power is derived by a different combi-
nation of force and velocity profiles. These results support the idea that this type of lift is a potentially valuable training exercise for athletes trying to improve lower body power production.

**Relationships Between Pull-Ups, Modified Pull-Ups, and a Modified Flexed Arm Hang for Fourth and Fifth Grade Girls**

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The importance and need for tests which accurately assess children’s fitness are well established. Three tests that have been recommended as arm and shoulder girdle performance and endurance for children are pull-ups (PU), Vermont modified pull-ups (VMPU), and a modified flexed arm hang (MFAH). Although each of these tests have been identified as viable alternatives for measuring upper body strength and endurance, relatively little research indicates the degree to which the tests are related. The purpose of this study was to examine the relationships between the PU, VMPU, and a MFAH for a group of 56 fourth (n = 27) and fifth (n = 29) grade girls. MANOVA indicated no significant difference between grades, \( F(3, 52) = 0.901, p = 0.447 \), therefore, data for the two grades were combined. The study received IRB approval. Students practiced each test and three separate days of testing were conducted with a minimum of 48 hour rest between tests. On test days, a general warm up was conducted and students were instructed on proper protocols. On previous tests, a supported grip with thumbs over the bar was used for each test and scoring modifications were used for PU. Both full and partial (0.25, 0.50, 0.75) PU were counted. VMPU procedures followed stan-
dardized protocol. For the MFAH, participants were lifted to an under grip, chin above bar position, released and timed by two independent judges until the elbow exceeded 90° of extension (visually identified). A coefficient of 0.99 was attained for inter-rater reliability; therefore, the average of the two timers was used for MFAH. Although all Pearson product-moment correlations of interest were significant \( (p < 0.05) \), PU and VMPU correlated most strongly \( r = 0.356 \), followed by MFAH and VMPU \( (r = 0.558, p = 0.311) \), and PU and MFAH \( (r = 0.486, p = 0.236) \). Results indicated that the three tests are only moderately related. Additional research is needed to determine which test best measures and if one test is superior. Prac-theoretical implications from these findings will be presented. Abstracts from the 2002 NSCA Conference
The purpose of this study was to quantify kinetic differences in various load values of the hang clean and snatch as well as compare the two exercises. Subjects included five division I athletes (mean ± SD; age = 21.7 ± 2.3 years, body mass = 90.3 ± 16.0 kg) who routinely performed the hang clean and snatch. Subjects performed a single repetition of the hang clean and snatch at loads of 50, 60, 70, 80, and 90% of their 1 RM. Hang clean/snatch order was randomly determined and all subjects progressed form 50% to 90% of their 1RM for each exercise, with five minutes rest between each repetition. Ground reaction forces (GRF) were evaluated on an AMTI force plate. A one-way ANOVA with post-hoc comparisons of the hang clean revealed that the repetition performed at 50% RM (2818 ± 478.4 N) was statistically different (p < 0.05) than repetitions performed at 60%-90%. The repetition performed at 60% (3120 ± 579 N) was statistically different from the repetitions performed at 90% (3633 ± 579 N). For the snatch, the repetition performed at 50% (2789 ± 399.5 N) was statistically different (p < 0.05) than the repetition performed at 70% (3165 ± 610.3 N) or more while the repetition performed at 60% and 70% were only statistically different from the repetition performed at 90% (3633 ± 579 N). Despite the fact that the average 1RM loads were approximately 50% higher for the hang clean (133 kg) than the snatch (88 kg), no statistically significant differences in GRF were found between the two exercises (p > 0.05). These data demonstrate that increased loads do not necessarily result in increased GRF and that compared to the snatch, the higher loads associated with the hang clean do not result in greater GRF. These results suggest other variables such as exercise form and movement velocity mediate the amount of force developed. Finally, hang clean do not result in greater GRF. These results suggest other variables such as exercise form and movement velocity mediate the amount of force developed. Finally, hang clean do not result in greater GRF. These results suggest other variables such as exercise form and movement velocity mediate the amount of force developed. Finally, hang clean do not result in greater GRF. These results suggest other variables such as exercise form and movement velocity mediate the amount of force developed. Finally, hang clean do not result in greater GRF. These results suggest other variables such as exercise form and movement velocity mediate the amount of force developed. Finally, hang clean do not result in greater GRF.
EMG/force ratio) for the knee extension exercise. MHC expression was %IIa = 26.6 ± 9.2, %IIb = 66.6 ± 10.7, and %Ib = 12.8 ± 8.9. Correlation coefficients (r < 0.10, *p < 0.05) between MHC expression and performance variables indicated that the SQuat was more related to MHC expression. Specifically, depth VJ height was correlated with %IIa (r = 0.677*), and %Ib (r = 0.0.42), mean power with %IIa (r = 0.855**), and %Ib (r = 0.42), and peak power with %IIa (r = 0.677*) and %Ib (r = 0.42). Adjusting for body mass, mean power/kg was correlated with %IIa (r = 0.677*), and %Ib (r = 0.0.42), %IIa (%r = 0.53**), and %Ib (%r = 0.53*). The explained variance for these data (r² = 16 ± 25%) indicate the relative contribution of MHC expression to performance as measured in this study.

The purpose of this study was to determine the extent of strength imbalance in the lower extremities. Thirteen collegiate female softball players participated in the study and were tested on two protocols. Back squat was performed using a barbell loaded to 80% of previously determined 1RM. Individual force-platforms were placed under each foot for each repetition. Vertical ground reaction force (VGRF) was measured during 3 sets of 5 repetitions. The second protocol involved knee flexion and extension performed on an isokinetic dynamometer with 3 sets of 3 repetitions at both 60 and 240 degrees per second (deg/sec). During the squat significant differences were found in both knee and ankle power and force between the dominant and non-dominant legs, and 60% and 60% respectively. Isokinetic testing also revealed significant differences between the dominant and non-dominant legs for flexion and extension at both speeds tested. At 60 deg/sec, a 15.3% difference existed between the dominant and non-dominant legs for flexion while a 13.5% difference existed during extension. Similar results were observed for 240 deg/sec condition with differences of 16.0% for flexion and 13.1% for extension between the dominant and non-dominant legs. To our knowledge this is the first study which examines forces under the individual feet during squatting. The differences of between 60% to 16% when there is a small might have relevance as hamstring imbalances. Contralateral imbalance may also have this potential but this needs to be substantiated. The practical significance of this study is that coaches and athletes must be aware that imbalances may exist in leg strength even in healthy, injury free athletes. Testing of such imbalances may prove instructive and unilateral training should be considered when differences occur.

Gender Comparisons of Strength and Power in Teenage Girls and Boys


The purpose of this study was to investigate gender differences in maximal strength and power in teenage girls and boys. Thirty-three teenage girls (mean ± SD; age 15.9 ± 1.4 yrs; body mass 60.8 ± 8.1 kg, percent body fat 27.0 ± 7.3% and twenty-six teenage boys; age 14.3 ± 1.3 yrs; body mass 62.5 ± 14.6 kg, percent body fat 17.5 ± 9.4% participated in this investigation. Maximal strength (squat and bench press) and peak power during jump squats using 30% and 60% of maximal strength were assessed. Body composition was determined using dual-energy X-ray absorptiometry. There were no statistical differences between boys and girls in body mass (62.5 ± 14.5 and 60.9 ± 8.1 kg, respectively); however, boys had significantly (P < 0.05) greater fat-free mass (49.0 ± 11.2 and 41.4 ± 4.3 kg, respectively). Maximal squat was not significantly different between girls (66.4 ± 16.4) and boys (66.3 ± 20.3 kg). When expressed relative to fat-free mass, the girls demonstrated significantly greater strength in the squat. Boys were significantly stronger in the bench press (48.5 ± 15.6 vs. 52.7 ± 5.9 kg). 30% depth VJ was most related to MHC expression. Specifically, depth VJ height was 25.8 (r = 0.53**) and %IIa (r = 0.53**). The explained variance for these data (r² = 16 ± 25%) indicate the relative contribution of MHC expression to performance as measured in this study. The greater lower body force production relative to fat-free mass in teenage girls compared to boys may be due to maturation and/or biomechanical differences. Supported by the National Dairy Council, Rosemont, IL.

Creatine Supplementation Does Not Adversely Affect Health Status of Division I Baseball Players

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Recent surveys report that creatine users may experience side effects such as fatigue, cramping, and/or musculoskeletal injury. However, the incidence of these potential side effects among creatine users was not compared to a control group of athletes. This study examined perceptions of health status among athletes who did and did not take creatine during training/competition. Forty-one Division I college baseball players participated in this study. Subjects completed a 17-item Health Status/Side Effects Inventory once a week for 18 weeks during pre-season and in-season training/competition. Twenty-three (56%) of the subjects ingested creatine during training/competition (20–30 g/d for 5–7 days and ~5 g/d thereafter administered in 5–10 g doses) during the course of the study. Responses to the health status/injury inventories were compared for creatine and non-creatine using chi-square and Fisher’s exact tests. Analysis of the health status inventory revealed creatine users feeling significantly less pain (P < 0.05) over-trained (weeks 1 & 2), and less arm and shoulder fatigue (weeks 4 & 6) compared to non-creatine users. In addition, the creatine users perceived themselves ready to perform at their personal best (weeks 4, 5, 7) in comparison to athletes who did not take creatine. However, these associations were not demonstrated consistently throughout the 18-week period. In addition, these findings support recent reports that creatine supplementation during training does not adversely affect health status or cause side effects.

KinetiCommotion of the Weight Shift and Pivot Throwing Techniques in a Collegiate Baseball Catcher: A Pilot Study

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The fundamentals of catching are exceptionally complex and the mastery of these fundamentals demands that a catcher develop a variety of catching skills (i.e., signaling, receiving, framing, blocking, throwing). In addition to the constant development of fundamental catching skills, the catcher must also sport-specifically train in order to withstand the physical and psychological demands of the position. Therefore, the purpose of this pilot study was twofold: 1) to kinetically compare the weight shift (WS) and pivot (P) throwing techniques of a collegiate baseball catcher and 2) to determine how variance in the resistance training protocols can be utilized to train catchers sport-specifically in relation to both throwing techniques. The subject (21 yrs, 1.88 m, 83.9 kg) who volunteered for this study was from a mid-south Division IA collegiate baseball team who had 11 years of catching experience. Data were collected using both WS and P throwing techniques on a force platform and included rate of force development (5693 vs 2280 N/s), force max (1485 vs 1219 N), and time to force max (121 vs 163 ms). The WS technique consistently produced greater values when compared to the P technique. Data were also collected while performing a speed squat with 30, 60 & 80% 1RM for a vertical and a horizontal jumped to a low box produced values most similar to the WS technique while a speed squat with 80% 1RM most closely resemble the P technique. Based on this pilot data it was concluded that a WS throwing technique requires greater power output than a P technique and that traditional resistance training exercises may be modified in order to train catchers in a sport-specific manner.

Modified Sinclair Coefficient Formulas for Junior and School-Age Weightlifters

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The Sinclair coefficient is a proportionality constant that is a statistically unbiased determinant of the overall winner of a weightlifting competition. The coefficient multiplies the total weight lifted by the competitor to the clean and jerk and to the snatch to determine the total. The lighter with the highest total is the overall winner. Junior and school-age winners are determined using the formulas for adult men and women despite physical attributes that may differentiate them from adults. The purpose of this study was to determine modified Sinclair coefficient formulas for junior men and school-age boys and girls. Current World Records for junior men and women and American Records for school-age girls and boys were found on reputable weightlifting internet sites. Body weights and lifting totals of record holders for junior men, junior women, school-age boys, and school-age boys were converted to logarithms and regression analysis was performed. The largest body weight of the record holder and the Rsquare value in each of the four groups was substituted into the current Sinclair coefficient formula. Group Condition Formula for coefficient School-age girls: If BM < 134.28, 104.30*(BMI/BMI0.025) (1); If BM > 134.28, School-boys: If BM < 105.0, 104.30*(BMI/BMI0.025) (2); If BM > 105.0, 104.30*(BMI/BMI0.025) (3); If BM > 119.42, 104.30*(BMI/BMI0.025) (4); If BM > 119.42, 104.30*(BMI/BMI0.025) (5); If BM < 134.28, 104.30*(BMI/BMI0.025) (6); If BM > 134.28, 104.30*(BMI/BMI0.025) (7); If BM > 134.28, 104.30*(BMI/BMI0.025) (8); If BM > 134.28, 104.30*(BMI/BMI0.025) (9); *BM indicates body mass in kg. The total weight lifted multiplied by the coefficients determined by the formulas produce appropriate totals for weightlifters in each of the four groups. Winners can now be determined using coefficients specifically formulated for the weightlifting category in which they compete.

Peak Force and Rate-of-Force Development during Dynamic and Isometric Muscle Actions

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Eight collegiate weightlifters (M ± SE: age 21.2 ± 0.9 yrs; height 177.6 ± 2.3 cm; body mass: 85.1 ± 3.3 kg) participated as subjects to compare isometric to dynamic force-time dependent variables. The subjects performed maximum isometric (IM) and dynamic pulls from a specially constructed rack while standing on a 61 x 22.9 cm AMTI force plate. The dynamic pulls were performed at 30% (DP30), 60% (DP60),
90% (DP90), and 120% (DP120) of the subject’s current 1-RM power clean (118.4 ± 5.5 kg). Subjects also performed countermovement (CVJ) and static (SJ) vertical jumps on the force platform. The position for all pull trials was standardized. Adequate recovery (3 min) was provided to assure maximum effort during subsequent trials. All trials were performed in duplicate. Interclass correlations values of R = 0.96 for isometric peak rate of force development (IPRFD) and R = 0.97 for isometric peak force demonstrated high-retest reliability. IPRFD showed moderate to strong correlations with peak force (PF) during DP30 (r = 0.51), DP60 (r = 0.55), DP90 (r = 0.82), DP120 (r = 0.60), SJ (r = 0.67), and CVJ (r = 0.87). IPRFD showed moderate to strong correlations with PF during DP30 (r = 0.67), DP60 (r = 0.54), DP90 (r = 0.69), DP120 (r = 0.74), SJ (r = 0.43), and CVJ (r = 0.85). Additionally, dynamic PF and peak power production during CVJ were strongly (DP30 = 0.70, DP60 = 0.85, DP90 = 0.98, DP120 = r = 0.80). These data suggest that the heavier the mass lifted, the more important IPRFD becomes. These data also suggest that both isometric and dynamic PF appear to be partially dependent on rate-of-force development. From a practical standpoint this data suggests that mid-thigh clean pulls performed at 90% of maximum appear to have the strongest relationship to peak power production and peak rate-of-force development during vertical jumping tasks.

Relationship of Upper Body Measurements of Strength and Power in College Male and Female Athletes

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The purpose of this study was to determine the interrelationships of the bench press, incline press, and seated shot put in NCAA Division II male and female athletes. Twenty-nine male and thirty-eight female collegiate athletes performed a 1-RM bench press (BP), a 1-RM incline press (IP), and a seated shot put (SSP) using a 4-kg shot in random order. The IP was performed at a 45° angle, and the SSP was performed at approximately a 40–45° angle. Correlation coefficients were determined for the performance variables.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Combined Group Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP vs IP</td>
<td>0.99**</td>
<td>0.95**</td>
</tr>
<tr>
<td>BP vs SSP</td>
<td>0.91*</td>
<td>0.44</td>
</tr>
<tr>
<td>IP vs SSP</td>
<td>0.91*</td>
<td>0.43</td>
</tr>
<tr>
<td>BP vs Bdy Wt</td>
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<td>0.50**</td>
</tr>
<tr>
<td>BP vs Bdy Wt</td>
<td>0.80*</td>
<td>0.48**</td>
</tr>
<tr>
<td>SSP vs Bdy Wt</td>
<td>0.83**</td>
<td>0.49**</td>
</tr>
<tr>
<td>SSP vs BP/Bdy Wt</td>
<td>0.84*</td>
<td>0.16</td>
</tr>
</tbody>
</table>

*p < 0.05. **p < 0.01.

The strong correlation between the BP and IP in both genders indicated that either test would be appropriate to measure upper body strength. Both upper body strength measures were more highly related to SSP in women than in men despite higher correlations between strength measures and body weight in men. In conclusion, upper body power performance may be more highly related to SSP in female athletes than in male athletes. Additional research is needed to establish if variables differ for each gender in determining power output.

Weightlifting Performance Changes Using Serum Chemistry Indicators

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PURPOSE/OBJECTIVE: The purpose of this study was to determine if the ratio of blood glutamine to glutamate (Gn/Gt) could be monitored and adjusted to improve performance. Additional research is needed to establish if variables differ for each gender in determining power output.

The Effects of an Eleven Weeks Spring-Season Low Intensity Resistance Training Program on a Division I Collegiate Male Rugby Players in Japan

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Thirty-four male Kansai region Division I collegiate male rugby players in Japan (18–23 years, 171.9 ± 5.8 cm, 79.2 ± 12.9 kg) participated in a study to examine the effects of 11 weeks low intensity resistance training program during a spring-season training that consist of 24-wk-1 of resistance training, 2d-wk-1 of endurance running program, 1d-wk-1 of skill and tactics practice, and 2d-wk-1of practice game. The purpose of the resistance training program was to improve the body size and the body composition as well as the basic muscular strength. Subjects were required to perform 3 sets of squat (SQ), bench press (BP), and bent-over-raw (BOR) in the first week, 4 sets in the following four weeks, and 5 sets in the final seven weeks. Inter-set rest period was 60–90 seconds throughout the study. Subjects started with 12 repetitions at 50–60 percent of their estimated 1RM test value calculated by Eley’s formula. When subjects could successfully perform 12 repetitions for every set, the weight was increased by 5 kg in SQ, 2.5 kg in BP and BOR. Results of the study showed significant (p < 0.05) increase for the fat free mass (1.8 ± 4.7 kg), 1RM of SQT (22.0 ± 18.3 kg), BP (13.5 ± 7.6 kg), and BOR (8.7 ± 6.1 kg). Percent body fat (1.9 ± 5.0%), girth of the chest (11.4 ± 22.0 mm), abdomen (8.5 ± 23.3 mm), and upper arm (8.6 ± 14.1 mm) decreased significantly (p < 0.05). No significant (p = 0.05) change for the body mass and the girth of thigh were observed. Significant correlations were observed between the average intensity (percent of initial1RM) and strength improvement in BP (r = 0.49, p < 0.05) and BOR (r = 0.49, p < 0.05). No significant correlation was seen between the volume (total repetition) and strength improvement in SQ, BP, and BOR. The results of this study suggest that even low intensity (60%) resistance training concomitant with endurance training, skill practice, and practice game in a week could improve muscular strength and fat free mass. Improvement in fat free mass and an important factor to increase strength even in the case of the program where low intensity was used. Further consideration for the scheduling training program would be necessary to increase body mass and size of the collegiate rugby players in spring-season in training.

Rating Differences between Hand Grip Dynamometry and 1RM Bench Press in Elderly Women


There is great interest in our aging population regarding objective performance-related fitness measures. Rating muscular strength is of particular concern due to the implications of sarcopenia. Categorizing upper body muscular strength by the use of field tests such as the handgrip dynamometry (HGD) is common. However, the use of these tests may not provide appropriate information regarding upper body strength in this population. Thus, the purpose of this investigation was to determine if category differences existed between the HGD test when compared to a 1RM bench press test in an elderly population. Seventy-seven females (age 68.7 ± 6.2 yrs, ht 162.5 ± 9.3 cm, wt 72.3 ± 16.3 kg) volunteered to participate and gave their written informed consent. Subjects performed a 1RM bench press test on a selectorized weight-stacked machine with the raw score expressed in kg/BW. Subjects also performed a bilateral HGD test according to protocol and expresed as a sum in kg. Standard categorization (excellent, good, fair, average, poor) of each was used. Results showed that there was an over-estimated categorization of upper body strength in 33% and underestimated upper body strength in 17% when compared to the 1RM test. Therefore, caution should be when interpreting HGD tests in elderly women.

The Effect of an Intercollegiate Soccer Game on Anaerobic Power Performance and Recovery


The purpose of this study was to examine the effect of a competitive soccer match on anaerobic power performance and recovery in a NCAA Division III female collegiate soccer team. Nineteen members of the College’s varsity soccer team volunteered to participate in this study. To assess changes in anaerobic power performance subjects were tested 24-hours prior to the game, 30 minutes prior to the game, immediately post-game (IP), and 24- and 48-hours post-game (2AP 48P). All testing occurred in the Human Performance Laboratory. Each subject performed a squat jump (SJ) and countermovement jump (CMJ). These jumps were performed with a position transducer attached to the subject’s waist to measure displacement of the trunk. A computer recorded force and displacement data, power output was subsequently calculated. All subjects participated in the contest (playing time ranged from 13-90 minutes). Comparisons between starters (n = 10) and nonstarters (n = 9) revealed no significant differences between the groups in power performance. However, significant correlations were seen between playing time and peak force during the SJ at 24P (r = 0.47), and between playing time and peak power during the SJ at IP (r = 0.57) and 24P (r = 0.51). A significant correlation between playing time and peak power during the CMJ was also seen at IP (r = 0.49). Comparisons in power performance between different positions were examined through a non-parametric analysis. PRACs were also examined to see if any differences in power performance between positions were seen. Results of this study indicate a correlation between playing time and performance decrements. However, there does not appear to be any greater rate of fatigue placed on any particular position during a soccer game.
Assessing a Three-Year Trend of Injuries on High School Football before and after a Strength and Conditioning Program

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Purpose: The purpose of the present investigation was to examine the impact of a high school strength and conditioning program on injury rates/years and days of practice/games missed for football. In addition, the relationship between attendance of the strength and conditioning program and number of days missed due to injury was also examined. Injury records prior to and following (i.e., first and second year) inception of the strength and conditioning program were compared. Methods: Archival records of 69 athletes (N = 24 pre-strength program, N = 22 first year of strength program, N = 23 second year of strength program) across three years were examined and interrelated to participation with the athletic trainers were performed to confirm accuracy of records with regard to injury type, practice days missed, and games missed. Then, attendance logs of the strength and conditioning program were examined to determine program adherence for the athletes who were injured in competition during the first two years of the program. Results: A non-parametric analysis demonstrated significantly fewer practice days missed for those athletes involved in the strength and conditioning program M + SEM = 8.07, 3.41 versus athletes not exposed to the training regimen M + SEM = 14.46, 5.97 (t(22) = 10.11, p < 0.01). In addition, strength-trained athletes missed fewer games M + SEM = 1.31, 0.12 compared to those not in an organized training program M + SEM = 1.71, 0.20 (2(22) = 9.63, p < 0.01). Overall, injury type sustained was not significantly different between those groups. Conclusions: Based on the results of the present study, the strength and conditioning program demonstrated an impact on practice missed as well as games missed due to injury. However, non-significant differences were found between the first and second years for injury type, attendance, and days/games missed while athletes were enrolled in the strength and conditioning program. Practical Applications was, the present study demonstrated the practical consideration for the implementation of a strength and conditioning program with high school athletes was to decrease injuries and thereby reducing practice days and games missed. The change in injury rates overall may warrant future study.

Kinetic Performance Effects of Astaxanthin Supplementation on Delayed Onset Muscle Soreness in Weight Trained Males


After uncustomized exercise, many people experience delayed onset muscle soreness (DOMS). The primary focus of this study was the antioxidant role of the astaxanthin, a strong carotenoid. Twenty weight trained male subjects ingested four gel capsules daily for 35 days. The capsule included either the astaxanthin supplement (S group, 430 mg safflower oil or olive oil, 144 mg haematococcus pluvialis alga extract [contains 2 mg astaxanthin, 240 µg lutein]) or safflower oil placebo (P group). At the end of the intervention period, subjects performed a DOMS-inducing work out consisting of 10 × 7–10 eccentric leg extension starting at 80% eccentric 1 RM using weight stack machine. Tests were executed at the following time points from the DOMS-inducing session; immediately pre [base line], immediately post, 10 hrs, 24 hrs, 48 hrs, 72 hrs, 96 hrs, and 288 hrs post. Peak and mean concentric power, force, and velocity were measured by using another knee extension machine which was interfaced with a computerized dynamometer (Fiziotyne, Bratislava, Slovakia). One RM (kg) decreased as follows: Mean ± SD: Pre = 44.0 ± 6.6 kg, Post = 43.8 ± 6.1 kg, 24 hrs = 43.6 ± 6.5 kg, 48 hrs = 43.2 ± 6.5 kg, 72 hrs = 43.1 ± 6.5 kg. Pre-mean concentric power (12 kg) was 488 ± 80; 24 hrs mean force = 361 ± 93 (−22.0%), 48 hrs = 451 ± 94 (−18.0%), 72 hrs = 452 ± 94 (−17.0%). Pre-mean concentric force (80 kg) = 68, 24 hrs mean power = 274 ± 72 (−21.7%), 48 hrs = 334 ± 84 (−36.9%). Pre-mean and mean force returned to base line by 72 hrs for both groups. Tests at 90% 1 RM exhibited the following data (Mean ± SD): Pre mean force (N–S) = 448 ± 69, P = 482 ± 81, 24 hrs mean force = 361 ± 93 (−22.0%), P = 451 ± 94 (−18.0%), 48 hrs = 452 ± 94 (−17.0%). Pre-mean concentric power (N–S) was = 68, 24 hrs = 361 ± 72 (−21.7%), 48 hrs = 334 ± 84 (−36.9%). Mean force and power returned to base line by 24 hrs for P group, and by 96 hrs for S group. Therefore, astaxanthin supplementation did not ameliorate DOMS. Funded by Cyanotech Corp.

Gastrointestinal Distress During High-Intensity Intermittent Training: Effect of Fluids Containing Carbohydrate (CHO)


During submaximal exercise, gastric emptying and intestinal fluid absorption are reduced when the CHO content of a sports drink is 8% or higher. This effect might increase across the session for water or either sports drink. ANOVA with repeated measures immediately before starting and at halftime (4.5 mL/kg) and between Q (1.5 mL/kg) and post Q (1.5 mL/kg) trials, suggesting that intensity of effort was consistent. We observed that protein intake may increase during high-intensity intermittent exercise training and that a beverage with 8% CHO provoked greater distress than did a beverage with 6% CHO.

The Influence of Vibration Stimulation on Muscular Strength, VMG AND EMG Signals During a Fatiguing Protocol

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At present there appears to be a lack of data on the effects of vibration stimulation and its influence on muscular strength characteristics. The purpose of this study was to investigate the effect of vibration stimulation on muscular strength, the behavior of the fatigued muscle and muscular activation levels. All vibromyography (VMG) and electromyography (EMG) data was collected from the rectus femoris muscle of the active and inactive legs when performing an isometric fatiguing protocol under conditions of vibration and no vibration. Sixteen recreational athletes (mean ± SD) age 22 ± 4.4 years, body mass 73.6 ± 11.7 kg and height 173.1 ± 5.7 cm participated in this study. Vibration stimulation was delivered at 50.42 ± 1.16 Hz with an acceleration of 13.2 ± 0.18 ms² to the dominant leg of participants. A paired t-test revealed no significant (p > 0.05) within condition differences between pre and post measures for the vibration conditioned. A paired t-test revealed significant (p < 0.05) within condition differences between peak isometric force (669.0 ± 561.7 N), percentage force decline (100% vs 85.6%) and peak normalized EMGmax (100% vs 80%) for the condition of no vibration. A one-way ANOVA revealed no significant differences between the post measures of the percentage force decline (p = 0.24, 0.05) and peak normalized EMGmax (0.30, 0.05) between pre and post vibration conditions. An ANOVA revealed significant (p < 0.05) differences between the peak frequencies at the completion of the isometric fatiguing protocols between the vibration (27.1 ± 12.2 Hz) and non-vibration (9.8 ± 3.5 Hz) conditions. The results of this study demonstrated an overall decline in strength characteristics for the condition of no vibration. The vibration condition resulted in an increase in peak frequency indicating a state of less fatigue. These results would indicate firstly, the benefits of vibration treatments to improve strength outputs by combating the effects of fatigue and secondly, the use of VMG peak frequency analysis derived from FFT’s to expand the potential for studying mechanisms of muscular fatigue. The implications of vibration treatments may prove beneficial as an accomplishment to rehabilitation techniques and as a countermeasure for recovery between heavy resistance training sets and sessions.

Comparison of Three Methods of Determining Grip Strength


Handgrip dynamometry (HGD) is a common method of assessing grip strength as an indicator of disease activity, function, or exercise capacity. Ottone, Strength and Conditioning Specialists rely on the information gained from this test to prescribe exercise or assess those unable to adequately perform 1RM tests. Many methods of attaining this information are described in the literature. Testing can be performed static, with the elbow at 90 degrees angle (90D), or dynamically through a 180 degree ROM (180D). The purpose of this investigation was to determine if significant differences existed between test methodologies. Ten subjects (5 men, 5 women, age 29.4 ± 6.6 yr, ht 172.0 ± 7.4 cm, wt 71.8 ± 8.4 kg) performed three trials of 90D, 90D, and 180D 5-5 days apart in a random order. The highest of each trial was recorded in kg. Results revealed that in this pilot study, no significant (p > 0.05) differences existed between methods of assessing grip strength. Therefore, instructor preference and/or client comfort may be indicated when choosing a method of HGD.

Relationship of Selected Strength Measures to Batting Velocity in College Baseball Players

B. Johnson, M. McLoud, and J.L. Maybeau. Athletic Department, North Dakota State University, Fargo, ND.

The assault on the major league home run record in recent years has prompted new interest in factors that could enhance baseball batting performance. Anecdotal evidence from leading performers may suggest a greater level of strength in the better hitters. The purpose of this study was to determine the contribution of selected upper body strength measures to batting performance. Twelve college baseball players with a minimum of 10 years of playing experience were measured for 1-RM dynamic bench press performance and top-hand and bottom-hand maximal isometric grip strength. Bench press performance measures and grip strengths, while grip strength was measured with a Jamar dynamometer. Bat velocity, determining from the time measured to impact of the ball by a 21 cm). Parcellating out the effect of weight and height reduced the correlation between bat velocity and 1-RM bench press (r = 0.51). While these results indicate that the muscle strength registered in the bench press movement is moderately related to bat velocity (r = 0.64), it is possible that measurements of strength in more specific movement patterns.

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to hitting could produce greater predictability for bat velocity. Further research determining lead-arm extension strength and trunk twisting strength may hold promise for explaining bat velocity.

Relationship of Tests Indicating Plyometric Readiness

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Previous standards to achieve readiness for advanced plyometric exercises has been to perform a 5-rep squat with 60% of body weight in under 5 seconds (5repSq), perform a 1-RM squat (SQ) at 1.5-2.0 times body weight, and achieve a greater height in the drop jump (DJ) than from a standing countermovement jump and reach. The purpose of this study was to assess the relationship among various performance parameters to determine readiness to begin plyometric training in college male and female volleyball players. Ten male and ten female NCAA Division II college volleyball players performed a 5repSq, 1-RM SQ, and a DJ from an 18-inch box. Subjects were also measured for lean body mass (LBMS), standing countermovement jump and reach (CMJ), and a countermovement jump squat (SJ) using 30% of 1-RM on a Plyometric Power System to determine peak power (PP) and peak force (PF). Correlations for the combined group were determined for the performance variables:

<table>
<thead>
<tr>
<th>5repSq</th>
<th>1-RM/kg</th>
<th>DJ</th>
<th>LBMS</th>
<th>PF</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.79**</td>
<td>-0.53</td>
<td>-0.33</td>
<td>-0.54</td>
<td>-0.47</td>
</tr>
<tr>
<td>1-RM/kg</td>
<td>0.61**</td>
<td>0.54</td>
<td>0.60</td>
<td>0.50</td>
<td>0.66**</td>
</tr>
<tr>
<td>DJ</td>
<td>0.81**</td>
<td>0.76**</td>
<td>0.84**</td>
<td>0.74**</td>
<td>0.93**</td>
</tr>
<tr>
<td>LBMS</td>
<td>0.88**</td>
<td>0.93**</td>
<td>0.60**</td>
<td>0.54*</td>
<td></td>
</tr>
<tr>
<td>PF</td>
<td>-0.94**</td>
<td>-0.94**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05. **p < 0.01.

Three male subjects performed both the 5repSq in less than 5 s and 1-RM SQ greater than 2 times body weight. Only one male subject was able to improve his CMJ and he was not one of the previous three. No female passed any of the tests. Although the readiness standards show a relationship to peak force and power, they do not conclusively determine advanced plyometric readiness.

The Effects of an In-Season Conditioning Program on Strength and Power of Collegiate Football Players

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Most studies on change in strength and power of in-season team sport athletes have observed peak strength following off-season training, then declines through the competitive season when less time is available for strength conditioning. A few studies have demonstrated strength maintenance or increase from high intensity programs typically greater than 80% 1RM. The purpose of this study was to evaluate amount and time-course of change in strength and power of NCAA Division II football players participating in an in-season program designed to be performed in minimal time. Conditioning sessions utilized complex training principles with intensities ranging from 72% to 88% 1RM and met 3 mornings a week for 30 minutes. The study was unique in that outcome measures were analyzed at mid-season (MS) as well as pre-season (PRS) and post-season (PSTS). Twenty athletes completed all training and testing. All athletes performed 1RM testing on Bench Press (BP), Hang Clean (HC), Squat (SQ), and Vertical Jump (VJ). Performance on all 3 measures followed a similar pattern. There were statistically significant decreases from PRS to MS and additional, but smaller, significant decreases from MS to PSTS. Mean 1RM for the SQ decreased 4.7% from PRS to MS (360.3 ± 60 to 343.2 ± 54.3 lb), then an additional 2.2% to PSTS (335.3 ± 55.8). Mean 1RM for the HC decreased 7.4% from PRS to MS (250.9 ± 44.3 to 232.4 ± 34.6), then an additional 5.0% to PSTS (219.7 ± 33.0). Mean 1RM for the BP decreased 6.4% from PRS to MS (271.8 ± 44.0 to 254.4 ± 35.2), then an additional 3.4% to PSTS (245.3 ± 34.4). For VJ there was a significant decrease of 3.8% from PRS to MS (23.5 ± 3.4 to 22.6 ± 3.4), but no additional change to PSTS (22.7 ± 3.3). The results of this study indicate maintenance of PRS strength and power levels requires more duration or higher intensity conditioning than provided in this program. Since this may not be a viable option for many coaches, an alternative is to focus on maximizing performance gains in the off-season in anticipation of the in-season decrease. Additionally, in this study, the largest absolute and relative decreases were observed during the first half of the season. Sport coaches should be aware that focusing on skills and execution while reducing conditioning time during early season practices may contribute to particularly rapid decreases in strength.

Bar Velocity As an Indicator of Relative Training Intensity in Olympic Weightlifters

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PURPOSE/OBJECTIVE: Coaches and athletes are searching for methods to ensure an appropriate intensity of training without inducing overtraining. Measurements studied have included testosterone/cortisol ratio (T/C ratio), glutamine/glutamate ratio, and psychological profiles. It is generally accepted that there is a velocity-specific training effect—greater strength gains are seen when the subject trains at speeds similar to the

speed of testing and/or performance. Our laboratory utilized a VS-120 Weightlifting Analysis System (V-scope) to attempt to identify if a relationship exists between velocity of movement, relative intensity of training, and T/C ratio, a known indicator of overtraining, while training for competitive weightlifting. PROCEDURE: The study population was randomly divided into either a CON group (n = 26) or a treatment group (TP). Peak bar velocity increased from T1 (97.0 ± 5.3 cm) to T2 (137.3 ± 5.7 cm) to T3 (181.6 ± 6.0 cm) to T4 (185.5 ± 5.8 cm) in the CON group (n = 26) and T1 (126.9 ± 5.6 cm) to T2 (162.8 ± 7.3 cm) to T3 (167.9 ± 5.6 cm) to T4 (171.2 ± 6.2 cm) in the TP group. The change in the CON group was not significant (p = 0.33). T1 and T2 differed with a significant increase at T2 (p = 0.001). However, T3 and T4 differed only with T4 being significantly higher than T3 (p = 0.001). The peak bar velocity increased between T2 and T4 in the TP group. The change in the TP group was significant only (p = 0.007). The results indicate that a velocity-specific training effect is seen.

Introduction: Previous research has demonstrated the benefits of preconditioning to enhance athletic performance and prevent injury. Purpose: The purpose of this study was to determine the effects of an 8-week pre-season conditioning program on power output, muscular endurance, agility, and flexibility in female adolescent soccer players. Methods: 11 female soccer players (age 16.5 ± 0.5 yr, W = 58 ± 1 kg, H = 167 ± 5 cm) participated in an 8-wk periodized strength and conditioning program. Training consisted of two 4-wk blocks. Block 1 focused on strength and power by combining weight training, plyometrics, and agility training. Block 2 focused on power endurance by employing interval weight training as outlined by O'Shea. Each subject was tested pre- and post-training on the following measures: push-ups, sit-ups, pull-ups, sit-n-reach test, vertical jump, agility T-test, and agility line test. Data was analyzed using paired 2-tailed T-tests. Results: Following 8-wks of training significant improvements were observed in: push-ups (41% chg, p = 0.000), sit-ups (31% chg, p = 0.000), sit-n-reach jump (46% chg, p = 0.002), vertical jump (10% chg, p = 0.000), T-test (8% chg, p = 0.000), and line test (7% chg, p = 0.001). Conclusions: Pre-season strength and conditioning as used in this study enhanced power output, agility, muscular endurance and flexibility in female adolescent soccer players. Practical Applications: Appropriately designed and supervised pre-season strength and conditioning programs can be an effective method to increase skills related to athletic performance in young women.

Neuromuscular and Hormonal Changes Following 6 Months of Periodized Heavy-Resistance Training in Women


The purpose of this investigation was to examine changes in muscular strength, power, and hypertrophy in different muscles of the upper arm and thigh to different periodized resistance training programs in women. Ninety untrained women were randomly placed into either a total-body strength/power (TP), hypertrophy (TH), upper-body strength/power (UP), or control (CON) group. Heavy-resistance training was performed on three alternating days per week for 24 weeks. Anthropometry, muscular performance, magnetic resonance imaging (MRI) cross-sectional area (CSA) of all of the arm and thigh muscles, and hormonal concentrations were determined pre-training (T1), and following 12 (T2) and 24 (T3) weeks of training. No standardized changes were observed in a CON group (n = 6). Magnetic resonance imaging showed that arm CSA significantly (p ≤ 0.05) increased at T2 and T3 in all training groups whereas thigh CSA increased at T2 and T3 only in TP and TH. In addition differential resistive force of muscles within the thigh and arm were affected by different resistance exercise protocols. Squat one-repetition maximum (1RM) increased at T2 and T3 only in TP and TH whereas all training groups increased 1RM bench press at T2 and T3. Peak power produced during loaded jump squats increased from T1 to T3 only in TP and TH. Peak power during the squat jump increased from T2 only in TP but increased from T1 to T3 in all training groups. Serum testosterone increased following an acute bout of resistance exercise in TP, UP and TH whereas resting testosterone concentrations increased mostly for TP and UP. These results indicate continual increases in strength, power, and hypertrophy with periodized resistance training in women and program
The Activation of the Biceps Brachii and Brachioradialis Muscles During Elbow Flexion Using the Straight and EZ-Curl Bars

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In the fitness world, a great deal of emphasis is placed on the muscularity and definition of the upper arms. During resistance training, individuals utilize both the straight and EZ-curl bars while performing elbow flexion exercises. However, it is unknown the extent to which these bars affect the level of activation present in the biceps brachii and brachioradialis as well as their relative time to peak activation in the exercise. Thirty-four subjects (age 20.9 ± 2.2 years; weight 82.5 ± 10.7 kg; experience 3.2 ± 2.2 years; and lifting frequency 3.6 ± 0.9 workouts/week) performed a straight bar and EZ-curl bar 5-repetition maximum in one testing session, with 15 minutes rest between sets. Electromyographic activity of the biceps brachii and brachioradialis was measured with Coulbourn Instruments bioamplifiers at 2000 Hz. Concentric and eccentric phases were indicated with a momentary delay switch. Data were rectified and integrated over 100 msec time intervals using DATAPAC 2000 software. Peak and mean activation levels were analyzed for the middle three repetitions for each muscle and each exercise. Thirty-four subjects (age 20.9 ± 1.7 years; weight 82.5 ± 10.7 kg; experience 3.2 ± 2.2 years; and lifting frequency 3.6 ± 0.9 workouts/week) performed a straight bar and EZ-curl bar 5-repetition maximum in one testing session, with 15 minutes rest between sets. Electromyographic activity of the biceps brachii and brachioradialis was measured with Coulbourn Instruments bioamplifiers at 2000 Hz. Concentric and eccentric phases were indicated with a momentary delay switch. Data were rectified and integrated over 100 msec time intervals using DATAPAC 2000 software. Peak and mean activation levels were analyzed for the middle three repetitions for each muscle and each exercise. Thirty-four subjects (age 20.9 ± 1.7 years; weight 82.5 ± 10.7 kg; experience 3.2 ± 2.2 years; and lifting frequency 3.6 ± 0.9 workouts/week) performed a straight bar and EZ-curl bar 5-repetition maximum in one testing session, with 15 minutes rest between sets. Electromyographic activity of the biceps brachii and brachioradialis was measured with Coulbourn Instruments bioamplifiers at 2000 Hz. Concentric and eccentric phases were indicated with a momentary delay switch. Data were rectified and integrated over 100 msec time intervals using DATAPAC 2000 software. Peak and mean activation levels were analyzed for the middle three repetitions for each muscle and each exercise. Thirty-four subjects (age 20.9 ± 1.7 years; weight 82.5 ± 10.7 kg; experience 3.2 ± 2.2 years; and lifting frequency 3.6 ± 0.9 workouts/week) performed a straight bar and EZ-curl bar 5-repetition maximum in one testing session, with 15 minutes rest between sets. Electromyographic activity of the biceps brachii and brachioradialis was measured with Coulbourn Instruments bioamplifiers at 2000 Hz. Concentric and eccentric phases were indicated with a momentary delay switch. Data were rectified and integrated over 100 msec time intervals using DATAPAC 2000 software. Peak and mean activation levels were analyzed for the middle three repetitions for each muscle and each exercise. Thirty-four subjects (age 20.9 ± 1.7 years; weight 82.5 ± 10.7 kg; experience 3.2 ± 2.2 years; and lifting frequency 3.6 ± 0.9 workouts/week) performed a straight bar and EZ-curl bar 5-repetition maximum in one testing session, with 15 minutes rest between sets. Electromyographic activity of the biceps brachii and brachioradialis was measured with Coulbourn Instruments bioamplifiers at 2000 Hz. Concentric and eccentric phases were indicated with a momentary delay switch. Data were rectified and integrated over 100 msec time intervals using DATAPAC 2000 software. Peak and mean activation levels were analyzed for the middle three repetitions for each muscle and each exercise. Thirty-four subjects (age 20.9 ± 1.7 years; weight 82.5 ± 10.7 kg; experience 3.2 ± 2.2 years; and lifting frequency 3.6 ± 0.9 workouts/week) performed a straight bar and EZ-curl ba...
should be taken when selecting a technique for assessing body composition in college football players.

Evaluation of Gender Differences in Strength and Power for High School Athletes Using Allometric Scaling

D. Martin, L. Coogre, C. Thompson, K. Thompson, and J.L. Mayhue. Kirksville College of Osteopathic Medicine, Kirksville, MO and Truman State University, Kirksville, MO.

The purpose of this study was to compare strength and power performances of adolescent males and females based on allometric scaling. Boys (n = 114) and girls (n = 107) were measured for total isometric grip strength (right = left hand), 4-kg seated shot put (SSP), vertical jump power (VJP), and 20-yd dash (R20). Lean body mass (LBM) was derived from gender-specific generalized skinfold prediction equations. The slopes of the relationships between BM and performance variables for the genders were evaluated using a multiple log-linear regression model and were all significantly different except for VJP. All the slopes for the relationships between LBM and performance variables were also significant. Using scaled ratios (Performance/BMP), male athletes had approximately 1.34 and 1.13 times greater performance ability in upper body tasks than female athletes after the influence of BM and LBM, respectively, were controlled but only a 1.11 and 0.96 times greater performance ability in lower body tasks. The major gender difference in performance in high school athletes appears to be in upper body tasks of strength and power which could be due to distribution differences of muscle mass. However, performance differences could also be due to a lack of muscular development in the upper body of females. Therefore, these results may lend support to the need for upper body resistance training for female athletes.

Use of Multiple Loads to Predict 1-RM Bench Press in College Football Players

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The purpose of this study was to evaluate the effectiveness of using multiple sub-maximal loads and repetitions-to-fatigue (RTF) to predict 1-RM bench press in college football players. Players (n = 122) from two NCAA Division II teams were tested for RTF in the 3-5-RM and 7-10-RM range one week following a 1-RM test at the conclusion of 10 weeks of a winter heavy resistance training program. All prediction equations significantly underestimated actual 1-RM by 2-3%. The Brzycki equation using the 3-5-RM had the greatest percent of predicted 1-RM within ±5.45 kg (%±3) of the actual 1-RM. Therefore, the two-load method does not appear to provide lower errors in prediction than a single-load estimate in the 3-5-RM range, and the Brzycki equation appears to offer the greater accuracy of prediction.

\[
\text{Predicted 1-RM} = \frac{0.6425 \times \text{Load}}{0.9744 - \frac{\text{Load}}{5.000}}
\]

\[
\%\text{Error} = \left| \frac{\text{Actual 1-RM} - \text{Predicted 1-RM}}{\text{Actual 1-RM}} \right| \times 100
\]

The Effect of Antagonist Pre-fatigue on Agonist Torque and Electromyography

J. Maynard and W.P. Ebben. Department of Physical Therapy, Program in Exercise Science, Marquette University, Milwaukee, WI.

This study assessed the effects of hamstring pre-fatiguing on peak torque, peak power, time to peak torque, knee angle of peak torque, and EMG activity of the quadriceps group during knee extensions at angular velocities of 60, 180, and 300 degrees · sec⁻¹. Twenty Division I footballers performed five maximal knee extensions in pre-fatigued and non-fatigued conditions of the hamstring group. This study demonstrated that when the hamstrings were pre-fatigued, the quadriceps produced a significant decrease in peak torque of 1.7% (p < 0.05), peak power of 11% (p < 0.05), and rate to peak torque of 6.4% (p < 0.01). When the hamstrings were pre-fatigued, they produced a 25% greater amount of EMG activity during knee extension (p < 0.01) when compared to the non-fatigued state. When the hamstrings were pre-fatigued, they produced a significant difference in quadriceps EMG activity whether the hamstring group was pre-fatigued or not (p < 0.05). The difference in quadriceps average peak torque between the non-fatigued and pre-fatigued groups was greater (p < 0.01) at an angular velocity of 60 degrees · sec⁻¹ than at 180 or 300 degrees · sec⁻¹. In other words, pre-fatiguings the antagonist appears to be most detrimental to torque output of the quadriceps in the condition that most closely replicates the speed at which isotonic weightlifting occurs (60 degrees · second) and suggests a limitation to agonist-antagonist superimposed training.

Strength Increased in Distance Runners with Minimal Changes in Body Composition: Effect on Lactate Accumulation

J.M. McBride, M. Abel, and T. Triplett-McBride. Musculoskeletal Research Center, University of Wisconsin—La Crosse, La Crosse, WI.

The purpose of this investigation was to determine the effect of heavy resistance training on muscle strength and mass and its possible relationship to lactate accumulation during aerobic exercise. Endurance running is associated with minimal body mass and mass-specific power. However, it has been demonstrated by several recent investigations that resistance training may improve performance in distance events. To investigate this concept eight endurance athletes (HRT) were trained with heavy resistance exercises for a period of seven weeks. Seven endurance athletes served as controls (C). Body composition before (Pre) and after (Post) the training was determined by dual-energy absorptiometry (DEXA). Maximal dynamic strength (1RM) was assessed in a six-week squat and bench press. Lactate threshold was determined by using a maximal VO₂ protocol (2.5 grade increase every two minutes) with lactate measurements obtained from a finger stick at defined intervals. The results indicated no significant changes (p > 0.05) in average mass (Pre = 74.85 ± 7.61 kg, Post = 76.43 ± 6.87 kg), fat mass (Pre = 63.28 ± 5.67 kg, Post = 64.21 ± 5.31 kg) or lower body fat free mass (Pre = 21.58 ± 2.19 kg, Post = 22.07 ± 1.90 kg). However, the IRM in the squat (Pre = 116.23 ± 17.43 kg, Post = 127.92 ± 20.61 kg) and bench press (Pre = 100.35 ± 15.99 kg, Post = 104.22 ± 13.15 kg) significantly increased. Lactate accumulation was significantly lower at exercise grade 6 (12.5) after heavy resistance training (Pre = 11.63 ± 1.91 mmol/L, Post = 8.96 ± 3.24 mmol/L). The data from this investigation indicate significant changes in strength can be accompanied by minimal changes in body composition in endurance athletes after ten weeks of heavy resistance training. In addition, these changes in strength may be associated with significant decreases in lactate accumulation at high aerobic workloads.

The National Football League Combine: A Reliable Predictor of Draft Status

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Three hundred twenty-six college football players who participated in the National Football League (NFL) combine were studied to determine if a relationship exists between various performance measurements and the level of draft success. The football players were separated into seven position categories: Quarterbacks (QB), Running Backs (RB), Wide Receivers (WR), Offensive Linemen (OL), Defensive Linemen (DL), Defensive Ends (DE), and Linebackers (LB). The combine consisted of each football player's height and weight as well as nine performance measurement tests. The combine performance measurements consisted of a 225-lb bench press test (REP), 10-yard dash (10Y), 20-yard dash (20Y), 40-yard dash (40Y), 20-yard "pro-agility" shuttle (20S), 60-yard shuttle (60S), the cone drill test (3C), broad jump (BJ), and vertical jump (VJ). Combine scores were used from drafted athletes to determine if a relationship exists between results of the combine performance measurements and the round in which the athlete was drafted. A Pearson correlation of coefficients determined that six of the nine performance measurement tests were found highly correlated (r≥0.85): 10Y, 20Y, 40Y, 20S, BJ, and VJ. The remaining three tests: REP, 3C, and 60S were unique in skills measured. Regression equations were calculated to predict draft round using the performance measurement results for the seven position groups with varying degrees of accuracy (QB: r = 0.84, OL: r = 0.90, DL: r = 0.90, WR: r = 1.00, RB: r = 1.00, LB: r = 0.22). The final analysis was a 2 × 11 repeated measures ANOVA using the performance measurement results from the first two draft rounds (1 & 2) and the last two rounds (6 & 7). The mean scores of the performance measurements for the athletes drafted in rounds one and two reflected the athletes were taller, heavier, faster, and could jump both higher and farther compared to the mean scores of the athletes drafted in the sixth and seventh rounds. Significant differences were seen in the performance measurements between the first two rounds compared to the last two rounds in the broad jump, vertical jump, and the three-cone drill (p < 0.05).

The Effects of Simultaneous Training on Muscular Strength and Aerobic Power

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The purpose of this investigation was to examine the effects of simultaneous (same moment), high-intensity, aerobic and resistance exercise on aerobic power and muscular strength. Free-weight 1RM elbow flexor strength and maximal aerobic power (VO₂max) were assessed for 15 untrained subjects. All tests were performed prior to and following a six-week training program. Subjects were randomly assigned to three training groups: an aerobic-training group, a strength-training group, and a simultaneous-training group. All training was performed three times per week. Aerobic training consisted of five, three-minute bouts of high-intensity exercise performed on an ergometer at 90% of VO₂max. Training intervals were separated by three minutes of rest. The first interval was performed at 50–60% of the subjects’ VO₂max, the second at 70–80%, the third at 80–90%, and the final two bouts at 90–100% VO₂max. Strength training consisted of performing the arm-flexion exercise on a commercial lat-dumbbell. The strength training protocol consisted of performing four working sets of exercise per session separated by three minutes of rest. The first two weeks of training consisted of four sets of 10RM, the third week at 8RM, the fourth at 6RM, the fifth at 4RM, and the sixth at 2RM. The simultaneous training group performed both the
aerobic and strength training protocols simultaneously. The aerobic and simultaneous groups significantly ($p < 0.05$) increased aerobic power $33.5 \pm 6.8$ and $36.2 \pm 7.7$ to $42.3 \pm 5.4 \times kg^{-1} \times min^{-1}$, respectively. There was no significant difference in aerobic power increase between the aerobic and simultaneous groups. The strength and simultaneous training groups significantly ($p < 0.05$) increased 1RM strength $11.3 \pm 5.1$ to $16.7 \pm 5.0$ and $13.7 \pm 5.1$ to $17.6 \pm 6.1$ kg, respectively. There was no significant strength difference between the strength and simultaneous training groups. In addition, simultaneous cycle ergometry training and one-arm, free-weight, strength training can be effectively utilized to increase maximal aerobic power and dynamic elbow-flexor strength. This study shows that the concept of simultaneous, high-intensity, aerobic and strength training is viable and that this approach to training may perhaps become an option for athletes and non-athletes.

### Comparison of Sports Drinks on Substrate Oxidation During Exercise

**R.W. Mendel, L. Lowery, T. Mick, and T.N. Ziegienfu. Phoenix Labs—Division of Nutrition, Metabolism & Exercise, Kent State University, Human Nutrition Lab, Kent, OH, 1Cleveland Clinic Foundation, Cleveland, Ohio.**

**Introduction:** Many individuals who exercise for fat loss ingest some type of liquid prior to and during the training bout. **Objective:** The purpose of this study was to clarify the difference in substrate utilization and net caloric expenditure between water (W), a popular carbohydrate containing sport drink (Powerade, PA) and a non-carbohydrate drink (AQ). Many individuals who exercise for fat loss ingest some type of liquid prior to and during the training bout. **Objective:** The purpose of this study was to clarify the difference in substrate utilization and net caloric expenditure between water (W), a popular carbohydrate containing sport drink (Powerade, PA) and a non-carbohydrate drink (AQ). Serum samples obtained prior to (±30 and 0) and during (15, 30, 45, and 60 min) the bicycle ride were analyzed for glucose, insulin, FFA and glycerol (data pending). Indirect calorimetry was used to calculate substrate oxidation from steady-state respiratory exchange ratios. Six timeframes were analyzed via RM ANOVA: (30 to 15 (Rest 1), 15 to 0 (Rest 2), 0-15 (T1), 15-30 (T2), 30-45 (T3), and 45-60 (T4). Results: Prior to each treatment, RMR was no different between conditions. During R1 and R2 a statistically significant condition by time interaction was found ($p < 0.05$). Specifically, the oxidized fluid mixture (%Fat%Solid ratio) for AQ, W, and PA were 82:18, 85:15, and 59:41 (R1) and 91:9, 91:9, and 57:43 (R2), respectively. During the exercise bout, fat oxidation for the AQ and W trials was 20% and 17% higher than PA (T1), 14% and 9.5% higher than PA (T2), 14% and 7% higher than PA (T3), and 11% and 5% higher than PA (T4). Conclusion: These data suggest that non-carbohydrate drinks like AQ or W promote greater fat oxidation during exercise. **Practical Applications:** Compared to PA, ingestion of AQ or W led to a 4-fold increase in net caloric expenditure (500 vs. 120 kcal)—an important consideration for individuals attempting to decrease fat mass. Supported in part by a research grant from Phoenix Labs, Inc. (Hicksville, NY).

### Comparisons of Fatigue Thresholds During Cycle Ergometry


A number of techniques, which measure a variety of physiological parameters, have been proposed for identifying the threshold of fatigue during cycle ergometry. The purpose of the present study was to compare the fatigue thresholds corresponding to the determinations of heart rate (the physical working capacity at the heart rate threshold; PWCHRT), muscle activation (the electromyographic fatigue threshold; EMGFT), and ventilatory responses (the ventilatory threshold; VT). Ten adult male volunteers (mean age $\pm SD = 22 \pm 2$ years) performed an incremental (30 W increase every 2 minutes) test to exhaustion on an electronically braked ergometer for the determination of VO2max and ventilatory threshold (VT). Standard open circuit spiroometry (Parvo Medics metabolic cart) was used to collect and analyze expired gas samples. The subjects also performed four randomly ordered eight-minute work bouts at different power outputs ranging from 65 to 255 W) for the determination of PWCHRT and EMGFT. Heart rate values were monitored using a Polar Heart Watch System and EMG data was collected using 256 bipolar surface electrode arrangements on the vastus lateralis muscle. A one-way repeated measure ANOVA indicated that there were no significant ($p > 0.05$) differences among the PWCHRT (mean $\pm SD = 80 \pm 24$ W), EMGFT (109 $\pm 33$ W), and VT (100 $\pm 39$ W). The results of this study indicated that there were similarities among fatigue thresholds determined from heart rate, oxygen consumption, and muscle activation procedures during cycle ergometry. These findings suggested an integration among central and peripheral factors with regard to the onset of fatigue during cycle ergometry.

### Heavy Elastic Bands Alter Force, Velocity, and Power Output During Back Squat Lift

**R.U. Newton, M. Robertson, E. Dugan, C. Hassen, J. Cecil, A. Gerber, J. Hill, and L. Schuier. Biomechanics Laboratory, Ball State University, Muncie IN.**

The purpose of this study was to examine the effect of heavy elastic bands on the force, velocity, and power output produced during the back squat. Ten male collegiate powerlifters were recruited. After 6RM squat weight was determined for each lifter, three conditions were evaluated. For the no bands (NB) condition the load was provided by the 6RM weight of the barbell alone. For the bands top (BT) condition, the elastic bands were placed around the barbell, and using the reactive mode for the reactive condition, the loaded band was placed in the parallel squat position. The subjects completed a series of lifts under each condition and force, velocity and power output were calculated and averaged over every 10% of concentric bar movement. No difference in force, power or velocity was observed between the NB and BB conditions. However, force during BT was lower for the initial 80% of the concentric movement by up to 0.503BW and 0.849BW for the NB and BB conditions respectively. Bar velocity was significantly higher for the BT condition for initial 50% of the concentric movement by up to 0.209 and 0.259ms for the NB and BB conditions respectively. Power output was significantly different between the BB and NB conditions at any point in the lift. It was higher for the first 50% of the lift for the BT compared to the BB conditions by between 0.37 and 0.72 W/kg. The use of elastic bands during squats clearly altering the force, velocity and power output with the greatest differences being when the weight on the barbell is adjusted as in the BT condition. Specifically, this allowed the lifter to produce greater velocity and power over the lower phase of the lift. This substantiates the anecdotal evidence that use of the bands permits the lifter to explode more out of the bottom without being inhibited by having to slow the bar at the top of the lift because the increasing tension in the bands achieves this. Such a technique has practical relevance because it modifies the traditional squat exercise possibly for greater transfer- ence to increasing vertical jump and ballistic performance.

### A Comparison Between Passive and Reactive Eccentric Peak Torques

**G.J. Neffelt, R. Kerrey, and M. Zahorski. Movement Analysis Laboratory, California State University, Fullerton, Fullerton, CA.**

The recent advances in isokinetic dynamometry have facilitated eccentric testing of many joints at a variety of speeds. The Biodex isokinetic dynamometer offers two protocols or modes for collecting eccentric data. The purpose of this study was to compare eccentric peak torques derived from passive versus reactive isokinetic protocols. Twenty-eight subjects (4 females $24.5 \pm 4.4$ years, $158.8 \pm 6.1$ cm, $63.2 \pm 12.3$ kg, 24 males $23.8 \pm 5.6$ years, $176.8 \pm 7.9$ cm, $81.6 \pm 15.0$ kg) signed a consent form and warmed-up on an upper body ergometer prior to the testing session. The testing session consisted of placing the subject in a supine position, with 90° of shoulder ab- duction, as well as 90° of elbow flexion, and stabilizing the wrist and trunk with straps to eliminate force contributions from these segments. The subjects were then instructed to exert maximal efforts over a range of 120° where the dominant shoulder joint was taken from an internally rotated position (60') through an externally rotated position (60'). Therefore the shoulder internal rotators were being eccentrically taxed for a total of 5 repetitions. Eccentric measures were determined at 180°/sec using the Biodex iso- kinetic dynamometer (Biodex Corp. Shirley, NY) in the passive and reactive modes. Subjects were given standardized verbal instructions ("Resist the movement of the handle as hard as and as smoothly as possible throughout the entire range of motion") for the passive mode, and "push against the handle continuously throughout the entire range of motion" for the reactive mode) prior to commencing the test, and no visual feedback was allowed during the testing procedure. Peak torque values were extracted from torque curves once these were both filtered and windowed. A dependent t-test revealed passive internal eccentric peak torques (mean $\pm SD = 61.7 \pm 9.8$ Nm) were not statistically different from reactive internal eccentric peak torques (mean $\pm SD = 59.4 \pm 9.8$ Nm). These results suggested the inter-relationship of the shoulder is capable of producing similar peak torque values irrespective of the mode utilized. Theses finding will allow investigators to choose the passive mode over the reactive mode. Passive mode advantages may include: greater patient comfort, an apparent greater ease of force production, higher isokinetic speeds are always achieved, and subjects are required to complete a full range of motion.

### Allometric Scaling of Isometric Strength Tests in College Males and Females and Their Relationship to Somatotype

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The purpose of this study was to evaluate the differences in strength parameters in college men and women using an allometric scaling approach and to determine if size-independent values were related to somatotype components. Untrained men ($N = 328$) and women ($N = 358$) were measured for right and left grip strength, back lift strength (BS), and leg strength (LS) using a Stoelting grip dynamometer and a Chilillon back-and-leg dynamometer. Grip strength (GS) was represented by the sum of right and left grip, and total strength (TST) was the sum of all four measures. Body composition (BFat and BM) was determined from popliteal site skinfold thickness using prediction equations, and somatotype was determined using the Heath-Carter method. A multiple, log-linear regression model was used to determine the commonality of slope for the relationship between BM and each strength measure and produced nonsignificant ($p > 0.05$) gender x BM interaction terms for all measures except for BS. BM ranged from 0.43 for GS to 0.66 for BS. The male:female strength ratio corrected for BM differences ranged from 1.30 for GS to 1.82 for BS, with the average male being 1.60 times stronger in isometric measures than the average female. The male:female strength ratio for LB ranged from 1.15 for GS to 1.57 for BS, with the average male

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Run times were increasingly negatively correlated with body weight in both genders, noted significantly decreasing velocity at each increment, approaching zero at 40 yds. to have significantly greater velocities than females at each increment. A second ANOVA values (on a Plyometric Power System using 30% of 1RMSQ. Men had significantly greater and PP were measured by having the subjects perform a countermovement squat jump on a Phymetric Power System using 50% of 1RMSQ. Men had significantly greater values (p < 0.01) in the VJ (63.12 ± 21.1 to 42.12 ± 6.93 cm), AVJ (74.93 ± 3.8 to 45.85 ± 7.0 cm), LBM (82.3 ± 6.7 to 56.6 ± 7.4 kg), IRMSQ (133.8 ± 23.7 to 84.2 ± 12.9 kg), PF (2274 ± 203 to 1625 ± 239 N), and PP (3537 ± 448 to 2064 ± 297 W). Men also had a significantly faster 5-rep squat time (p < 0.05) than women (5.81 ± 0.82 to 6.64 ± 0.71 s). Values for PF/LBM, PP/LBM, and IRMSQ/LBM were significantly different (p < 0.01) between men (AVJ only in men and women only in PF/LBM). When holding LBM and IRMSQ constant, ANCOVA values showed no significant difference (F = 1.29, p > 0.28) in PP between genders, but still showed a significant difference in VJ (F = 11.01, p < 0.005) and AVJ (F = 20.66, p < 0.001). Results of this study tend to indicate that LBM and absolute strength are the major factors in power output differences between genders, but other variables (i.e., skill, coordination, etc.) may play contributory roles in jumping performance differences between male and female athletes.

Comparison of 40-Yd Dash Characteristics in Male and Female Adolescent Athletes

F.C. Piper, D. Martin, L. Gugliott, C. Thompson, and J.L. Mayhew. Truman State University, Kirksville, MO, and Kirksville College of Osteopathic Medicine, Kirksville, MO.

The purpose of this study was to compare the acceleration characteristics of male and female adolescent athletes during the 40-yd dash. Male (n = 73, age = 15.2 ± 1.2 y) and female (n = 66, age = 14.8 ± 1.5 y) members of high school athletic teams were evaluated for two 40-yd dash performances timed in 10-yd increments using infrared photocells attached to digital timers. The average of the two trials was used for analysis. The sprints were performed on an indoor synthetic track in the Spring following various lengths and types of training. Intracorrelation coefficients indicated that reliability increased at each increment (10-yd, r = 0.89, 20-yd, r = 0.95, 30-yd, r = 0.95, 40-yd, r = 0.98). A gender × velocity (2 × 4) repeated measures ANOVA revealed males to have significantly greater velocities than females at each increment. A second ANOVA noted significantly decreasing velocity at each increment, approaching zero at 40 yds. Run times were increasingly negatively correlated with body weight in both genders, reaching significance at 30 and 40 yds (r > 0.25).

Males accelerate faster, reach higher velocities, and maintain greater acceleration than females.

The Effect of Position on Knee Acceleration During an Isokinetic Fatigability Test


Acceleration (ACC) is the essence of kinetics given that it is solely responsible for determining the range of motion spent under constant velocity. Manipulating subject position has been shown to produce differences in ACC and torque production characteristics during standardized testing due to length-tension and neurophysiological changes. However, it is unclear if manipulating subject position in muscle fatigability assessments affect ACC. Thus, the purpose of this investigation was to determine if ACC is position-dependent during an isokinetic knee extension fatigability test. Fourteen subjects (5 male, 9 female, age 28.1 ± 7.3 y, ht 167.7 ± 8.3 cm, wt 65.9 ± 13.0 kg) performed 50 repetitions of isokinetic concentric knee extension/flexion exercise in the seated, supine and prone positions at 180 d/s. Testing order was randomized with 3–5 days rest between trials. ACC for each repetition was measured and the mean for 5 repetition intervals was recorded. Data analysis using *tests indicated significant differences (p < 0.05) as indicated in the table (Mean ± SEM). The results of this investigation appear to indicate that dissimilar ACC fatigue patterns result from altering subject position. Therefore, specificity of athletic performance should be considered when determining testing position.

<table>
<thead>
<tr>
<th>Repetitions</th>
<th>Seated</th>
<th>Supine</th>
<th>Prone</th>
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<tbody>
<tr>
<td>0–5</td>
<td>4.61 ± 0.51</td>
<td>4.17 ± 0.78</td>
<td>5.08* ± 0.42</td>
</tr>
<tr>
<td>6–10</td>
<td>4.04 ± 0.31</td>
<td>3.94 ± 0.17</td>
<td>5.02* ± 0.41</td>
</tr>
<tr>
<td>11–15</td>
<td>4.15 ± 0.18</td>
<td>5.25 ± 0.09</td>
<td>4.80 ± 0.20</td>
</tr>
<tr>
<td>16–20</td>
<td>5.19 ± 0.28</td>
<td>4.72 ± 0.14</td>
<td>5.09 ± 0.07</td>
</tr>
<tr>
<td>21–25</td>
<td>5.81 ± 0.21</td>
<td>5.74 ± 0.21</td>
<td>5.48 ± 0.28</td>
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<tr>
<td>26–30</td>
<td>6.40 ± 0.21</td>
<td>6.45 ± 0.17</td>
<td>6.02 ± 0.19</td>
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<tr>
<td>31–35</td>
<td>6.53 ± 0.34</td>
<td>6.71 ± 0.30</td>
<td>6.42 ± 0.24</td>
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<tr>
<td>36–40</td>
<td>7.57 ± 0.71</td>
<td>7.09 ± 0.14</td>
<td>6.57 ± 0.29</td>
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<tr>
<td>41–45</td>
<td>7.78 ± 0.33</td>
<td>7.558 ± 0.13</td>
<td>6.94 ± 0.14</td>
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<tr>
<td>46–50</td>
<td>8.11* ± 0.79</td>
<td>8.20* ± 0.33</td>
<td>8.69 ± 0.36</td>
</tr>
</tbody>
</table>

* Significantly greater (p < 0.05) than supine. † Significantly greater (p < 0.05) than seated. # Significantly greater (p < 0.05) than prone.

A Meta-Analysis of Research on the Periodization of Strength Training

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The periodization of strength training has become widely accepted as the most effective method of organizing training intensity and volume to prevent overtraining and optimize performance. However, the most effective approach to periodization is equivocal. This is problematic in that no single program could be considered the optimal approach to periodization, and likewise it is difficult to identify clearly, inferior approaches to periodization. The purpose of the present study was to use both a qualitative and quantitative meta-analytical approach to previous research in order to determine the effectiveness of the reported approaches to periodized strength training. Following a comprehensive literature search of research studies investigating the effects of a periodized strength training program, only twenty-two (N = 22) studies met the inclusion/exclusion criteria of this research paper and were included in further analyses. A qualitative meta-analysis was performed by evaluating the acceptability and appropriateness of the research methodology and the reported outcomes. The quantitative meta-analysis was conducted using effect sizes calculated for three dependent measures 1-RM Bench Press (BP), 1-RM Squat (SQ), and Vertical Jump (VJ), and both trained and untrained levels of training experience. The qualitative meta-analysis revealed that only four of the 22 studies included in the meta-analysis reported sample sizes of greater than 20 subjects. Further, only 12 of the research studies, included in this study, examined the changes in strength in individuals with greater than one year of strength training experience. The quantitative meta-analysis revealed no statistically significant differences between studies for changes in strength based on a 1-RM BP or 1-RM SQ test, in both trained and untrained subjects. One study was found to have a significantly greater increase in VJ with trained subjects when compared to similar studies. Based on the results of the qualitative meta-analysis, it is clear that more attention to research methodology, including sample size and level of training experience, is required. Given that the results of the quantitative meta-analysis did not differentiate between superior and inferior approaches to periodization, further research comparing the effects of different approaches to periodization on changes in strength is necessary.

The Dose-Response Relationship for Strength Development: Volume, Intensity, and Frequency of Training

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A dose-response relationship between volume, intensity, and frequency of resistance training and the amount of strength increases elicited has been somewhat elusive. For many years, strength professionals have relied on relatively little research concerning this dose-response for program design. The research that has been done has often been performed using small sample sizes and involving low statistical power which increases the chance of misleading results. However, by using statistical techniques such as the effect size (ES), this body of research can be systematically combined in order to examine....
trends in treatment effects. This analysis was performed to identify these trends and a dose-response relationship. A total of 529 ESs were calculated. ESs demonstrated different responses based on training status of the participants. Untrained individuals exhibited maximal strength gains by training 3 days per week at an average of 60% of 1 RM. However, performing 4 sets at 80% of 1 RM only 2 days per week elicited the greatest treatment effects in trained individuals. Untrained individuals respond to less volume and intensity more so than trained individuals with a gradual decline in the magnitude of treatment effects as the level of training increases.

3-Week Unloading Cycle In-Season Increases Vertical Jump of Collegiate Women Volleyball Players

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It is often difficult to optimize strength qualities in-season due to the conflicting influences of extensive skill practices combined with frequent game play of the competition schedule. PURPOSE: The purpose of this study was to investigate the effects of a 3-week period of unloaded training performed late in the season on jumping ability and explosiveness. METHODS: Nine women volleyball players competing in NCAA Division I were tested before and after three weeks of an in-season training program with emphasis on unloading or assisted jumping. Large rubber cords attached to the ceiling and by a padded harness to the athlete were adjusted in tension such that the body weight was reduced to 50%. Subjects were instructed to perform vertical jump for maximum height for 2–3 times per week, performing six sets of six repetitions with 30 seconds rest between sets. Vertical jump testing was performed using both a squat jump (SJ) and countermovement jump (CMJ) on a force plate. Concurrent strength training was also utilized to help maintain strength levels. RESULTS: In the CMJ, there was a significant increase in both peak power output and peak velocity. Peak power increased from 3961±4852 watts (18.3%), while peak velocity increased from 2.85±3.3 m/s (13.7%). SJ performance significantly increased in both peak force (163±163 N) and maximum height (0.333–0.373 cm). Throughout training, there were no decreases in maximal strength levels, as determined by a dynamic squat test, or post-test Vertec jump and reach, which were insignificantly increased from those recorded earlier in the season. CONCLUSIONS: This study indicates that unloading training can improve the explosive qualities of athletes when used as a peaking cycle late in season. Athletes maintained dynamic strength and jumping ability from pre-testing scores, while significantly increasing both peak power and velocity in the CMJ. This kind of training could be undertaken by any athletes who jump frequently (volleyball, basketball, etc.), to help maintain jump- ing height while simultaneously making the jumps more explosive. Further, the lowered impact and loading during such training may reduce injury and limit overtraining at a time in the competitive season when such problems tend to occur.

Bilateral Comparison of Bar Kinematics During a Weighlifting Competition

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Twenty-two Olympic Weightlifters (age 18 ± 3.2, body mass 84 ± 14.2) participating in the Top of Texas weightlifting competition had both ends of the bar simultaneously analyzed to determine if there were asymmetries in barbell kinematics between the right and left sides of the barbell. Snatch and clean and jerk data were collected and analyzed using the 2 V-Scope Systems (Lipman Electronic Engineering Ltd., Israel). Data were collected on the following measurements: peak acceleration (PA), time to peak acceleration, peak velocity (PV), time to peak velocity, peak vertical displacement (PVD), and time to peak vertical displacement. Significant differences were determined in PVD during the snatch and when both the clean and snatch were combined. PV was significantly different during the snatch, clean, and both lifts combined. The snatch was the only lift to demonstrate significant difference in PA and PV. Time to PVD showed significant difference when both lifts were combined. Barbell trajectories (A, B, C) for the right and left side were analyzed for each lift, no significant difference were found in trajectory type between sides in all lifts. The frequencies of type C bar trajectory were the most prevalent in each lift and were as follows: snatch (right side 88.2%, left side 63.7%), clean (right side 76.9%, left side 65.4%), and combined (right side 83.3%, left side 76.7%). These findings would suggest that a single V-scope system is sufficient for quick and easy determination of barbell trajectories in competition and training.

The Effects of Combined Strength and Cardiovascular Training with Stress Management Coping Techniques in Untrained Women

1111 Emergency Call-Center Dispatchers

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The purpose of this study was to identify and improve the strength, body composition and mental stress changes elicited by 6-8 repetitions maximum (RM) at 85% intensity, or combining with cardiovascular training at 85% intensity, on the 911 women police dispatchers. Thirty-Eight 911 women police dispatchers volunteered. The subjects performed strength training 6 times per week using free weights and machine equipment. Subjects performed 6 sets at 85% of their 1RM, including thirty minutes of cardiovascular work on three days following strength-training sessions. Body composition (3 site: skinfold with calipers- Triecps, Suprailiac, Thigh) was measured at 0 and 12 weeks. Comparisons to their initial, baseline values were totalized and revealed that the average fat loss was 9.75 pounds and the average muscle gain was 3.78 pounds. The subjects improved an average of 16% in fat reduction and a 3% increase in lean muscle. Stress Test #1—Vulnerability. Baseline indicated average score was 44.1. Post-score average was 40.32, an 8.65% reduction. Stress Test #2—Responses to Stress. Baseline indicated average score was 21.3. Post-score average was 19.3, a 9.28% reduction. Stress Test #3—Hardiness (Control, Commitment, Challenge). Baseline indicated average score was 7.74. Post-score average was 8.68, a 12.24% increase. As one learns to cope with stress, one’s level of hardiness increases. Absenteeism was reduced by 6%, which indicate the subjects are less likely to become physically ill due to stress stimulation. These results suggest that daily coping stress skills coupled with combined strength and cardiovascular training protocols increase greater tolerance for mental stress, increase lean muscle tissue and reduce body fat over a 12-week period in previously untrained 911 call center women police dispatchers.

Muscle and Performance Adaptations to High-Load Resistance Exercise Overtraining


To examine the contributing physiological mechanisms to high-load resistance exercise overtraining, 16 moderately weight trained males (MEAN ± SD age = 20.2 ± 1.9 y; height = 179.7 ± 8.0 cm; weight = 77.7 ± 9.4 kg) performed 2 weeks of either a high load weight training protocol designed to induce 1 repetition maximum (1-RM) strength decrements (HL: n = 8), or a normal weight training protocol designed to maintain 1-RM strength (CON: n = 8). After 5 weeks of normal training to familiarize the subjects with the exercise device, the HL group performed 10 x 1 at 100% 1-RM load daily (high load phase) on a squat simulating machine (Tru-Squat; Southern Xercise, Cleveland, TN), while the CON group lifted 2/wk using 50%–70% 1-RM loads. Test batteries were administered before (pre) and after (post) the 2-week high load training phase. Tests included various biopsies from the vastus lateralis and were analyzed for relative myocardis heavy chain expression (%MHC) using SDS-PAGE. Performance measures included training-specific 1-RM strength, isotonic force and EMG variables during knee extension exercise, and various vertical jump parameters. The high intensity phase induced an overtraining state in the HL group based on the significant (p < 0.03) decrease in 1 RM levels on the squat machine (HL group, max 1 RM = 159.3 ± 10.1, last 1 RM = 51.4 ± 9.9; CON group, max 1 RM = 146.0 ± 12.9, last 1 RM = 144.9 ± 13.3). No changes in %MHC expression were observed for the HL group (%IIa: pre %IIa = 15.3 ± 2.5, post %IIa = 15.4 ± 2.5, p = 0.911; %IIb: pre %IIb = 58.5 ± 4.8, post %IIb = 59.0 ± 4.2, p = 0.327; pre %Ib = 26.4 ± 3.4, post %Ib = 25.4 ± 3.5, p = 0.717) or the CON group (pre %IIa = 12.1 ± 1.6, post %IIa = 12.1 ± 1.7; pre %IIb = 63.4 ± 2.7, post %IIb = 59.7 ± 3.1; pre %Ib = 24.4 ± 2.3, post %Ib = 28.3 ± 3.7). In addition, no significant changes (p > 0.05) were observed in the V-scope analysis of EMG variables, or any vertical jump variable for either group. These data suggest that the decreases in training-specific strength were not due to alterations in contractile protein expression (i.e., MHC). Furthermore, in this case high load overtraining does not affect measures of voluntary isometric and EMG characteristics and V performance.

Abstracts from the 2002 NSCA Conference 15
Fat Free Mass, Strength, and Power Changes in Division III College Wrestlers During a Competitive Season

W.D. Schmidt, C. Pienczowski, R. Vandervest, L. Marchionda, and K. Williams. Human Performance Lab, University of Wisconsin Oshkosh, Oshkosh, WI.

The purpose of this study was to investigate changes in body composition, muscular strength, and muscular power in weight cycling NCAA Division III college wrestlers throughout a competitive wrestling season. Ten wrestlers were assessed in late October, four weeks prior to the first official wrestling competition (pre-season), in late January (mid-season), and in late March (post-season) of the following year. Measurements included body weight, body composition (? site skinfold), muscular strength (power cleans, squats, and bench press), and muscular power (vertical jump and seated medicine ball throw). A repeated measures analysis of variance (ANOVA) revealed a significant main effect of time (p < 0.001) such that fat free mass (FFM) and body weight declined at mid-season compared to pre-season followed by an increase in both parameters from mid-season to post-season. A statistically significant main effect of time (p < 0.01) was also observed for all three muscular strength measures but not for the measures of muscular power. There was a correlation between FFM and strength but not between FFM and power. The data indicate that Division III college wrestlers who lose and then regain a significant amount of FFM during the course of a competitive wrestling season will experience concomitant changes in muscular strength but not in muscular power.

Physiological Predictors of Throwing Velocity and Bat Speed in Adolescent Baseball Players

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Four hundred and twenty five adolescent male baseball players (ages 15.1 ± 1.3 yrs.) were studied to determine the relationship between upper body power, lower body power, abdominal endurance, grip strength, body composition, and flexibility to throwing velocity, and bat speed. Upper body power was measured by the medicine ball toss (MBT = 21.7 ft. ± 5.6 ft.) while lower body power was measured by the vertical jump (VJ = 17.3 in. ± 5.7 in.). Abdominal endurance was measured by the 1-minute sit-up test (SU = 47.5 ± 5.7). Grip strength was measured by the handgrip dynamometer strength (GS = 35.8 kg. ± 8.4 kg.). Body composition was determined by a two-site skinfold test (SF = 25.2 ± 10.2). Flexibility was measured by the modified sit-and-reach test (F = 13.4 in. ± 3.1 in.). Throwing velocity was measured with the Jugs Radar Gun by averaging five throws from the stretch position on flat ground (63.4 mph ± 6.9 mph). Bat speed was measured with the ATEC 2000 Bat Speed Chronograph, by averaging five dry swings on a batting tee (68.5 mph ± 7.7 mph). Correlation coefficients were calculated for all variables by utilizing a correlation matrix from raw scores. Statistical analysis indicates significant relationships (p < 0.05) between throwing velocity and upper body power (r = 0.83), lower body power (r = 0.75), and grip strength (r = 0.80). Significant relationships also existed between bat speed and upper body power (r = 0.78), lower body power (r = 0.70), and grip strength (r = 0.75).

Use of Absolute Loads to Predict 1-RM Bench Press in College Football Players

M. Steinberg, J.S. Ware, M. Copeland, D. Mayhew, and J.L. Mayhew. Truman State University, Kirksville, MO, Kirksville College of Osteopathic Medicine, Kirksville, MO.

The purpose of this study was to evaluate the effectiveness of using repetitions-to-failure (RTF) with absolute loads to predict 1-RM bench press in college football players. Linebackers (n = 36) from NCAA Division II mean performed RTF with 225 lbs., while backs (n = 29) performed RTF with 205 lbs one week following the completion of the Fall competitive season. A 1-RM test was determined the week after the RTF test. While linemen had significantly greater 1-RMs (324.0 ± 42.7 lbs) than backs (260.2 ± 33.5 lbs), their relative strengths were not significantly different (1.36 ± 0.24 vs 1.45 ± 0.19 lbs/lbs BW, respectively). Backs (14.9 ± 4.1) performed significantly more RTF than linemen (9.3 ± 4.5) despite correctings for differences in %1-RM. Prediction equations for each absolute load were moderately successful in estimating 1-RM. Combining the loads into one equation improved prediction only slightly. Using separate absolute loads to predict 1-RM in backs and linemen does not appear to be accurate enough for program design purposes.

Electromyographical Analysis of Abdominal Muscle Activity Using Portable Abdominal Exercise Devices and a Traditional Crunch

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The purpose of this study was to compare the abdominal muscle activity elicited using four portable abdominal training devices to a traditional crunch. Thirty-three adults participated in this study. The exercise devices tested included: the Ab Roller Plus, Toro Track 2, AB-DOer Pro, and the Perfect Abs. The Perfect Abs, currently the only device of the group not on the market, is a bandaged device that spans the abdominal region with one end supported on the thighs and the other held with the hands at chest level. Subjects were tested in the Perfect Abs in both a seated and a supine position using low, medium, and high resistance bands. The Toro Track 2 was also tested at low and high resistance settings. Surface electromyography was recorded from the upper and lower portions of the rectus abdominis, external oblique, and the rectus femoris. Statistical analyses were performed on the mean EMG values using a repeated analysis of variance procedure. The data from this study support previously published reports that showed no significant difference in abdominal muscle recruitment between the Ab Roller Plus, the Toro Track 2—high resistance, and a traditional crunch. The mean abdominal muscle recruitment was significantly lower, however, when using the AB-DOer, Toro-Track-low resistance, and the Perfect Abs seated with the low resistance band, when compared to a crunch. In the seated position, the Perfect Abs with the medium and high resistance bands was not significantly different from a crunch. In contrast, the Perfect Abs, when using the supine position and the medium and high resistance bands, elicited significantly greater mean abdominal muscle recruitment when compared to a crunch. For example, the mean EMG activity for the upper portion of the rectus abdominis during a crunch was 1.30 (0.10) volts. Using the Perfect Abs in the supine position, however, increased the activity of the upper portion of the rectus abdominis by 58% to a mean of 2.05 (0.18) and by 72% to 2.23 (0.18) volts, with the medium and high resistance bands, respectively. The results suggest that portable abdominal devices are most effective if they not only mimic the mechanics of a traditional crunch, but also provide external resistance to increase the involvement of the muscular abdincation.

Maximum Strength-Power-Performance Relationships in Moderately Strength-Trained Collegiate Throwers


Presently the degree to which peak force influences power production or “explosive” performance such as throwing (shotput and weight throw) is unclear. The purpose of this study was to describe the relationships between peak isometric force (IPF), dynamic peak force (PF) and peak power (PP) measured using 1-REP force plate (500 Hz), PP was measured using an infra-red/ultrasound tracking device (V-Scope, Lipman Electronics). Test-retest reliability was: PF ICC = 0.98, PP ICC = 0.86. Mid-thigh pulls (knee angle 135–140°) were assessed isometrically and dynamically at 20, 30, and 60% of peak isometric force (IPF). “Specific explosive strength” was evaluated using a power snatch (SN) and using the shotput (SP) and weight throw (WGT) measured under meet conditions. Variables (PF, PP, SN) were assessed within 3 days of the meet. Correlation coefficients (r) indicate that IPF is strongly related to dynamic PP and PP at 20, 30%, 60%, the SN and the distance for the shotput and weight.

Use of Absolute Loads to Predict 1-RM Bench Press in College Football Players

M. Steinberg, J.S. Ware, M. Copeland, D. Mayhew, and J.L. Mayhew. Truman State University, Kirksville, MO, Kirksville College of Osteopathic Medicine, Kirksville, MO.

The purpose of this study was to document the physiological profile of “responders” versus “non-responders” to a 5-day creatine (Cr) load (0.3 g x kg-1 x d-1) in 11 healthy males (mean age = 22.7 ± 2 yrs). Pre- and post-5-day cellular measurements included total Cr content ([Cr + Ca], fiber type composition and fiber type cross-sectional area (CSA) determined from muscle biopsies of the vastus lateralis. Body mass, daily dietary intake, 24-hour urine outputs and strength performance measures (1RM bench and leg press) were also assessed before and after the 5-day loading period. Results indicated that there were 3 levels of response to the 5-day supplementation: responders (R), “quasi-responders” (QR) and non-responders (NR) with mean changes in resting [Cr + Ca] of 29.5 mmol/kg x dm (r = 3), 14.9 mmol/kg x dm (r = 5) and 5.1 mmol/kg x dm (r = 3), respectively. There were discernable mean differences between R and QR with regard to percentage fiber type populations (Rtype I = 34.3%, II = 63.1%; QRtype I = 51.4%, II = 45.5%; NRtype I = 55.4%, type II = 39.55%). Responders had a mean fiber area increase of 319.7um2, 971.1um2, and 839.2um2 in type 1, IIa, and IIb, respectively, with NR having the least mean fiber area increase of 59.9um2, 129gum2, and 121gum2 in type 1, IIa, and IIb, respectively. R and QR groups had greater initial type I and II fiber CSA areas, prior to loading. Body mass and daily dietary protein intake also reflected a descending trend for R, QR, and NR (24.6 kg, 2.04 kg, and 1.96 kg, respectively and 167 g x d, 123 g x d, and 121 g x d, respectively). There were no discernable differences
in 24-hour urine outputs or urinary [Cr] and creatinine. R increased RM leg press by 25.8 kg, while QR and NR had little change (2.5 and 2 kg, respectively). There was no change in RM bench press for any group. The results suggest that a threshold increase of 20 mmol/kg-dm in total muscle [PCr + Cr] may be necessary to observe any ergogenic acute strength performance benefits. Initial cross-sectional areas of muscle fibers may also be a determining factor in identifying responders versus non-responders. Strength and conditioning specialists should consider these findings when interpreting Cr supplementation research. There may be a predominating muscle morphological profile that dictates those individuals who respond and can actually benefit from acute Cr supplementation.

Evaluation and Comparison of Timing Characteristics for Division I College Female Volleyball Games

J.D. Vecori. The George Washington University Medical Center, Washington, D.C.

Women's college volleyball changed to rally scoring during the 2001 season. The purposes of this investigation were to 1) determine the timing characteristics of matches played using rally scoring and 2) compare them to the timing characteristics of side out scoring. Mean duration of work (W), total rest (TR), rest without time-outs and substitutions (RA), substitution rest (SR), time-out rest (TOR) as well as the number of tallies (R), substitutions (#SUB), and time-outs (#TO) per game were determined. Eighty three games (4348 tallies) from the 1999 and 2000 seasons and 41 games (2118 tallies) from the 2001 season were observed and timed using a hand held stopwatches. Work is defined from when the ball is served until the whistle is blown ending the rally, while rest is defined from when the whistle is blown from the preceding rally to the next serve.

Using Body Mass to Select the Best Weight for Predicting 1-RM Bench Press Strength in College Football Players

J.S. Ware, M. Steinberg, M. Copeland, and J.L. Mayhew Truman State University, Kirksville, MO and Kirksville College of Osteopathic Medicine, Kirksville, MO.

One problem yet unresolved in using repetitions-to-fatigue (RTF) to predict 1-RM strength is the selection of the best submaximal load to use. The purpose of this study was to evaluate the efficacy of using a percentage of body mass as a means of identifying the best weight for RTF. College football players (n = 58) were tested during the last two weeks of a 10-week winter resistance conditioning program for RTF using 100%, 110%, and 120% of body mass (BM) and for 1-RM in the bench press. The 100% group performed 10 x 1 sets of 1 RM daily on a simple medicine ball (Eastern Xercise, Cleveland, TN), while the CON group lifted 2x/wk at 50% of 1 RM. Resting ECG data were collected before (pre) and after (post) the two-week high intensity training phase using datalogger monitors. The data was analyzed at 500 Hz. The under-maximal peak detection for the determination of the inter-beat interval (IBI: msec) time series, from which the root mean square of successive differences (RMSSD; a time domain index of vagal modulation) and the low-frequency/high-frequency (LF/HF) ratio (a frequency domain index of sympathovagal balance) were calculated. The HI group experienced an overtrained state based on a decrease (p < 0.05) in 1 RM (HI group, max 1 RM = 159.5 ± 4.6, last 1 RM = 151.4 ± 4.5; CON group, max 1 RM = 146.0 ± 5.9, last 1 RM = 144.3 ± 6.0). For all ANS measures, there were no significant (p > 0.05) group x time interaction effects, indicating that there were no differences in ANS modulation between groups across training. However, the main effect for time was significant for LF/HF (p = 0.03) and approached significance for RMSSD (p = 0.12) and IBI (p = 0.09), indicating that both groups experienced a shift in sympathovagal balance towards increased parasympathetic modulation. In conclusion, these results indicate that short-term high-intensity resistance training overtraining do not result in changes in autonomic modulation that are different than those seen in controls. The changes in autonomic modulation experienced by both groups may be due to decreases in training volume that were similar in both groups.

Relative External Loads Eliciting Maximum Concentric Force and Power During Non-Countermovement Squats


The principle of training specificity indicates that each adaptation corresponds to a specific training stimulus. And, although strength is a variable that is often treated as a specific entity, different independent variables may collectively account for it. For example, mechanical force and power are two different “strength” variables that differentially vary with changing loads. This suggests that for a given application, it may be important to focus on a unique relevant aspect of strength rather than to consider it as a solitary all-purpose concept. PURPOSE: To determine the relative external load during maximum-acceleration, dynamic constant external resistance (DCER) squats that results in the greatest mechanical force and power production. METHODS: The concentric (body wt 77.7 ± 12.7 kg) fitness-trained lifters took part in this study. Subsequent to familiarization, each subject's 1RM non-countermovement parallel squat was determined to standardize loading on subsequent tests. Within one week, subjects performed single-repetition maximum-acceleration, concentric-only jump squats at 50, 60, and 90% 1RM in a counterbalanced manner. Force and power measurements were obtained using a computer-interfaced dynamometer coupled to the squaring bar by means of a tether. RESULTS: (See Table 1). The highest (p < 0.05) peak force was obtained at 90% 1RM and for mean force at 60 and 90% 1RM. The highest (p < 0.05) peak power occurred at 60 and 90% 1RM and for mean power at 30% 1RM. CONCLUSION: Based upon this study, it appears that single-repetition, maximum-acceleration, non-countermovement jump squats by young men are likely to produce the highest external peak force at near-maximal loads and the highest external peak power at intermediateto-high loads. When expressed as a mean of the concentric phase of the lift, the highest force is likely to take place at intermediate-to-high loads and for power at relatively low loads. PRAC-TICAL APPLICATIONS: If specificity of training applies and high force development is desired during non-countermovement squats, then high relative loads are needed dur-
ing training. If high power development is desired, then the picture is less clear as the maximum force in a countermovement jump (CMJ) and a drop jump (DJ) from 0.2 m, respectively. CMJ height increased 12% while DJ height increased 10.3%. No significant changes were seen in maximum force and rate of force development in the CMJ. Subjects were required to perform each exercise at an intensity equating to approximately 80% of the subject’s 1-RM.

During the second year (n = 14; 175.0 ± 7.1 cm, 94.2 ± 20.5 kg) the in-season training program was also 2 d × wk − 1 but the program was nonlinear (NL). The first training session of the week was performed at approximately 90% of the subject’s 1-RM, while the second session was performed at approximately 70% of the subject’s 1-RM. Subjects were tested for maximal strength in the squat (1-RM SQT) and bench press (1-RM BP) exercises. A significant improvement in 1-RM SQT was seen in LT, but not in NL. No significant pre to post season improvements were seen in 1-RM BP in either group. Analysis of D scores in 1-RM SQT and 1-RM BP showed greater improvements in LT (13.8 ± 7.4 kg and 2.9 ± 7.3 kg, respectively) than NL (1.6 ± 12.6 kg and −2.4 ± 6.8 kg, respectively). However, only D1-RM SQT results were different (p < 0.05) between the groups. Results of this study suggest that LT may be more effective in eliciting strength gains than NL in freshman football players during an in-season resistance-training program.

**Table 1.** External force and power output for load-spectrum, concentric-only jump squats.

<table>
<thead>
<tr>
<th>Variable</th>
<th>30% 1RM</th>
<th>60% 1RM</th>
<th>90% 1RM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pk Force (N)</td>
<td>610.8 ± 27.2</td>
<td>1,071.0 ± 47.9</td>
<td>1,398.1* ± 54.2</td>
</tr>
<tr>
<td>Mean Force (N)</td>
<td>501.3 ± 23.5</td>
<td>753.6* ± 56.5</td>
<td>739.5* ± 55.3</td>
</tr>
<tr>
<td>Pk Power (W)</td>
<td>1,251.5 ± 109.4</td>
<td>1,711.1* ± 188.0</td>
<td>1,529.8* ± 169.2</td>
</tr>
<tr>
<td>Mean Power (W)</td>
<td>1,011.2* ± 99.7</td>
<td>648.9 ± 50.9</td>
<td>548.9 ± 48.3</td>
</tr>
</tbody>
</table>

* p < 0.05.

**Immune Cell Response and Frequency of URTI Following Weightlifting Competition**

K. Wells, T. Kilgore, E. Haist, G. Pendley, G. Haist, and L. Kilgore. Strength Research Laboratory, Midwestern State University, Wichita Falls, TX.

The objective of this study was to investigate the theory that leukocytosis following near maximal exercise permits a “window of decreased immuno-surveillance” for 2–4 days, increasing the athlete susceptibility to URTI. Thirteen Olympic weightlifters mean age 17.2 ± 1.3 having a least 6 months of training background participated in the study. Fasting blood samples were obtained before competition. The weightlifting event consisted of a warmup, 6 competition lifts (3 snatch attempts, 3 clean and jerk attempts). Samples were repeated immediately post competition (C) and at the following intervals: 2 h, 24 h, 48 h, and 72 h. A quantitative automated hematology analyzer (Coulter Onyx) for in vitro diagnostics of hematologic parameters analyzed immune cell counts. The participants were monitored daily for signs/symptoms of URTI. Total Leukocytes (WBC) count prior to C 6.39 ± 1.85, post C 8.38 ± 2.08, 2 h 10.50 ± 1.98, 24 h 6.92 ± 1.95, 48 h 6.32 ± 1.84, 72 h 6.64 ± 6.44. Lymphocytes (LY#): prior to C 2.24 + 0.65, post C 2.18 ± 1.08, 2 h 2.53 ± 0.83, 24 h 2.66 ± 0.91, 48 h 2.40 ± 0.76, 72 h 2.40 ± 0.86. Total granulocytes (GR#): prior to C 3.65 ± 1.29, post C 3.62 ± 1.75, 2 h 7.38 ± 1.91, 24 h 3.66 ± 1.12, 48 h 3.39 ± 1.34, 72 h 3.52 ± 1.34. The increase in total GR# is attributed to the increase in neutrophils (N#) from the marginned pool into circulation. Eosinophils and Basophils remained unchanged in each subject throughout the study. Results were analyzed using an ANOVA. The total number of WBCC and GR#, specifically N#, were elevated and statistically significant at 2 h post competition. No other results were found to be significant (p < 0.05). There was no report of URTI symptoms by the participants for the duration of the study. The findings of this study were that the change in WBC count was statistically significant, but not clinically significant, and that none of the athletes contracted an URTI post competition. This study indicates while there is a prominent leukocytosis 2 h after competition, the phenomenon is likely a mechanically driven de-margination and re-margination of existing cells. This points to a pseudo-inflammatory response rather than one of immune nature.

**Comparison Between Linear and Nonlinear In-Season Training Programs in Freshman Football Players**


The purpose of this study was to compare a 1-RM performance with free weight bench press (FW) an Nautilus leverage (NA) bench press. Twelve experienced lifters were video taped with a Panasonic camcorder operating at 60 Hz and digitized with the Peak Performance Motion Analysis System. The camera was set perpendicular to the transverse plane of motion to evaluate absolute arm angle at the start of motion, relative time of sticking point, and relative time of peak velocity between the two devices. Paired t-tests indicated that subjects lifted significantly more on the NA (315 ± 50 lbs) than the FW (248 ± 40 lbs). The absolute angle of the arm at the start of the concentric movement was significantly greater for NA (127.0 ± 6.5 deg) than for FW (110.0 ± 6.9 deg) requiring the lifter to push the weight through a greater range of motion. NA also produced a greater peak velocity (0.56 ± 0.01 m s⁻¹) than FW (0.30 ± 0.01 m s⁻¹) perhaps due to the control of the bar path. There was no significant difference between the two lifts for relative time of peak velocity or relative time of sticking point, possibly indicating that the muscle length/tension relationship was similar in each condition. Qualitatively a slight initial leading rotation of the nondominant shoulder on both NA and FW was observed on video recordings. While NA does not place the shoulder muscles on a dynamic eccentric stretch as does the downward phase of the FW, the greater degrees of freedom might allow the generation of more force to explain the greater amount lifted on the NA.

**Biomechanical Comparison Between Wide-Grip Free Weight Bench Press and Nautilus Leverage Machine Bench Press**

J. Whaling, T. Lacey, M. Bird, and J.L. Mayhew. Human Performance Laboratory, Truman State University, Kirksville, MO.

The purpose of this study was to compare 1-RM performance with free weight bench press (FW) an Nautilus leverage (NA) bench press. Twelve experienced lifters were video taped with a Panasonic camcorder operating at 60 Hz and digitized with the Peak Performance Motion Analysis System. The camera was set perpendicular to the transverse plane of motion to evaluate absolute arm angle at the start of motion, relative time of sticking point, and relative time of peak velocity between the two devices. Paired t-tests indicated that subjects lifted significantly more on the NA (315 ± 50 lbs) than the FW (248 ± 40 lbs). The absolute angle of the arm at the start of the concentric movement was significantly greater for NA (127.0 ± 6.5 deg) than for FW (110.0 ± 6.9 deg) requiring the lifter to push the weight through a greater range of motion. NA also produced a greater peak velocity (0.56 ± 0.01 m s⁻¹) than FW (0.30 ± 0.01 m s⁻¹) perhaps due to the control of the bar path. There was no significant difference between the two lifts for relative time of peak velocity or relative time of sticking point, possibly indicating that the muscle length/tension relationship was similar in each condition. Qualitatively a slight initial leading rotation of the nondominant shoulder on both NA and FW was observed on video recordings. While NA does not place the shoulder muscles on a dynamic eccentric stretch as does the downward phase of the FW, the greater degrees of freedom might allow the generation of more force to explain the greater amount lifted on the NA.

**Proprioceptive Training Improves Vertical Jump Performance in Untrained Women**

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The purpose of this study was to observe possible performance changes in vertical jump after proprioceptive training. Thirteen college-aged, non-athletic females participated in a control and training period. Subjects were tested for postural sway, vertical jump height in a countermovement jump (CMJ) and a drop jump (DJ) from 0.2 m, maximum force in a CMJ, and rate of force development in the CMJ. Subjects were tested initially (control test), performed normal daily activities for two weeks as a control period, and then were retested prior to training (pre-test). Subjects trained 3 times per week for 6 weeks utilizing floor balance activities, single-plane wobble-board, and multi-plane wobble board activities. The post-test was conducted after training. Changes in scores during the control period were insignificant in all measures with the exception of a small decrease in CMJ height. Changes during the training period showed a 36.3% decrease and 43.1% decrease in postural sway on the right and the left lower extremities respectively. CMJ height increased 12% while DJ height increased 10.3%. No significant changes were seen in maximum force and rate of force development in the CMJ. It appears that proprioceptive training using ankle disks is a viable means of increasing vertical jump height in a non-athletic female population. However, the mechanisms for the performance changes remain unclear.