NSCA Conference Abstracts

These abstracts are from the 1994 NSCA National Conference held in June in New Orleans.

Intra-arterial Blood Pressure and Heart Rate Responses to Various Forms of Resistance Exercises
Douglas M. Kleiner, Daniel L. Blessing, W. Ross Davis, and John W. Mitchell. Illinois State University; and Auburn University

Several forms of resistance are currently available for use with resistance training. The present study evaluated the acute cardiovascular responses to maximal resistance exercises with various forms of resistance and compared the data to that of maximal nonresistance exercise. Six subjects performed single-leg, concentric extension and eccentric flexion exercises at the knee. The exercises were performed to momentary muscular failure, or the inability to complete another repetition, with accommodating (ACC), variable (VAR), and fixed (FIX) forms of resistance. The order in which the subjects performed the resistance exercises was counterbalanced. In addition, they performed a maximal graded exercise test (GXT) on a cycle ergometer. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and rate-pressure product (RPP) were directly and continuously recorded during all exercises. Blood pressures were obtained through an intra-arterial catheter placed in the radial artery. The data revealed that peak heart rates and blood pressures were highest and lowest, respectively, during the GXT. Within the resistance exercises, peak cardiovascular values were highest with the ACC resistance, followed by FIX and then VAR resistance. Mean peak values for HR, SBP, DBP, and RPP were 189 bpm, 330 mmHg, 184 mmHg, and 545, respectively. There were significant differences (p < 0.05) between aerobic activity and resistance exercises for HR, SBP, and DBP, but not RPP. There were also significant differences (p < 0.05) between ACC vs. FIX and VAR resistance for SBP and RPP. Where statistical significance was not achieved within the resistance exercise data, nonsignificant trends were observed. These data suggest that cardiovascular values are greatly increased during resistance exercises and that differences occur when manipulations are made in the form of resistance. It is suggested that considerable attention be paid to resistance selection when prescribing resistance exercises.

Prediction of 1-RM From Free Weights and Machines Using Upper and Lower Body Exercises
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Many athletes use free weights and machines in their training programs. However, it is often difficult to determine the appropriate weight to use when switching from one type of equipment to the other. The primary purpose of this study was to develop predictive equations to be able to convert weight from one type of equipment to another for common upper and lower body resistance exercises. Subjects were 57 females (F) ages 22.6 ± 3.1 yrs and 67 males (M) ages 23.2 ± 3.3 yrs. Following instruction and practice, they performed a one repetition maximum (1-RM) in the free weight bench press (FWBP), Universal bench press (UBP), free weight back squat (FWSQ), and Universal leg press (ULP). Test-retest reliability for the lifts were as follows: FWBP r = 0.998, UBP r = 0.998, FWSQ r = 0.996, and ULP r = 0.996. The 1-RM (mean ± SD) for each of the lifts is given below (all values in kg).

<table>
<thead>
<tr>
<th>Body</th>
<th>Wt</th>
<th>FWBP</th>
<th>UBP</th>
<th>FWSQ</th>
<th>ULP</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>71.5 ± 10.7</td>
<td>81.0 ± 17.7</td>
<td>78.1 ± 16.7</td>
<td>108.9 ± 23.4</td>
<td>202.8 ± 38.3</td>
</tr>
<tr>
<td>F</td>
<td>60.9 ± 10.6</td>
<td>32.6 ± 6.8</td>
<td>34.3 ± 6.3</td>
<td>61.5 ± 14.1</td>
<td>126.3 ± 22.2</td>
</tr>
</tbody>
</table>

Regression equations were developed in order to predict 1-RMs using the various exercises (Wt = body weight, all values in kg).

Females
ULP = 0.95 (FWSQ) + 0.91 (Wt) + 12.17, Se = 13.78, R = 0.79
FWSQ = 0.51 (ULP) - 0.37 (Wt) + 19.35, Se = 10.10, R = 0.71
UBP = 0.99 (FWBP) - 0.095 (Wt) + 5.81, Se = 1.86, R = 0.96
FWBP = 0.97 (UBP) + 0.12 (Wt) - 7.73, Se = 1.88, R = 0.96

Males
ULP = 0.90 (FWSQ) + 1.11 (Wt) + 25.35, Se = 26.80, R = 0.72
FWSQ = 0.41 (ULP) + 26.38, Se = 17.59, R = 0.67
UBP = 0.89 (FWBP) + 5.72, Se = 5.51, R = 0.94
FWBP = 1.00 (UBP) + 2.97, Se = 5.83, R = 0.94

These prediction equations may be useful to coaches and athletes who wish to convert to the approximate weight necessary when switching from one type of equipment to the other.

Influence of Heavy Resistance Exercise on Leukocyte Counts

No data exist regarding the response of leukocytes to heavy resistance exercise. The purpose of this study was to determine if there were acute changes in leukocyte counts following heavy resistance exercise, and whether these acute changes were related to the immediate response of cortisol. Nine healthy, recreationally weight-trained men volunteered for this investigation. Protocol 1 consisted of 8 sets of 10 reps maximum (RM) leg press exercise using short rest periods of 1 min between sets. Protocol 2 was identical (same total work and power output) except for longer rest periods (3 min) between sets. In order to evaluate the influence of cortisol on leukocyte counts for each subject, the exercise protocol that elicited an elevation in cortisol concentrations was designated as the response protocol (R). The protocol that elicited little or no changes in cortisol concentrations was designated as the nonresponse protocol (NR). A nonexercise protocol was used as a control treatment (C). Venous blood samples, heart rates, and ratings of perceived exertion (RPE) were obtained pre-, mid-, and 5 min postexercise. Total and differential leukocyte counts, serum cortisol, and blood lactate concentrations were analyzed. Significance of p ≤ 0.05 was selected for this study. The R protocol had a higher stress response as measured by RPE, heart rate, and blood lactate concentrations. Significant increases in serum cortisol occurred from pre- to midexercise and pre- to postexercise for R. No significant changes in cortisol occurred for NR or C treatments. Significant increases in total leukocyte counts occurred from pre- to midexercise and pre- to postexercise for only R and NR. No significant changes in differential leukocyte counts were observed. No significant correlations occurred between cortisol
and total or differential leukocyte counts during this acute period of measurement. These data indicate that the acute changes in total leukocyte concentrations are independent of metabolic stress and cortisol's influence and are not observed within the workout or immediate period of recovery. Furthermore, no changes in the differential leukocyte count are observed acutely with heavy resistance exercise. The influence of heavy resistance exercise on white blood cell counts may be more dramatic over the longer 24-hr recovery period and requires further study. Such data aids our understanding of the effects of heavy resistance exercise and immune system function.

Supported by a grant from R.F. and S.M. Leitzinger Award in Sports Medicine.

Influence of Acid-Base Changes on Plasma Epinephrine After High Intensity Cycle Exercise

The effect of HCO₃⁻-induced pH alterations on venous epinephrine concentration were studied in 10 healthy active men (age 24.6 ± 1.5 yrs) following 90 s of maximal-effort cycle ergometry against an opposing force of 0.49 N (0.05 kg) kg body mass⁻¹. A randomized double-blind counterbalanced experimental study design was used. Each subject reported in a fasted state at the same time of day for two experimental sessions separated by 1 wk. For each session, subjects ingested a decaffeinated tea solution containing either 0.3 g NaHCO₃ kg body mass⁻¹ (alkalosis [ALK]) or 0.04 g NaCl kg body mass⁻¹ (placebo control [CNTR]). Venous blood samples were obtained before (baseline) and 75 min after the ingestion period (preexercise), as well as postexercise at 1, 2.5, 5, and 10 min. The exercise task immediately followed the preexercise blood draw. There was no difference between ALK and CNTR in mean or peak power output or total work of the task. Whole blood pH was significantly (p ≤ 0.05) elevated in ALK above CNTR at all times except baseline, with the lowest pH occurring at 5 min postexercise (ALK, 7.14 ± 0.02; CNTR, 7.07 ± 0.02). Plasma epinephrine concentrations were not significantly different between ALK and CNTR at any time, with greatest epinephrine values occurring at 0 min (ALK, 3.970 ± 680 pmol L⁻¹; CNTR, 4.170 ± 810 pmol L⁻¹). These results indicate that during short-term high intensity exercise, changes in blood pH do not significantly affect plasma venous epinephrine concentrations. It is proposed that the intense neural stimulus from the exercise bout may override or mask the influence of peripheral changes in pH.

Supported by a grant from R.F. and S.M. Leitzinger Award in Sports Medicine.

Jump Height, Force, and Power Output During Vertical Jumping by NCAA Division I Volleyball Players
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The sport of volleyball involves more vertical jumping than any other sport. This study examined the jump height, force, and power output for 18 male and 18 female NCAA Div. I volleyball players performing vertical jumps with and without arm swing, from ground level, 0.3-m, and 0.6-m drop heights. The effect of performing a step prior to jumping was also investigated. Peak force and peak power output were recorded using an AMTI force plate. Vertical jump and reach was measured using a Vertec with the subjects performing a standing jump and reach, as well as a 3-step, then jump and reach. Subjects performed 3 trials for each condition; the best score was recorded. Jump and reach was significantly (p ≤ 0.05) higher for males, both for standing (0.77 ± 0.09 and 0.48 ± 0.07 m) and 3-step approach (0.85 ± 0.10 and 0.54 ± 0.07 m). Both sexes produced significantly higher jump and reach with a 3-step approach. Peak power output was significantly higher for males (3.617 ± 1.065 W) than females (3.465 ± 0.54) as well as power-to-weight ratio (males: 6.9 ± 1.3 W/kg; females: 5.2 ± 1.2 W/kg). There was no effect of arm swing on peak force or peak power for either sex. For females, peak force increased for each drop height; however, power output was lower for the 0.3-m drop height than for the ground or 0.6-m levels. There was a significant effect of drop height on power output (i.e., 0.3-m drop height lower than 0.6 m or ground level). The males produced higher force for the 0.6-m drop than the other two heights. Power output was significantly lower for both drop heights than the jump performed with no drop. These results demonstrated that the males were significantly more powerful than the females, even when allowing for body weight, and this was evident in the females' lower vertical jump scores. Greater emphasis on power training for females may be beneficial. The use of the arms did not contribute to jumping performance and may indicate a skill-specific effect of the arm movement in volleyball not contributing to the jumping action but more to striking the ball. The increase in peak force with increasing drop height may have implications for injury. Power output did not increase with drop height, possibly due to the inexperience of these subjects to this form of training. Overall, the results indicate that jump capabilities may be specific to the sport context in which they are used. Coaches should consider the use of jump and reach testing which mimics the sport context. Also, the use of generalized plyometric drills such as drop jumps needs to be questioned, and consideration should be given to volleyball-specific plyometrics incorporating step takeoff and arm striking actions.

Supported by a grant from the U.S. Olympic Committee.

Acute Endocrine Responses With Long-Term Weightlifting in a 51-Year-Old Male Weightlifter
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To study the effects of long-term (>35 yrs) competitive weightlifting training on acute endocrine activity, a 51-yr-old male (Subject A) was compared to a group of highly trained young male weightlifters (controls, n = 23; age = 17.7 ± 0.3 yrs). Subject A was a current age-group U.S. national weightlifting champion, a two-time Olympic champion, and was consistently training at the time of the study. Between 2 and 5 p.m., all subjects performed an exercise test of 15 max effort vertical jumps, a series of single repetitions of the snatch lift every 15 s progressing to a maximal effort, and 3 × 10 snatch pulls at 60% snatch 1-RM. Blood samples were collected at 7 a.m., preexercise (P), and at 5 and 15 min postexercise. Exercise test performances for Subject A were comparable to those of the controls and elicited similar lactate responses at 5 min (mmol L⁻¹; A = 9; controls = 8.1 ± 0.4). As expected, resting testosterone at 7 a.m. was lower for Subject A than for the controls (mmol L⁻¹; A = 13.9; controls = 25.4 ± 2.0), although acute responses at 5 min were comparable (A = 21.6; controls = 18.3 ± 1.5), suggesting intact acute sympathetic regulation. Acute responses of cortisol (nmol L⁻¹; A = 468.4; controls = 540.6 ± 32.3) and testosterone/cortisol ratios (A = 0.046; controls = 0.0376 ± 0.0004) were similar at 5 min for Subject A and the controls. Growth hormone did not demonstrate an acute increase for Subject A at 5 min, while control subjects exhibited a large increase (μg L⁻¹; A = 0.4; controls = 16.7 ± 2.6). Total pituitary dysfunction may be ruled out for Subject A since β-endorphin responses at 15 min were similar to control responses (nmol L⁻¹; A = 30.1; controls = 33.8 ± 3.7). In conclusion, resting and exercise-induced endocrine physiology is partially modified with aging despite long-term competitive weightlifting training.

Supported by a grant from R.F. and S.M. Leitzinger Award in Sports Medicine.
Effect of the Pattern of Weight Loss on Hydration Status in NCAA Division I Wrestlers


This study examined the effect of the pattern of weight loss on hydration status in NCAA Div. I collegiate wrestlers preparing for competition. Twelve wrestlers from the Penn State wrestling team volunteered to be subjects and lost an average of 6% of body weight (BW) by thermal and exercise-induced dehydration, but at various rates during the week of the experiment. Subjects were grouped into gradual (G), moderate (M), and rapid (R) weight loss patterns by their change in BW from Day 1 to Day 6 of the investigation. The wrestlers chose to accomplish nearly all of this severe weight loss during the 24-hr period immediately prior to the weigh-in. Hydration status was assessed by measuring blood volume (BV), plasma volume (PV), red cell volume (RCV), osmolality, and total protein concentration (TP). The BW of subjects following 15 hrs of rehydration was still below the baseline average, indicating that wrestlers did not replace all of the BW loss during the night after a weigh-in. There was a significant correlation ($r^2 = 0.4986$) between the pattern of weight loss and the total % Δ BW. Gradual weight reducers were able to incur a greater decrement in BW. The weight loss regimen had no effect on precompetition osmolality or TP, but it significantly reduced pre-weigh-in BW for all three groups. The three groups experienced a similar reduction in PV (approximately 400 to 500 ml) following dehydration. The results indicate that the weight loss patterns compromise PV equally, and therefore the rate of weight reduction during the week prior to weigh-ins has no effect on hydration status, but athletes in the G group were able to achieve a higher absolute weight loss during the week.

Supported in part by a grant from the United States Olympic Committee.

Effect of Resistance Training on Muscle Strength and Relative Muscle Endurance

Lisa Wilson, Chris Sebelski, Jerry Mayhew, and Thomas Ball. Northeast Missouri State University; and Northern Illinois University

A primary objective of resistance training and rehabilitation therapy is to regain both muscle strength and endurance. The purpose of this study was to determine the effect of resistance training on muscle strength and relative muscle endurance in the bench press. College men ($n = 75$) and women ($n = 74$) who were enrolled in a fitness class volunteered to be evaluated for a one-repetition maximum (1-RM) and the number of repetitions completed in 1 min using 60% of 1-RM. Subjects were tested before and after a 14-week program consisting of Nautilus and free weight resistance training and aerobic conditioning. Resistance training was performed with a circuit weight training program using exercises for the upper and lower body. One set of 8 to 12 reps was performed in each of 7 exercises 3 times a week. The 1-RM bench press increased significantly in men by 11.3%, from 71.0 (±15.6) to 78.5 kg (±16.6), and in women by 12.2%, from 32.3 (±4.7) to 36.1 kg (±5.0), with no significant difference between the sexes. Relative endurance was not changed significantly following training in men (22.7 ± 4.7 vs. 22.3 ± 3.8 reps), but it was in women (20.1 ± 6.3 vs. 22.8 ± 5.1 reps). Despite high correlations for both men ($r = 0.98$) and women ($r = 0.80$) between actual 1-RM bench press and 1-RM predicted from repetitions and load, actual 1-RM was significantly underestimated in men and women by 7.0% and 10.5%, respectively. Therefore, significant increases in strength were not accompanied by alterations in relative muscle endurance at low intensity in men, but they were in women, and high repetitions cannot be used either before or after training to accurately predict 1-RM performance in the bench press.

Variables Predictive of Rebound (Depth) Vertical Jump Performance in Men and Women

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If accurate statistical models for the vertical jump were available, investigators could focus on determining how to optimize performance on those variables identified as contributing significantly to jumping ability. In the present investigation, equations were developed for predicting rebound (depth) vertical jump (DVJ) distance. Body composition and numerous variables generated via velocity spectrum isokinetic squats were obtained using 52 men and 50 women subjects. Squatting velocities represent upward bar movement on the testing apparatus consequent to concurrent multiple-joint actions and included 25, 40, 55, 70, 85, and 100% of the potential predictors of DVJ distance were those generated by the testing apparatus whose test-retest reliability coefficient at each squat speed was at least 0.94. Variables included peak force, average force, peak-force-to-body-weight ratio, average-force-to-body-weight ratio, peak power, average power, peak-power-to-body-weight ratio, and average-power-to-body-weight ratio. Two multiple regression equations were generated via a forward stepwise approach, both of which had $R$ values of 0.90 and SEE values ranging from 0.058 to 0.059 meters. When all 6 squat testing speeds were considered, peak-power-to-body-weight ratio at 85% of 1-RM ($X_2$) was significantly and positively related to DVJ, while % body fat ($X_1$) was inversely related: $DVJ = 0.283618 + 0.000103146 (X_1) - 0.002069 (X_2)$. When each individual’s optimal speed for peak-power production was considered (mean = 62.5 s⁻¹), peak-power-to-body-weight ratio ($Y_2$) was significantly and positively related to DVJ, and being female ($Y_1$) was negatively related: $DVJ = 0.209196 + 0.00011843 (Y_1) - 0.007535 (Y_2)$. It appears that better DVJ performance occurs in young adults who can generate high power-to-body-weight-ratios during moderately fast squatting movements, and that high levels of body fat and/or being female are negatively related to DVJ.

Percent Activation of Two Quadriceps Muscles During the Squat Exercise in Trained Individuals

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This study investigated the percent motor unit activation of the vastus lateralis and vastus medialis during the squat exercise in weight-trained individuals. Five weight-trained males (age 23.4 ± 1.36 yrs, stature 177.92 ± 4.49 cm, mass 97.92 ± 10.99 kg) performed a 1-RM test and on a separate day a single-set-to-failure (SSTF) exercise with a load intensity of 85% of 1-RM. Activation of the vastus lateralis (VL) and vastus medialis (VM) was recorded during both the 1-RM and SSTF using surface electrodes. The data were digitally filtered, rectified, and integrated (IEMG) for each repetition of the SSTF and the 1-RM. The IEMG for each repetition of the SSTF and the 1-RM were expressed as a percent of 1-RM IEMG for the first repetition as well as 40, 60, 80, and 100% of the repetitions completed in the SSTF. Mean 1-RM squat was 198.2 ± 26.53 kg. Subjects completed between 8 and 14 reps (9.6 ± 1.33) during the SSTF. Percent 1-RM IEMG for Rep 1, 40, and 60% of the completed repetitions, was 62.15 ± 5.14%, 69.93 ± 5.46%, and 75.54 ± 6.96% for VM, and 53.35 ± 8.04%, 62.06 ± 10.17%, and 66.78 ± 11.82% for VL. For 80 and 100% of the completed repetitions, the % I-RM IEMG was 94.43 ± 9.04 and 109.01 ± 14.69% for the VM, and 82.13 ± 12.59% and 95.73 ± 17.69% for the VL. Activation of the vastus medialis and vastus lateralis during the squat began below the loading intensity and at 80% of the completed repetitions exceeded the loading intensity. Furthermore, at 100% of the completed repetitions, activation surpassed or approached the 1-RM IEMG. In conclusion, this discrepancy of the load intensity to IEMG relationship and the wide range of completed repetitions suggests that the prescription of load intensity as a percentage of 1-RM may not be appropriate for trained individuals.

Estimates of Body Mass Vertical Displacement and Total Work During Snatch Pulls and Parallel Squats

H.S. O'Bryant, Appalachian State University

The purpose of this study was to determine the accuracy of an indirect method for estimating body mass vertical displacement and total work during large muscle mass, multijoint movements using free weight exercise. The 1-RM parallel squat was performed by 20
male novice weight trainers (age 20.2 yrs ± 0.6, body mass 78.1 kg ± 2.5, height 181.2 cm ± 1.8). Snatch lifts (bar mass 123 kg ± 5.1) performed by 25 male lifters (body mass 86.3 kg ± 5.0) were selected upon representation of all weight classes during the 1991/92 USW National and the 1992 U.S. Olympic trials. All lifts were videotaped perpendicular to the sagittal plane of movement at 60 Hz. Data were gathered during the upward phase of the squat and the pull portion of the snatch using 2-D spatial models and a Peak Performance analyzer. Movement of body mass contributed 38.3% (402 j ± 2.7) toward total work (1,048.6 j ± 47.7) of the squat with vertical displacement of body mass 73.1% ± 0.9 relative to the bar. Regression analysis (vertical displacement of body mass = 0.8905741 + vertical bar displacement × 0.1119974, r = 0.94, R² = 0.88; total work = -2,567.2 + bar mass × 7.345 + body height × 15.7 + body mass × 1.131, R² = 0.82) appeared reasonably accurate. Body mass contributions during 1st pull (292.2 j ± 23.1), 2nd pull (119.3 j ± 11.3), and complete pull (411.5 j ± 28.5) toward total work (1,782.3 j ± 97.8) of the snatch was 16.4, 6.7, and 23.1%, respectively, with vertical displacement of body mass 63.4% ± 1.6, 45.2% ± 2.8, and 53.3% ± 1.0 relative to the bar. Regression analysis for snatch pull 1st pull: vertical displacement of body mass = 0.4754981 × vertical bar displacement + 0.8810834, r = 0.81, R² = 0.66; 2nd pull: vertical displacement of body mass = 0.3244863 × vertical bar displacement + 0.0337434, r = 0.83, R² = 0.69; complete pull: vertical displacement of body mass = 0.3680049 × vertical bar displacement + 0.1586677, r = 0.70, R² = 0.49; total work = -147.8 + bar mass × 13.4 + R² = 0.80, also appears promising.

Future study is needed to enlarge the data base to includes additional variations in anthropometry and to characterize different lifting styles of other populations over a variety of lifts.

Muscular Endurance in Women Through Adulthood: A Predictor of Muscular Strength?
A.K. Kuramoto and V.G. Payne, San Jose State University

The prediction of midback muscular strength (1-RM) using relative muscular endurance (ME) was examined in 73 non-strength-trained women. Subjects were divided into three age groups: 20-30 yrs (G1), 40-50 yrs (G2), and 60-70 yrs (G3). ME and 1-RM testing were performed using a constant resistance lat pulldown machine. The ME test required repetitions (Reps) to fatigue in concert with a taped cadence to maintain proper form and technique. The designated weight load (ME Wt) represented 45% of total body weight. Using a one-way ANOVA, significant differences were found between age groups for Reps (p < 0.00008). Scheff’s post hoc comparisons revealed that G3 (n = 23) completed significantly less Reps than G1 (n = 23) and G2 (n = 27), while no differences were noted between G1 and G2. The practical significance was 59.7%. Therefore, multiple regression for muscular strength prediction was performed separately for G3, while G1 and G2 were combined. The best predictors for G1/G2 were Reps, ME Wt, Age, and body mass index (BMI). The G1/G2 prediction equation was: predicted 1-RM = -2.203 + (-0.154 × Age) + (0.874 × Reps) + (1.719 × ME Wt) -0.537 - BMI; R = 0.94, adjusted R² = 0.87, SEE = 2.11 kg. For G3, the relationship between ME and 1-RM was: predicted 1-RM = -3.730 + (0.870 × Reps) + (1.092 × ME Wt); R = 0.91, adjusted R² = 0.81, SEE = 1.94 kg. The results of this study suggest relative ME can accurately be used as a safe alternative to assess muscular strength. Effective training weight loads for strength programs can then be determined when 1-RM testing is inappropriate or prohibitive. Examples include musculoskeletal limitations, and training novice or older individuals.

Biomechanics and Neural Activation During Fast Bench Press Movements: Implications for Power Training
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The most important requirement for many sports is explosive power rather than pure strength. It has been recognized that traditional heavy weight lifting, while producing increases in maximum strength, does not improve strength at higher velocities of movement nor the rate of force development. Subsequently, weight training programs have been modified using lighter loads and faster movement speeds in an attempt to increase the specificity of movement velocity. The aim of this study was to investigate the biomechanics and neural activation of fast bench press movements and "ballistic" bench press movements. "Ballistic" bench press was measured using an instrumented Smith machine linked to a computer that measured bar displacement, velocity, and acceleration. Electromyographic (EMG) activity was recorded from the pectoralis major, anterior deltoid, triceps brachii, and biceps brachii. Vertical force was measured using a specially constructed bench mounted on a Kistler force plate. Subjects were 17 males with at least 6 months bench press experience. Each completed 3 trials for each condition. A bar weight of 45% of the subject’s previously determined 1-RM was used. The bench press movement was performed as explosively as possible off the chest, but the bar was decelerated to stop at the end of the movement. For the throw condition the bar was accelerated off the chest, but it was released at the end of the range. There was no significant (p ≤ 0.05) difference between the two conditions in terms of either the peak or mean EMG activity in any of the muscles examined. Peak force and total impulse were not different between the conditions. However, average velocity (0.67 ± 0.07 m s⁻¹, 0.89 ± 0.07 m s⁻¹ [press, throw, respectively]), peak velocity (0.96 ± 0.08 m s⁻¹, 1.31 ± 0.10 m s⁻¹), peak acceleration (5.0 ± 0.8 m s⁻², 5.6 ± 0.8 m s⁻²), average force (575 ± 113 N, 708 ± 118 N), total work done (199 ± 36 J, 279 ± 41 J), mean power output (346 ± 86 W, 559 ± 88 W), and peak power output (569 ± 133 W, 948 ± 179 W) were all significantly higher for the ballistic throw compared to the rapid press movement. The time of the concentric muscle action was greater for the press (0.57 ± 0.11 sec) compared to the ballistic throw (0.49 ± 0.06 sec). These results suggest that attempting to move a weight rapidly through the range, then slowing it to a stop at the end, results in a greatly reduced velocity of movement and power output. Further analysis of the acceleration and force profiles reveals a significant deceleration phase for a considerable portion of the movement, during which the subjects were controlling the bar velocity. This type of training does not overload the muscle effectively, especially in the crucial final stages of the movement. Ballistic weight training in which the load can be accelerated throughout the movement results in a greater quantity and better quality of resistance overload.

Effectiveness of a Modified Plyometric Program on Improving Power and the Vertical Jump
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Plyometric exercise has been used frequently to improve power and the vertical jump (VJ). In previous research, a modified plyometric program was developed and tested with a biomechanical analysis. The analysis revealed that the modified program trained the extensors of the ankle, knee, and hip with forces greater than that of a maximum countermovement jump (CMJ). This study compared the effectiveness of the modified plyometric program and several conventional training programs on power and VJ. Fifty-one college age males were given a pre- and posttest using a Kistler measuring platform to determine power and VJ height. The modified plyometric program (n = 10) was compared to a VJ training program (n = 10), a weight training program (n = 12), a conventional plyometric depth jump program (n = 10), and a control group (n = 9). The test jumps included the CMJ and a static jump (SJ). The subjects trained in the respective programs 3 days/wk for 8 weeks. All groups showed improvements from pre- to posttests in both peak power and VJ. For CMJ, peak power increased in all training groups but decreased in the control (−160 W). The CMJ training group increased by 198 W, the weight training by 240 W, the plyometric by 347 W, and the modified plyometric by 220 W. VJ height increased for all groups. The improvements were 1.2 cm (control), 4.7 cm (CMJ), 3.5 cm
(weight training), 6.1 cm (pulymetrics), and 4.8 cm (modified plo-
metrics). Analyses of variance with repeated measures were used to
compare the differences in pre- and posttest for the five training
groups. No significant differences were found for power and VJ
height (p ≤ 0.05). The results revealed that no training method was
superior. However, this study demonstrates 4 effective training
methods the strength and conditioning coach can use to improve
power and the vertical jump. Additional research with less experi-
enced jumpers and longer training periods should be conducted to
identify the most effective training method.

Differential Training Effects of Barbell Squat Exercise
Performed at Normal and Fast Speeds
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Han4, 1U.S. Army Research Institute of Environmental Medicine,
Natick, MA; and 2Boston University

To examine the importance of repetition speed during lower
body multijoint exercise, two groups of women (24 ± 4 yrs, 162 ± 5
cm, 59 ± 7 kg) with little resistance training experience squatted to
a 90° knee angle at (a) 2 sec up, 2 sec down (Slow, n = 11), and (b)
1 sec up, 1 sec down (Fast, n = 10), doing 3 warmup sets and 3
8-RM sets, 3 times a wk for 7 wks, adding weight as needed. Pre-
and posttests included force-platform/video biomechanical analysis
of the vertical jump, standing long jump, and max squat, and isokinetic
knee extension testing at 0, 25, 50, 100, and 125° sec. Results:
Slow and Fast improved similarly in squat weight (+26%), vertical
jump (jump height +15%, peak force rate of change +60%, peak
force +10%, average power +30%), isometric torque (+15%), and
the 25 and 50° sec isokinetic tests (work +10%, peak torque +5%).
Differential training effects: While both groups improved signifi-
cantly in long jump distance (Slow +31%, Fast +44%), only Fast
improved significantly in long jump vertical and horizontal power
(+16%, +17%). In the 100 and 125° sec isokinetic tests, Fast showed
significant (p < 0.05) major improvements in work and most angle-
specific torques, while Slow showed no significant improvements.
There was an overall trend toward more and greater improvements
by Fast than by Slow. Conclusions: While both slow and fast training
improved performance, the faster training showed some advantages
in quantity and magnitude of training effects. Further testing is
needed to determine whether the faster repetition speed would also
be advantageous for trained athletes.

Effect of Knee Extension vs. Flexion Exercise on Load
Range in Women at High Velocities
R. Gilbert, L.E. Brown, M. Whitehurst, and B.W. Findley, South Palm
Orthopedics, Delray Beach, FL

The benefits of isokinetic strength training may be proportional
to the percentage of range of motion (ROM) that is sustained at
a predetermined isokinetic velocity, termed load range (LR). The
purpose of this study was to determine whether there were differ-
ences for LR between isokinetic knee extension and flexion exercise
at fast contractile speeds. Nine women (age 36.6 ± 2.6 yrs) performed
three maximal concentric reciprocal knee extension and flexion exer-
tions at 240° and 360° sec. The LR for each exercise was determined
by summing acceleration and deceleration ROM, then subtracting
that from total test ROM. Although knee extension exercise exhibited
greater LR at all speeds, no significant differences were observed
when compared with flexion exercise. The results are listed below
as LR percentage values; mean ± SEM.

<table>
<thead>
<tr>
<th>Extension (%)</th>
<th>Flexion (%)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>240° sec</td>
<td>71.9 ± 0.77</td>
<td>70.7 ± 0.87</td>
</tr>
<tr>
<td>360° sec</td>
<td>48.7 ± 1.9</td>
<td>48.4 ± 1.9</td>
</tr>
</tbody>
</table>

The nominal variations between movements exhibited in this study
suggest there are only slight LR differences between extension and
flexion isokinetic exercise in women at fast contractile speeds. There-
fore the potential for strength benefits associated with resistance by
means of sustained velocity during isokinetic exercise may be equally
realized across knee extension and flexion exercise at high velocities.

Full and Half-Range Barbell Squat Exercise: Differential
Training Effects
Peter Frykman1, Matthew Morrissey2, Everett Harman12, and Ki-Hoon
Han1, 1U.S. Army Research Institute of Environmental Medicine,
Natick, MA; and 2Boston University

To compare the training effects of full-range and half-range
squats, two groups of women (24 ± 4 yrs, 161 ± 6 cm, 58 ± 8 kg)
with little training experience squatted through knee angle ranges of
(a) 180°-90° (Full, n = 11) and (b) 180°-135° (Half, n = 10), doing
3 warmup sets and 3 8-RM sets, 3 times a wk for 7 wks, adding
weight as needed. Bar velocity was controlled and similar for both
groups. Half could handle over 60% more weight than Full. Pre/
posttests included force-platform/video biomechanical analysis of
the vertical jump, standing long jump, and max squat, and isokinetic
knee extension at 0, 25, 50, 100, and 125° sec. Results: Differential
training effects: Specificity was supported in that (a) each group
improved about twice as much in the type of squat at which it
trained than did the other group, and (b) across the isokinetic speeds
the mean increases by Half in work and torque over the 140°-180°
knee range of motion were larger than those of Full. For the vertical
jump, ankle average torque increased significantly more in Half than
in Full, but only Full increased significantly in knee average power.
Similar training effects: Both groups improved about 20% in isomet-
ric average torque; long-jump peak power (16%) and distance (28%);
and vertical jump peak power (25%) and peak force rate of change
(+65%). Conclusions: Both full and half-squats can improve perfor-
ance. Their training effect similarities indicate that half-squats can
substitute for full squats for people with range-of-motion problems.
The training effect differences indicate the importance of matching
exercises and sport movements according to range of motion, and
suggest incorporating both types of squat into some training programs.

Effects of Eccentric Training vs. Concentric Training on
Functional Motor Performance Skills of College Football
Players
G. Connelly, Z. Kendrick, J. Kimura, and M. Sitler, Temple University

This study compared the effects of eccentric training and concen-
tric training on two selected motor performance skills. Fifteen Div.
III college football players were randomly assigned to one of three
groups: eccentric training, concentric training, and control. The ec-
centric training group performed a modified daily adjusted progress-
ive resistance exercise leg extension program for the eccentric phase
only. The concentric training group performed the same modified leg
extension program for the concentric phase only. Both groups
performed the exercise on the Polaris variable resistance machine
(Spring Valley, CA). The control group performed their normal off-
season conditioning program. All groups completed their training
twice a week for 8 weeks. The modified Sargent jump test and
standing broad jump tests were used to pre- and posttest all groups.
All 3 groups had 2 days rest before posttesting data were collected.
Analysis of variance revealed a significant difference (p < 0.05) be-
tween the eccentric training group and the control group for the
modified Sargent jump; eccentric training subjects jumped farther
Although pre- to posttest scores for the eccentric training subjects
were greater than those of the concentric training subjects, these
differences were not significant. There was no significant difference
between the groups for the standing broad jump. It was concluded that
eccentric training may assist athletic performances that require
vertical jump activities.
8 Weeks of Moderate Simulated Stair Stepping (StairMaster® 4000PT) Failed to Alter Lower Extremity Peak Torque in Elderly Subjects
J.M. Clemens and C.M. Foret, University of Southwestern Louisiana

The purpose of this investigation was to determine the effect of 8 weeks of StairMaster® exercise on lower extremity peak torque (i.e., flexion and extension at the knee and hip, ankle plantar and dorsiflexion, and food inversion and eversion). Eighteen subjects volunteered: 14 women and 4 men (ages 57 to 74 yrs). The best of 5 reps at maximum effort on a Lido active multijoint isokinetic system at 90° sec was used. Parameters for hip and knee were set at 0 to 90°. Ankle and foot parameters were selected based on each subject’s range of motion (ROM). Pre and post parameters were held constant. Following the pretest, subjects were randomly assigned to treatment and control groups. The treatment group participated in StairMaster exercise 3 times a week (alternate days) for 30 min, 5 min for warmup, 20 min for moderate exercise at 55-60% of heart rate reserve, and 5 min for cooldown. Subjects were permitted to use handrails for balance during training. The control group did not use the StairMaster but were permitted to walk and go unsupervised, on their own. Posttesting on all dependent variables was done after 8 weeks. Data were analyzed collectively using repeated-measures multivariate analysis of variance at an alpha level ≤0.05. There was an overall significant difference for time (pre to post) regardless of treatment (StairMaster vs. control). No significant differences were observed for either treatment or the interaction of time and treatment. There were no differences between those involved in chronic, short-term moderate StairMaster exercise and those who walked periodically to effect changes in lower extremity peak torque. In practical application, StairMaster training periods may have to be longer than 8 weeks to effect such changes.

Prediction of the Energy Cost of Slideboard Exercise
H.N. Willford, L.A. Richards, M.S. Olson, D.L. Blessing, and N. Wang, Auburn University

This study was conducted to evaluate the effect of board length (BL), sliding rate (SR), weight (W), total leg length (LL), percent fat (%F), inseam length (IL), and height (H) on the energy cost of slideboard exercise. Thirty-four women were evaluated by open-circuit calorimetry while performing the basic slide technique. They were evaluated on slideboards 152.4 and 182.88 cm in length at SR 30, 40, and 50 metronome cadences per min. Sessions consisted of randomly assigned 5-min routines. Subject characteristics included the following mean ± SD values: age 24.3 ± 5.4 yrs, W 58.9 ± 9.4 kg, H 164.7 ± 6.3 cm, %F 19 ± 6%, LL 86.1 ± 3.8 cm, and IL 79.2 ± 3.8 cm. A multiple regression analysis determined that B, BL, W, and L significantly affected energy cost (VO₂ L·min⁻¹) p < 0.0001, VO₂ L·min⁻¹ = -2.793 + 0.026 · SR + 0.00893 · BL + 0.012 · W + 0.012 · LL, r = 0.86. SR and BL accounted for 60% of the VO₂, with W accounting for another 13%. The addition of %F, H, and IL did not significantly affect VO₂. These results demonstrate that SR, BL, and W were all important predictors of the energy cost. While LL was significant, it accounted for less than 1% of the prediction of energy cost. From a practical standpoint, energy cost can be predicted by knowing the BL, SR, W, and LL. An individual can apply these variables to the regression equation and determine the energy cost of slideboard exercise.

Funded by Fitness Innovations, Inc., Winchester, MA.

Effects of Aquatic Simulated and Dry Land Plyometrics on Vertical Jump Height
J. Stemn, M. Owen, L. Kimura, and M. Stiler, Temple University

This study compared the effects of aquatic simulated and dry land plyometrics on vertical jump height. Subjects, untrained 18- to 35-year-old male students at Temple University, were divided into 3 groups: Group 1 (n = 7) trained in the water, Group 2 (n = 8) trained on land, and Group 3 (n = 9) acted as the control. Plyometric exercises selected were the squat jump, side hop jump, and kneetuck jump. For each plyometric exercise Groups 1 and 2 performed 3 sets of 15 jumps with a 1-min rest between sets. Training took place twice a week for 6 weeks. Vertical jump height was measured by using the VERTEC apparatus as the data collection instrument. Subjects were given three chances to reach maximum height. The highest of the three jumps was used as the comparison measure for pre- and posttest scores. A 2 × 3 analysis of variance with repeated measures (p < 0.05) was performed to examine the differences among groups. The results revealed a significant interaction. A Tukey post hoc test revealed that vertical height for the two training groups was significantly greater than that of the control group, but there was no difference between training groups. Based on these results, one can conclude that plyometric training in an aquatic environment produces vertical jump increases similar to those obtained from training on dry land.

Performance Enhancement Training of Male Volleyball Players
D. Johnson, G. Gehlsen, D. Pearson, A. Hall, D. Grason, and D. Shondell, Ball State University

The purpose of this study was to determine the effects of a preseason performance enhancement training program on the mechanical power, flexibility, and vertical jump performance of 18 college male volleyball players. The 8-wk training program consisted of speed and agility drills, weight training, and a major emphasis on flexibility training. The volleyball players also participated in team practices during the entire 12 weeks. The subjects were tested for lower body flexibility, vertical jump height, and mechanical power determined from the vertical jump off of a force platform. Testing occurred prior to training, at the end of the training program, and 4 wks after the training program. Significant improvements were seen (p < 0.05) in hip adduction, hamstring, and quadriceps flexibility and maximal power output, 304.42 W, between the pre and 12-wk tests. Also, significant improvements (p < 0.001) occurred in vertical jump performance, 3.87 cm, and peak vertical jump velocity, 0.06 m/s, between the pre and 12-wk tests. There were no significant differences involving the 8-wk tests. The results indicate that the maximum benefits of enhancement training may be obtained after a period of decreased training volume and intensity. Athletes participating in high intensity sporting events may improve their performance by decreasing their training volume and intensity prior to the competition.

Ankles to the Bar: Testing Standardization, Norms, and Relationship to Anthropometry, Pull-Ups, Obstacle Course, and Freshman Gymnastics Performance
P.F. LaChance, USMA, West Point

A number of institutions and conditioning coaches incorporate a variety of exercises and tests into their training and evaluation programs to develop and assess components of muscular fitness. The pull-up (PU) and a biomechanically related movement, "ankles to the bar" (AB), may be performed wherever there is a high bar. A repetition of the PU is performed from full arm and body extension with a palms-facing-away grip. The concentric portion of the PU is completed when the arms and shoulders are flexed to elevate the chin and hyoid up to the bar. An AB rep involves the same PU starting position but is executed by partially flexing the arms and shoulders, with the torso, hips, and knees until the hips are elevated above the level of the shoulders and the shoeless are in contact with the bar. As part of the required program in 4th-class gymnastics, 112 college males (age 19.2 ± 1.1 yrs; body mass 72.8 ± 9.0 kg; height 177.1 ± 6.0 cm) from 4 of 32 PE classes were evaluated for maximal A8 (9.5 ± 3.4) and PU reps (9.4 ± 2.8), indoor obstacle course time (2.98 ± 22 min), as well as abdominal circumference (79.1 ± 5.2 cm) and corresponding estimates of % body fat (10.7 ± 3.5%) and lean
body mass (64.9 ± 6.8 kg). Students were encouraged on Lesson 1 to prepare and perform up to 12 AB and 14 PU for a maximal of 10 points toward their overall 230-point class grade. Respectively, AB and PU tests were administered Lessons 15 and 17 on a one-to-one basis with an instructor from a series of 10-6 ft bars suspended 2.43 m above the ground. One attempt was given to perform as many nonballistic AB and PU reps. Eighteen others were excluded from this evaluation because they performed >12 AB and 14 PU. Pearson correlations between AB, PU, and obstacle course performances, anthropometric, and final course grades are presented below.

<table>
<thead>
<tr>
<th>AB</th>
<th>PU</th>
<th>HT</th>
<th>BM</th>
<th>circ</th>
<th>% fat</th>
<th>LBM</th>
<th>IOC</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB reps</td>
<td>- .57</td>
<td>.05</td>
<td>.12</td>
<td>- .01</td>
<td>-.06</td>
<td>.17</td>
<td>-.22</td>
<td>.51</td>
</tr>
<tr>
<td>PU reps</td>
<td>- .13</td>
<td>-.08</td>
<td>-.11</td>
<td>-.12</td>
<td>-.03</td>
<td>-.10</td>
<td>-.03</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>-.53</td>
<td>.25</td>
<td>.12</td>
<td>.56</td>
<td>-.10</td>
<td>.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass</td>
<td>-.72</td>
<td>.49</td>
<td>-.90</td>
<td>-.12</td>
<td>.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominal circumference</td>
<td>-.95</td>
<td>.35</td>
<td>.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% body fat</td>
<td>-.06</td>
<td>.12</td>
<td>.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lean body mass</td>
<td>-.08</td>
<td>.14</td>
<td>.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoor obstacle course</td>
<td>-.07</td>
<td>.17</td>
<td>.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Percentile standards for AB were: 10th percentile = 4 reps, 25th = 6 reps, 50th = 11 reps, 75th to 100th = 12 reps. This pilot study provides some normative data for AB, and indicates that AB and PU performances appear to encompass similar components of fitness (r² = 0.32 ± 2.4 reps). Further, AB and PU ability are unrelated to either body size or composition in this homogeneous group. Although AB was moderately related to PU, these findings suggest that AB performance is a better indicator of potential gymnastics proficiency than are PU.

Growth Hormone Responses to Resistance Exercise: Relation to the Percent of Maximum Lifting

Richard R. Suminski, Robert J. Robertson, Sergio G. DaSilva, Jie Kang, Alan C. Luster, Fredric L. Goss, and Kenneth F. Metz, University of Pittsburgh

Growth hormone (GH) release during resistance exercise may be related to the exercise intensity (load), which dictates the degree of tissue hypoxia, as denoted by blood lactate concentration ([HL]). However, this relation has not been elucidated, especially at moderate resistance exercise intensities. Therefore this study compared the response of GH to moderate intensity resistance exercise. Subjects were 8 males (20.5 ± 1.9 yrs old, 80.1 ± 7.2 kg body weight, 133.3 ± 5.0% body fat, 40.9 ± 4.6 ml/kg · min⁻¹ maximal oxygen uptake). All experimental procedures conformed to the ACSM guidelines for subject experimentation. Subjects completed 3 experimental trials using a randomized, counterbalanced design as follows: (a) single session of resistance exercise at 50% 1-RM (i.e., 10 reps, 3 sets, 7 different exercises, 1 min rest between sets, and 3 min between exercises); (b) exercise as in Trial A except at 70% of 1-RM; (c) no exercise (i.e., baseline). Blood samples were drawn immediately before exercise (Time 0), and 30, 60, 90, 120, and 180 min after Time 0 for GH determination. Growth hormone concentration was determined via radioimmunoassay. Blood samples were obtained after the third set of each exercise for determination of [HLa]. Lactate was measured with a Yellow Springs lactate analyzer. Mean [HLa] and GH concentrations were higher (p < 0.05) during both bouts of exercise compared to Trial C, i.e., [HLa] mmol · L⁻¹ (50%) 5.56 ± 1.7, (70%) 8.79 ± 3.0, (baseline) 0.98 ± 0.18; GH ng · ml⁻¹ (50%) 15.6 ± 3.2, (70%) 16.7 ± 7.8, (baseline) 2.64 ± 0.63. [HLa] was higher (p < 0.05) during exercise at 70% compared to 50%. Growth hormone did not differ between the exercise trials. No significant correlation was found between [HLa] and GH. In conclusion, GH secretion does not appear to parallel increases in the intensity of resistance exercise or [HLa] when moderate loads are employed. Therefore the strength and conditioning coach may have the option of using lower percent-ages of 1-RM for muscle training without sacrificing GH related benefits.

Strength, Anaerobic Power, and Cycling Pursuit Performance During High-Intensity Aerobic Interval Training and Recovery


Six USCIF Category II and two Cat. I cyclists (n = 8), with a mean ± SEM age, height, weight, body fat, and VO2max of 20.8 ± 0.9 yrs, 180.3 ± 2.0 cm, 74.0 ± 2.0 kg, 7.7 ± 0.8% and 63.0 ± 2.0 ml · kg⁻¹ · min⁻¹, respectively, completed 3 weeks of high-intensity interval training followed by 2 weeks recovery. Weekly training included 8 max-effort interval sessions (94.0 ± 0.3% HRmax) aimed at improving 4-K pursuit performance, a 60-min easy ride (<65% HRmax), a 21–26 min GXT, a Wingate test, and a simulated lab pursuit test resulting in 12 hrs total cycling (25% at high intensity). The Wingate test, pursuit test, and isokinetic leg strength at 30, 180, and 300° · sec⁻¹ were measured weekly at baseline (B), during training (T1–T3), and every 3 days during recovery (R1–R4). Peak Wingate anaerobic power (974.0 ± 42 watts) and average 30-sec power (776.9 ± 30 watts) were unchanged from baseline during training and recovery, although there was a trend for anaerobic power to increase during recovery. Cycling pursuit performance significantly improved by 6.5% during training (B–T3), and further increased by 2.0% at 8 days of recovery (R2). Peak torque at 30° · sec⁻¹ for quadriceps, but not hamstrings, decreased significantly from baseline following training (T3), and then rebounded with a nearly significant increase above B during recovery (R2–R4). Quadr and ham strength at faster angular velocities were not significantly changed during training or recovery. These results suggest that high intensity aerobic interval training substantially improves pursuit performance in developing pursuit cyclists despite a training-induced decrease in quadriceps leg strength. Optimal recovery time from this type of high-intensity training appears to be between 8 and 11 days.

This study was funded by a United States Olympic Committee Grant.

Responses of Serum Creatine Kinase Activity to Heavy Resistance Exercise in Endurance and Recreational Trained Women


Questions arise as to whether athletes who are used to high intensity exercise training (e.g., track runners) may be less susceptible to initial soreness and tissue disruption associated with the first few workouts in a weight training program than just physically active people (e.g., recreational joggers). The purpose of this study was to determine if competitive female intermediate distance runners would be more resistant to exercise-induced muscle membrane disruption following an initial weight training session as compared to female recreational joggers. Serum creatine kinase activity was used as a marker for membrane disruption. Eight competitive NCAA Div. I collegiate intermediate distance runners and 8 recreational joggers (15–20 miles/wk) performed a heavy resistance exercise bout consisting of 9 exercises. Three sets of a 10-RM were performed for each exercise. A 2-min rest period was allowed between sets. Both groups refrained from any exercise 2 days prior to the day of the exercise bout. No significant difference was found between groups in total work (J) performed during the resistance exercise protocol. Resting serum creatine kinase activity was determined prior to exercise bout. Creatine kinase activity was measured immediately postexercise and 24 hrs after exercise. The competitive runners had significantly (p < 0.05) higher creatine kinase responses 24 hrs after the exercise bout as compared to the recreational joggers. Mean creatine kinase response for competitive runners 24 hrs postworkout was 271.88
HR, VO₂, Lactate, and Cycling Pursuit Performance During 3 Weeks of Interval Training and a 2-Week Recovery


This study investigated common GXT parameters and lab pursuit performance during and after 3 weeks of intense interval training. Eight accomplished USCF Cat. II (n = 6) and Cat. I (n = 2) cyclists (20.8 ± 0.9 yrs, 77 ± 0.8% body fat, 63.0 ± 2.0 ml·kg⁻¹·min⁻¹ VO₂peak) were tested weekly before (B), during training (T1–T3), and during a 2wk recovery (R1, R2). Weekly training included 8 interval training sessions (94.0 ± 0.3% HRmax), a 60-min continuous ride (<65% HRmax), a Wingate power test, a 21–25-min GXT, and a simulated 4km pursuit resulting in 12 hrs of weekly cycling (~3 hrs a week at 94% HRmax). Training during the 2wk recovery was of high intensity but low duration. During GXTs, heart rate (HRblood lactate (HlA), and oxygen uptake (VO₂) were recorded following each 3-min stage and at volitional fatigue. Time to complete 110 kL of work was recorded as pursuit time than using a computerized friction-braked bicycle ergometer. Best pursuit performance (78.4% from B), peak GXT time (77.7% from B), peak HlA (73% from B), and lowest HR at 300 Watts (35.8% from B) were observed following 8–9 days of recovery (R1). Interestingly, peak VO₂ (77% from B) occurred following 3 days of recovery (T3). A repeated measures ANOVA with a Bonferroni post hoc test determined that only changes in pursuit time and HR at 300 Watts were significantly different from B. Changes in mean pursuit time significantly correlated with changes in peak HlA (r = 0.93) and HR at 300 Watts (r = 0.92), suggesting that these variables may be useful for monitoring pursuit fitness. Further, it appears that an 8–9 day recovery is necessary for optimizing pursuit performance following 3 wk of intense interval cycling. Additional research is needed to better understand why peak pursuit performance does not coincide with the time of peak VO₂.

Funded by USOC Science and Technology Grant # S94-0174-07.

Effects of Conditioning on Isokinetic Leg Strength in Female Basketball Players

Adam W. Miller, University of the Pacific

The effects of a 12-week strength and conditioning program on knee extensor (quadriceps) and flexor (hamstring) strength were examined in 10 female Div. I basketball players (age 18.1 ± 3.2 yrs, body fat 19.3 ± 2.6%). The 12-week program (preseason) consisted of endurance (3–5 miles run) and plyometric training (2 times a wk); circuit weight training and jump-rope training (3 times a wk); and calisthenic and stretching exercises (3–5 times a wk). The Cybex 11 Isokinetic Dynamometer (Lake Ronkonkoma, NY) was used to assess isokinetic leg torque. Each subject was tested at 60, 180, and 240° in both left and right legs. The repetition that generated the greatest torque at each speed was recorded as peak torque for that speed. Data were analyzed by matched paired difference (p < 0.05). Posttesting showed significant decreases in isokinetic torque of knee extensor and flexor muscles in both left and right legs across all speeds tested (Table 1). A decrease in peak torque was seen in quadriceps and hamstring muscles of both legs as velocity (deg/sec) increased. Also, as velocity increased, the mean difference between quadriceps and hamstring torque decreased. The results indicate that although subjects were not trained isokinetically, significant decreases in isokinetic strength across varying speeds suggest possible losses in functional strength and power in leg musculature. Based on this, reevaluation of practice sessions and team or individual training variables must be addressed. This can ensure that program goals are achieved and that decreased athletic performance and increased injury rates do not occur over the course of the competitive season.

Table 1

<table>
<thead>
<tr>
<th>Torque Results Quadriceps and Hamstrings (N = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque (deg/sec)</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Pretest M SD</td>
</tr>
<tr>
<td>Change M SD</td>
</tr>
<tr>
<td>Left quadriceps</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>180</td>
</tr>
<tr>
<td>240</td>
</tr>
<tr>
<td>Right quadriceps</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>180</td>
</tr>
<tr>
<td>240</td>
</tr>
<tr>
<td>Left hamstring</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>180</td>
</tr>
<tr>
<td>240</td>
</tr>
<tr>
<td>Right hamstring</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>180</td>
</tr>
<tr>
<td>240</td>
</tr>
</tbody>
</table>

*Torque expressed in foot-lbs.

*Denotes statistical significance.

p < 0.05 = 2.26.

Power Output and Range of Motion of High School Football Placekickers


Indiana State University, and Texas Center for Sports Med & Orthopaedic Surgery, Sugar Land

Football is one of the most popular high school sports, and although placekicking is not physically demanding, the skill of the kicker often dictates the outcome of the game. It is accepted that kicking a football requires technique, power, and flexibility for optimal accuracy, velocity, and distance. At the high school level, the coach has limited insight into which of these variables need improvement to successfully kick a football. Since there is limited published research, the purpose of this study was to quantify physical attributes deemed necessary for football placekicking. Power (squat jump, countermovement jump) and 2A0OS extension, flexion, and rotation flexibility measurements—hip (14), spine (6), knee (4), ankle (4)—were performed on 14 varsity high school placekickers (age 17.5 ± 0.9 yrs, Ht 176 cm, Wt 72.7 kg). Right/ left leg power (ft lb/sec, watts,
watts/kg) were assessed. Data were subjected to SYSTAT procedures with means ± SEM shown below:

<table>
<thead>
<tr>
<th></th>
<th>Placekickers</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat jump (cm)</td>
<td>52.6 ± 1.5</td>
<td>n.a.</td>
</tr>
<tr>
<td>Countermove jump (cm)</td>
<td>53.6 ± 1.5</td>
<td>n.a.</td>
</tr>
<tr>
<td>Peak power (ft lb/sec)</td>
<td>839.8 ± 25.8</td>
<td>n.a.</td>
</tr>
<tr>
<td>(watts)</td>
<td>1137.8 ± 35.0</td>
<td>n.a.</td>
</tr>
<tr>
<td>(watts/kg)</td>
<td>15.7 ± 0.2</td>
<td>n.a.</td>
</tr>
<tr>
<td>Left hip extension (deg)</td>
<td>19.8 ± 1.2</td>
<td>20-30</td>
</tr>
<tr>
<td>Right/ left hip exter. rotation (deg)</td>
<td>35.2 ± 2.1</td>
<td>45-50</td>
</tr>
<tr>
<td>Right/ left ankle dorsiflexion (deg)</td>
<td>11.4 ± 1.0</td>
<td>15-20</td>
</tr>
</tbody>
</table>

In general, these high school athletes lacked overall power output observed with other sport athletes. Joint flexibilities were within normal range except for hip extension, hip external rotation, and ankle dorsiflexion. In addition, there were right/left flexiblity differences in most hip (3.8%), spine (2.2%), ankle (1.0%), and knee (0.5%) measurements. Placekickers may benefit from supplementing conventional sport activity with intensified power training and flexibility exercises to improve leg power and symmetry in range of motion.

Influence of the Strength Shoe and Three Plyometric Drills on Peak Torque, 40-Yd Dash, and Vertical Jump of High School Football Players


This study investigated the influence of the Strength Shoe and three plyometric drills on concentric and eccentric peak torque values of the triceps surae, 40-yd dash time, and vertical jump height. Subjects, 30 high school football players, were randomly divided into 3 groups of 10. All subjects participated in their regular football practice regimen. Two groups performed 3 additional plyometric drills. The first group, exercising in the Strength Shoe (EXSS), wore it for these drills. The second group, exercising in conventional shoes (EXCS), wore their own shoes. The third group, the control group (CG), also wore their own shoes but did not participate in the additional plyometric drills. Concentric and eccentric peak torque, 40-yd dash, and vertical jump data were collected before and after a 6-wk training period. Each subject was allowed only one attempt at the 40-yd dash and vertical jump during pre- and posttest data collection sessions. The Biodex B-2000 Isokinetic Dynamometer was used to collect left triceps surae concentric and eccentric peak torque data at 30 and 90° sec through a 50° arc of motion. Peak torque data collection involved randomly ordering isokinetic modes of contraction and velocities. Four 3-way ANOVAs with repeated measures (p < 0.05) were performed to examine the differences among test conditions. The results indicated a significant difference between velocities concentrically and between pre- and posttests eccentrically. Concentric means revealed greater peak torque generated at 30° sec than at 90° sec across groups for pre- and posttests. Eccentric means increased in the EXSS and CG groups and decreased in the EXCS group during the posttest at both velocities. The results also indicated significant decreases in 40-yd dash times and increases in vertical jump heights after the 6-wk training period across all groups. Significant differences were revealed among groups in the vertical jump test. Tukey post hoc test results revealed a significant increase in vertical jump heights in the group exercising in conventional shoes when compared to the group exercising in the Strength Shoe.

Ocular Hemodynamics Before and After Aerobic and Resistive Exercise

W.G. Horsky, J.G. Feghali, R.A. Yenter, and I.H. Ullrich, West Virginia University

Heart rate and systolic and diastolic blood pressures can show marked increases during resistance exercise. Theoretically, these factors could result in pronounced elevations in ocular blood flow. This study evaluated ocular hemodynamic responses to aerobic and resistive exercise in 11 healthy subjects (mean age 23 yrs). The Langham ocular blood flow system was used to record minimum and maximum intracocular pressures and pulse, and to calculate the pulsatile ocular blood flow (PBF). Recordings, with a pneumatic probe placed against the eye, were made at rest, following 3 min of steady-state exercise on a recumbent bike at 50 and 85% heart rate reserve (HRR), and after performing 2 sets of 15 alternate dumbbell curls. All recordings were started within 10 sec after exercise and were 5–10 sec in duration. Heart rates were monitored continuously by ECG during rest and exercise (HR), and during ocular measurements (HRM). Results were:

<table>
<thead>
<tr>
<th>HR (b·min⁻¹)</th>
<th>HRM (b·min⁻¹)</th>
<th>PBF (μL·min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest</td>
<td>75 ± 12</td>
<td>69 ± 11</td>
</tr>
<tr>
<td>50% HRR</td>
<td>138 ± 7b</td>
<td>114 ± 16b</td>
</tr>
<tr>
<td>85% HRR</td>
<td>178 ± 6b</td>
<td>161 ± 12b</td>
</tr>
<tr>
<td>Weights</td>
<td>171 ± 23b</td>
<td>132 ± 16b</td>
</tr>
</tbody>
</table>

*p < 0.05 vs. HR; **p < 0.01 vs. rest.

Heart rates during ocular measurements were correlated to PBF (r = 0.61, p < 0.001). PBF was significantly higher only after exercise at 85% HRR. HRM were significantly lower than HR obtained after exercise, or at rest without the pneumatic probe applied. Conclusion: As measured with the Langham system, ocular blood flow is not markedly increased by resistance exercise or moderate aerobic activity.
Two-Week Suppression of Lymphocyte Function Following 3 Weeks of High-Intensity Interval Cycling

Eight accomplished USCF Category II (n = 6) and Category I (n = 2) cyclists (20.8 ± 0.9 yrs, 77.7 ± 8.8% body fat, 63.0 ± 2.0 ml · kg⁻¹ · min⁻¹ VO₂max) completed 3 wks of high-intensity interval training followed by 2 wks of recovery. Weekly training included 8 interval training sessions (94.0 ± 0.3% HRmax), a 60-min continuous ride (<65% HRmax), a Wingate power test, a 20- to 26-min GXT, and a 4-km laboratory pursuit resulting in 12 hrs of weekly cycling (25% at high intensity). Cycling pursuit performance, while white blood cell count (WBC), percentage of lymphocytes (Lymph %), and mitogen-induced lymphocyte proliferation using concanavalin A (ConA), phytohemagglutinin (PHA), and pokeweed mitogen (PWM) were determined for baseline (B), following each week of training (T1-T3), and every 3 days during the 2-wk recovery (R1-R4). Venous blood for immune assay was sampled via venipuncture >36 hrs post intense training. WBC decreased significantly from B to T2 by 10.4% and increased consistently throughout the remaining training and recovery to a value 7.8% above B at R4. Lymph % continuously increased from B (33.8 ± 2.6%) to R4 (39.1 ± 2.3%). Despite increased WBC and Lymph %, lymphocyte proliferation decreased below the baseline stimulation index at R1 by 40, 28, and 38% for ConA, PHA, and PWM, respectively. These values remained depressed throughout the 2 wks of recovery for all mitogens. Increased WBC and Lymph % did not correlate (r = -0.28-0.28) with a decreased responsiveness to ConA, PHA, and PWM, suggesting the lack of relationship between WBC and lymphocyte numbers and lymphocyte function. The observation that pursuit performance peaked 8 days into recovery, whereas lymphocyte function was suppressed, suggests that optimal training for cycling pursuit performance may not be optimal for immune function and warrants further investigation.

Support in part by a grant from Quaker Oats.

Physiological and Performance Effects of 2 Commercially Marketed Supplement Systems

This study examined effects of Cybergenics and Weider anabolic mass on body composition, resting testosterone, cortisol, HGH, and 1-RM squat and bench press before and after 6 wks. Subjects, 28 males (22 ± 0.7 yrs, 178.2 ± 1.3 cm, 81.3 ± 2.3 kg), were assigned to one of three groups equalized for 1-RM strength. Groups (C = Cybergenics, W = Weider, P = Placebo) followed a prescribed training and supplementation program. F followed the W training program but received a placebo. Data were analyzed using ANCOVA (p ≤ 0.05) with the pre values used as the covariate. C showed significantly decreased body mass (~2.5%); no interactions for body mass were noted. W and P improved significantly more in the lifts than did C. In the 1-RM squat, W improved 11.7%, P improved 10.4%, and C improved 16%. In the 1-RM bench press, W improved 9.4%, P improved 3.8%, and C decreased 1.7%. Dietary recalls indicated no difference in total Kcal intake. W showed a significantly decreased cortisol and C showed a significantly decreased within-group T.C. These data suggest that C does not provide the same type of stimulus for strength gain as W and P, and C may cause a shift toward a less anabolic state.

Support by a grant from Weider, Inc.

Effect of Creatine Monohydrate Supplementation on Muscular Strength, Muscular Endurance, and Body Weight
C.P. Earnest, A.L. Ahmed, R. Rodriguez, P.G. Snell, and T.L. Mitchell, Goodbody’s Fitness Clinic and The Cooper Clinic, Dallas

Creatine monohydrate (Cr·H₂O) has previously been demonstrated to increase intramuscular creatine (Cr), phosphocreatine (PCr) (Harris et al., Clin. Sci. 83:367, 1992), and anaerobic performance indices (Balsom et al., Scand. J. Med. Sci. Sports 3:143, 1993). It has also been postulated that the Cr/PCr energy shuttle may promote muscle hypertrophy. To further explore these observations, 8 weight trained men (age 29 ± 3 yrs, experience 10 ± 3 yrs) were randomly assigned to receive, double-blinded, either oral Cr·H₂O (4 x 5 g Cr·H₂O + 1 g glucose/day, n = 4) or a glucose placebo (PL, 4 x 6 g glucose/day, n = 4) for 28 days. Prior to and immediately following the supplementation period, each subject was evaluated for body weight (BW), percentage of fat mass (%FM) via hydrostatic weighing,
and 1-RM bench press. In addition, subjects performed as many reps as possible at 70% of their pretest 1-RM. This test was metronome- paced using a 1-s cadence so that both concentric and eccentric movements were similar for all participants. Total lifting volume (TLV) was defined as the number of complete lifting reps × 70% 1-RM. A dependent t test was used for analysis of pre- vs. posttest results. The Cr2H20 group showed significant (p < 0.05) increases in the following parameters:

<table>
<thead>
<tr>
<th></th>
<th>Pre-Cr. H2O</th>
<th>Post-Cr. H20</th>
<th>±Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-RM:</td>
<td>126.4 ± 20.5 kg</td>
<td>134.6 ± 18.9 kg</td>
<td>8.2 kg</td>
</tr>
<tr>
<td>TLV:</td>
<td>101.77 ± 93.5 kg</td>
<td>145.90 ± 122.3 kg</td>
<td>441.3 kg</td>
</tr>
<tr>
<td>Reps at 70% 1-RM:</td>
<td>11.5 ± 1.0</td>
<td>15.5 ± 2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>BW:</td>
<td>86.5 ± 11.9 kg</td>
<td>88.2 ± 12.2 kg</td>
<td>1.7 kg</td>
</tr>
</tbody>
</table>

No changes were noted in any of the above parameters for the PL group or for %FM in either group. This study confirms that Cr2H20 supplementation can increase muscular strength and endurance and may augment muscle hypertrophy.

Grant support: Experimental and Applied Sciences, Inc., Pacific Grove, CA.

**Effects of Solid Carbohydrate Feddings on Glycogen Resynthesis Following Aerobic and Anaerobic Exercise**

D.R. Pearson, B.A. Edordas, D.L. Costill, and W.J. Fink, Ball State University

The importance of muscle glycogen as a fuel source during exercise has been well documented. Maintaining a high glycogen level before and during activity is a major determinant of performance. Elevation of glycogen levels during recovery from both aerobic and anaerobic bouts of exercise is critical. The purpose of this investigation was to determine the effect of a solid carbohydrate feeding on glycogen resynthesis following aerobic and anaerobic exercise. Eight male cyclists were recruited for this investigation. One-hour ride trials at 70% VO2 max followed with feeding (H-F), one sprint trial followed with feeding (S-F), and one sprint trial followed with no feeding (S-NF) were randomly performed and separated by 10 days. Feeding trials consisted of a solid CHO source (1g CHO per kg BW per hr) fed for 4 hrs of recovery following 1 hr of passive recovery with no food. Muscle biopsies were obtained immediately post and at 6 hrs of recovery. Blood was collected at 1, 4, and 30 min of recovery for lactate determination. Muscle specimens were analyzed for glycogen and lactate. Muscle glycogen (mmol·Kg-1 protein) levels postexercise for H-F, S-F, and S-NF trials were 336.9 ± 48.1, 417.5 ± 26.4, and 481.0 ± 47.0, respectively, with H-F significantly lower than S-NF. The increase in muscle glycogen 6 hrs postexercise for H-F, S-F, and S-NF trials were 117.9 ± 24.8, 207.2 ± 20.4, and 59.3 ± 10.7, respectively, which were all significantly different (p < 0.05). Blood lactate at +4 min for H-F, S-F, and S-NF trials were 3.0 ± 0.5, 18.8 ± 1.3, and 19.1 ± 0.9, respectively. These data suggest that an athlete training twice during the day with both anaerobic and aerobic components will have greater muscle glycogen available later in the day if anaerobic training is completed first in the day, providing that adequate carbohydrate is consumed between training bouts.

Grant funding from Nabisco 63-94.

**Anthropometric Effects on Load Range During Knee Extension Exercise at High Velocities**

M. Whitehurst, L.E. Brown, B.W. Findley, and R. Gilbert, Florida Atlantic University

This study investigated the relationship between range of motion (ROM) which is sustained at a predetermined isokinetic velocity, termed load range (LR), and the anthropometric variables of gravity effect torque (GET) and lever length (LL) during isokinetic knee extension exercise at fast contractile speeds. Nine men (age 34.2 ± 2.3 yrs) performed three maximal concentric knee extension repetitions at 240, 360, and 450° sec. The LR was determined by summing acceleration and deceleration ROM, then subtracting that from the total test ROM. Results revealed negative correlations between the variables GET, LL, and LR. Below are the results of Pearson product moment correlations between variables:

<table>
<thead>
<tr>
<th></th>
<th>240° sec</th>
<th>360° sec</th>
<th>450° sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET</td>
<td>-0.13 GET</td>
<td>-0.43 GET</td>
<td>-0.66 GET</td>
</tr>
<tr>
<td>LL</td>
<td>-0.48 LL</td>
<td>-0.40 LL</td>
<td>-0.61 LL</td>
</tr>
</tbody>
</table>

These results demonstrate an inverse relationship between LR and the anthropometric variables of GET and LL. This suggests that individuals with heavier and longer lower limbs may sustain velocity through less ROM during knee extension exercise under isokinetic conditions at fast speeds. Therefore, anthropometric influences may negatively affect load range and associated isokinetic strength training benefits during knee extension exercise at high velocities.

**Effect of Exogeneous Movements on Peak Torque and Constant Joint Angle Torque-Velocity Curves**

J.P. Weir, S.A. Evans, and M.L. Houff, Teachers College-Columbia University; and University of Nebraska-Lincoln

We have observed that some subjects tend to perform extraneous movements during isokinetic leg extension and flexion tests. Often these movements involve flexion of the trunk and contralateral leg during leg extension and flexion of the trunk and contralateral leg during leg flexion. This investigation assessed the effect of these extraneous movements on isokinetic peak torque (PT) and constant joint angle (CJA) torque-velocity curves. Subjects were 7 males (23.3 ± 0.8 yrs) and 12 females (22.4 ± 1.2 yrs). Each subject performed isokinetic leg extensions and flexions of the right leg under two conditions. Under the stabilized (ST) condition the trunk and contralateral leg were securely stabilized. Under the nonstabilized (NS) condition, leg extensions and flexions were performed with trunk and contralateral leg movements. Testing order was randomized and test conditions were at least 48 hrs apart. All testing was performed on a calibrated Cybex II isokinetic dynamometer at 1.05, 3.14, and 5.24 rad · s-1. The CJA torque values were recorded at a joint angle where the lever arm was 0.26 rad below the horizontal plane. Data were analyzed with two (PT and CJA) 4-way sex × condition × velocity × movement (male, female × ST, NS ×1.05, 3.14, 5.24 rad · s-1 × extension, flexion) mixed-factorial ANOVAs. The results showed that for CJA torque, the ST condition resulted in greater torque values (collapsed across sex and velocity) than NS for extension (9.9%) and flexion (63.4%). Similarly, for PT, the ST condition resulted in greater torque values (collapsed across sex and velocity) for extension (7.4%) and flexion (31.3%). These results indicate that the extraneous movements reduced torque production.

**Lower Abdominal Muscle Recruitment**

L. Silbert and D. Lally, University of Hawaii

Seventeen lean athletes, 9 trained to recruit lower abdominal muscles and 8 untrained (skinfold at abdominal site 10 ± 5) executed 7 different abdominal exercises with surface electrodes bilaterally placed on the rectus abdominis muscles both caudal and cephalad to the umbilicus. Mean action potentials (MAP) were quantitatively evaluated and differentiated between the upper and lower rectus abdominis both within and between the exercises and between the 2 groups. ANOVA indicates that specific lower abdominal training significantly (p < 0.03, F = 1.10) increases the ability to isolate and recruit the lower abdominal muscles in the 7 abdominal exercises tested. Two-tailed T test (p < 0.05) indicates that the MAP of both groups were significantly greater for upper and lower abdominals when either a crunch or a reverse curl were performed on a 20°
Topographical Differences in Isokinetic Torque-Velocity-Angle Curves Among Specific Athletes

J.F. Signorile and J.F. Caruso, University of Miami

3-D surface plots of the knee extensors, encompassing 14 isokinetic speeds and 59 knee angles, were produced for 4 college male track athletes. Two subjects were 100-m sprinters (SP), and two competed at the 800- to 1,500-m distances (MD). Data were collected on a Biosys isokinetic dynamometer at speeds ranging from 30 to 450° sec and at angles ranging from 68 to 174°. Subjects performed 3 reps per speed, and the repetition producing the highest torque was used for analysis. The MD curves showed a far greater decline in torque across speeds than SP (MD = 120.2 ± 26.1 ft-lbs, SP = 99.5 ± 1.3). In addition, the MD curve was more curvilinear, showing its greatest slope during dramatic torque reductions at the lower speeds. When viewed across angles, the MD curve showed a more delineated torque peak at all speeds while the SP curve exhibited a flatter overall surface and greater area. This was especially evident at the higher speeds of contraction where the integral (total work) was 135.1 ± 4.8 ft-lbs for SP compared to 83.05 ± 28.49 ft-lbs for MD. Preliminary examination of the curves suggest that SP were able to maintain torque throughout the range of motion far better than MD. It is suggested that more careful analysis of such curves can lead to diagnosis of decrements and exercise prescription for both athletic and injured populations.

1-RM Prediction From Repetitions to Fatigue Using the Bryzcki Formula

D.A. LeSuer, J.H. McCormick, J.L. Mayhew, and M.D. Arnold, Washburn University of Topeka; Northeast Missouri State University; and Clark College, Vancouver

The purpose of this study was to determine the accuracy of predicting a 1-RM bench press (BP), 1-RM squat (SQ), and 1-RM deadlift (DL) using the Bryzcki formula. This formula indicates that a predicted 1-RM = weight lifted/1.0278 - (1/0.0278) (x) (x = no. of reps performed). Participants were 68 untrained college males and females, ages 18 to 36, who enrolled in weight training classes. Prior to data collection, four 45-min class sessions were used to instruct subjects on proper form and technique of the BP, SQ, and DL exercises. During this period subjects found an appropriate resistance that would bring them to fatigue in 10 or fewer reps. They were randomly assigned to two experimental groups. Subjects in Group A were tested using a 1-RM BP. After a minimum rest period of 10 min they were asked to perform 2 to 10 reps of a resistance that would bring them to fatigue. Subjects in Group B first performed the reps to fatigue on the BP. After the 10-min rest period they were tested using a 1-RM BP. The next two class periods were used to test the SQ and DL exercises using the same two group procedures mentioned above. The data was then analyzed to determine if the Bryzcki formula could accurately predict a 1-RM on the BP, SQ, and DL exercises. The results found a high correlation, r = 0.99 for the BP, 0.97 for the SQ, and 0.95 for the DL when comparing the reps to fatigue using the formula and the actual 1-RM. Therefore the formula developed by Bryzcki can be used to accurately predict a 1-RM for all three exercises.

Effective Lumbar Strengthening in a Rehabilitation Setting

J. Keeler, I. Lowenstein, J. Devitt, and D. Lehman, Miami Beach Sportsmedicine

Due to the prevalence of lumbar back injuries in sports and work activities, this study examined lumbar strengthening in a clinical setting. Patients, 23 M and 25 F, were diagnosed with a lumbar back injury. Of these, 36 were LS sprains (LS) and 12 were disc complications (DC). Patients completed a 4- to 17-wk strengthening program. Testing and strengthening were completed on a MedX (Ocala, FL) lumbar extension machine. Patients were tested isometrically (pre 1) at 7 equidistant points between 0–72°. This was followed by dynamic exercise to momentary muscle fatigue, followed by a second isometric test (post 1). The strengthening program consisted of one session a wk at a workload of 60–85% of pretest max. At the end of the program they were retested as above (pre 2, post 2). Paired t tests indicated significant increases in lumbar strength from pre 1 to pre 2 (p < 0.001) as well as post 1 to post 2 (p < 0.001) at each tested angle. Independent t tests revealed no significant differences in relative strength gains from pre 1 to pre 2 or from post 1 to post 2 between the sexes or diagnoses for any of the test angles. Patients with DC also had significant gains between all test angles except at 72°. Results indicate that one session a wk of MedX lumbar strengthening is effective for both males and females with LS and DC.

Reliability and Validity of a Force Platform System for Measuring Vertical Jump Performance

G.K. Kandil, J.H. Oppelger, J.L. Wise, and J.M. Zody, Fort Hays State University

The IMPAX 420 is a commercially available force platform system (FPS) designed for jump training and measurement programs. This study evaluated the reliability and validity of this FPS as a measure of vertical jump performance. Vertical jump (VJ) of 53 NCAA Div. II athletes, 29 males and 24 females, was measured three times using the FPS and a traditional reach jump (RJ) protocol concurrently. Intraclass reliability coefficients were calculated from repeated measures ANOVA. Mean jump performance improved for each trial, with RJ measurements consistently higher than FPS (RJ = 19.4, 20, and 20.5 in.; FPS = 14.4, 14.7, and 15.1 in.). Stability reliability R values were 0.99 (FPS) and 0.98 (RJ) for females, 0.98 (FPS) and 0.93 (RJ) for males, and 0.99 (FPS) and 0.98 (RJ) for both sexes combined. Validity was evaluated from the correlation between RJ and FPS. The R value was 0.93 for females, 0.81 for males, and 0.94 for both combined. The error (difference between RJ and FPS measurement) tended to increase with higher jumps (R = 0.71), which may partly explain the lower correlation for males. In summary, the IMPAX 420 force platform system is a reliable, objective, and valid indicator of vertical jump performance. However, this FPS consistently underestimated actual jump height. The difference between FPS and RJ measurements tended to increase as jump height increased.

Effects of Eccentric Resistance Training on the Cross-Sectional Areas of the Muscles of the Quadriceps Femoris

D.J. Houle, T.J. Houle, J.P. Weir, L.L. Weir, and G.O. Johnson, University of Nebraska–Lincoln

This investigation examined the effects of eccentric dynamic constant external resistance (DCER) training on the cross-sectional
areas (CSA) of the individual muscles of the quadriceps femoris. Subjects were 17 men (24 ± 3 yrs), 9 comprising the eccentric training group (ECC) and 8 serving as controls (CTL). The ECC group performed 3 to 5 sets (3 sets for Week 1, 4 sets for Week 2, and 5 sets for Weeks 3-8) of 6 reps of eccentric DCER contractions of the nondominant quadriceps at 80% of a one repetition maximum (1-RM) load. The 1-RM load was determined every 2 wks and the training resistance was set accordingly. Magnetic resonance imaging (MRI) was used to determine the CSA of the vastus intermedius (VI), vastus lateralis (VL), vastus medialis (VM), and rectus femoris (RF) muscles at mid-thigh prior to and following the 8-wk period for both groups. Mixed-factorial ANOVAs (2 × 2; pretraining and posttraining by ECC and CTL groups for each muscle) with 1 test post hoc procedures were used to examine training-induced changes for eccentric strength and muscle CSA. The results indicated a significant (p < 0.05) increase in eccentric strength for the ECC group (29%) but no change for the CTL group. Furthermore, there were no significant (p > 0.05) increases in CSA at mid-thigh for any muscles of the quadriceps femoris (VI, VL, VM, and RF) for either group. These findings demonstrated a substantial increase in eccentric strength that was not accompanied by changes in muscle CSA. Traditionally, disproportionate increases in DCER strength (compared to changes in muscle CSA) have been attributed to neural adaptations that allow for a greater expression of strength or improved coordination.

Validity of Skinfold, Bioelectrical Impedance, and Near-Infrared Interactance Equations for Assessing Changes in Fat-Free Weight in Females

Joan M. Eckerson, Jeff R. Stout, Terry J. Housh, and Glen O. Johnson. Eastern Michigan University; and University of Nebraska-Lincoln

The present study examined the validity of selected skinfold (SF) (Sum 7 and Sum 3), bioelectrical impedance (BIA), and near-infrared interactance (NIR) (Futrex 5000 and Futrex 1000) equations (Eq) for assessing changes in fat-free weight (FFW) following 9 wks of weight training by comparing the estimates to values obtained from underwater weighing (UWW). Subjects were 15 female volunteers (21.5 ± 2.8 yrs). FFW (from UWW) increased significantly by 1.7 kg (47.3 to 49.0 kg; p < 0.01) following the training period. Validation analyses pretraining and posttraining included examination of the constant error (CE), standard error of estimate (SEE), r, and total error (TE):

<table>
<thead>
<tr>
<th>Pretraining</th>
<th>Posttraining</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE</td>
<td>SEE</td>
</tr>
<tr>
<td>Sum 7 vs. UWW</td>
<td>1.9*</td>
</tr>
<tr>
<td>Sum 3 vs. UWW</td>
<td>2.3*</td>
</tr>
<tr>
<td>FI000 vs. UWW</td>
<td>0.1</td>
</tr>
<tr>
<td>FS000 vs. UWW</td>
<td>0.2</td>
</tr>
<tr>
<td>BIA vs. UWW</td>
<td>~1.6*</td>
</tr>
</tbody>
</table>

*p < 0.01

The results indicated that the BIA Eq that resulted in a TE value of 2.3 kg was most accurate pretraining while the Sum 7 SF Eq of Jackson et al. (1980) was most accurate posttraining (TE = 1.5 kg). Correlational analysis between the actual and predicted changes in FFW indicated that none of the equations accurately monitored individual changes in FFW (r = 0.56 to 0.40). Given that TE values were generally greater than changes in FFW, and the correlations between actual and predicted changes were low to moderate, caution should be used when applying these equations (SI, BIA, and NIR) for monitoring training-induced changes in FFW.

Selected Physical Fitness Characteristics of Professional Male Firefighters


While firefighting has not been shown to be dependent on physical fitness, it may take high fitness levels to meet the demands of this profession. Therefore this study measured selected physical fitness characteristics of male firefighters with comparisons made to age-matched norms. Subjects, 206 male firefighters (age 33.0 ± 5.6 yrs, Ht 178.5 ± 7.9 cm, Wt 85.4 ± 12.9 kg), were divided into three age groups (20-29, n = 59; 30-39, n = 116; 40-49, n = 31) and were evaluated for cardiorespiratory endurance (VO2), body fat (BP), upper body muscular endurance (PU), trunk flexion (TF), and relative upper body muscular strength (1-RM bench press/body weight). The results listed below are means ± SD with comparisons made to age-matched norms as the percentage scoring above average (%AA).

<table>
<thead>
<tr>
<th></th>
<th>20-29</th>
<th>%AA</th>
<th>30-39</th>
<th>%AA</th>
<th>40-49</th>
<th>%AA</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO2</td>
<td>33.7± 8.5</td>
<td>17</td>
<td>33.1± 8.8</td>
<td>18</td>
<td>27.9± 9.1</td>
<td>10</td>
</tr>
<tr>
<td>BF</td>
<td>17.0 ± 6.3</td>
<td>31</td>
<td>18.5 ± 5.6</td>
<td>32</td>
<td>21.3± 5.2</td>
<td>13</td>
</tr>
<tr>
<td>PU</td>
<td>37.7 ± 13.1</td>
<td>34</td>
<td>34.8 ± 15.6</td>
<td>34</td>
<td>28.6± 13.2</td>
<td>55</td>
</tr>
<tr>
<td>TF</td>
<td>30.6 ± 9.0</td>
<td>54</td>
<td>28.5 ± 8.6</td>
<td>49</td>
<td>27.5± 11.0</td>
<td>45</td>
</tr>
<tr>
<td>1-RM</td>
<td>1.1 ± 0.3</td>
<td>41</td>
<td>1.1 ± 0.2</td>
<td>55</td>
<td>1.0± 0.2</td>
<td>55</td>
</tr>
</tbody>
</table>

The majority of these firefighters did not have greater than average levels of physical fitness. While this may suggest that firefighters need not possess higher levels of physical fitness, future studies should identify the minimum levels of fitness needed to sustain professional firefighting duties during typically adverse working conditions.

Relationships Between Upper Body Strength, Power, and Anthropometric Variables in Black and White College-Age Males

D. Fields1, M. Renbom1, and J. Mayhew2. 1University of Oklahoma; and 2Northeast Missouri State University

Researchers have used anthropometric measures to help explain strength and power relationships in the upper body; however, these relationships have not considered race as a possible confounding factor. Therefore the purpose of this study was to determine if the observed relationships between strength, power, and anthropometry were similar for both black and white males. Written informed consent was obtained from 29 college age males (mean age 21.1 yrs, height 177.8 cm, and weight 77.8 kg) prior to testing. Upper body strength was measured by a 1-RM bench press (BP; Smith press machine), power was estimated by a seated pot shot put (SSP), and anthropometric variables included height (Ht), body weight (BW), lean body mass (LBM), % body fat (%F), upper arm and chest circumferences (AC and CC), arm length (AL), and estimated upper arm cross-sectional areas (CSA). Removing the effect of BW and LBM by the partial correlation technique reduced the strength-power relationship for the entire subject sample from r = 0.53 to r = 0.48 and 0.40, respectively.

<table>
<thead>
<tr>
<th>Race</th>
<th>Ht (cm)</th>
<th>BW (kg)</th>
<th>LBM (kg)</th>
<th>% Fat</th>
<th>AC (cm)</th>
<th>CC (cm)</th>
<th>CSA (cm²)</th>
<th>AL (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>177.4</td>
<td>82.8*</td>
<td>71.6</td>
<td>12.3*</td>
<td>31.3*</td>
<td>92.9</td>
<td>63.5</td>
<td>76.1</td>
</tr>
<tr>
<td>White</td>
<td>178.6</td>
<td>73.7</td>
<td>67.0</td>
<td>9.1</td>
<td>28.1</td>
<td>89.6</td>
<td>55.8</td>
<td>74.4</td>
</tr>
</tbody>
</table>

A similar pattern was observed if race was considered. The strength-power relationship for white males declined from r = 0.60 to 0.45 (BW) and r = 0.36 (LBM) whereas the strength-power relationship for black males declined from r = 0.49 to 0.45 (BW) and finally to r = 0.40 (LBM). Stepwise regression analyses selected different variables to predict SSP performance and BP depending on whether race was considered. LBM and BP predicted SSP (R² = 0.44) when all subjects were considered; however, only BP (R² = 0.36) was a significant predictor of SSP for the white male subsample whereas only LBM (R² = 0.39) was significant for the black subjects. If BP was predicted, AC, CSA, and SSP (R² = 0.61) were chosen from the total sample while only CSA was a significant predictor of BP from each subsample (R² = 0.76 and 0.34, white and black subjects, respectively). Therefore it appears that strength-power relationships are
not only influenced by anthropometric variables but that race may also be an important factor to consider.

Effects of a Supervised Resistance Training Program on Adolescents and Young Adults With Mental Retardation
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This study conducted a program of resistance training to adolescents and young adults, with mild to severe mental retardation (MR), to determine what strength gains if any occurred. Twelve individuals with MR, ages 17 to 21, with mild to severe mental retardation (IQ range 60-82), participated in a 30-min resistance training program for 23 weeks. They exercised twice a wk on 6 Nautilus machines. During each exercise session subjects completed one set of 10 to 15 reps on each machine and one set of situps. When the subject could complete more than 15 reps using correct form, the weight load was increased. Before and after the resistance training program, muscular strength was assessed with a 3-RM test on the chest press (CP), leg extension (LE), and lat pulldown (LP) machines, and by a 30-sec situp (SU) test. Subjects demonstrated significant (p < 0.05) absolute and relative (relative to body weight [RBW]) strength gains in all tests of bilateral muscular strength. Results were as follows:

<table>
<thead>
<tr>
<th>BW</th>
<th>CP (RBW)</th>
<th>LE (RBW)</th>
<th>LP (RBW)</th>
<th>SU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>159</td>
<td>75.0</td>
<td>101.7</td>
<td>76.7</td>
</tr>
<tr>
<td>Post</td>
<td>160</td>
<td>95.4</td>
<td>122.5</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The magnitude of improvement for the criterion measures ranged from 20.4 to 30.5% and is similar to improvements seen in subjects without MR. It was concluded that adolescents and young adults with moderate to severe MR can participate and experience significant improvements through a supervised resistance training program. In addition to these strength gains, such a program would be helpful for improving body composition and overall health, as well as the learning of physical skills, to facilitate more successful integration of these individuals in both their work and recreational environments.

Relationship Between Knee Flexion Unilateral and Bilateral Deficit in Women
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The bilateral deficit (BD) during force production is thought to be a function of decreased muscle unit activation as well as a possible neural inhibition of the dominant limb when coupled with a weaker limb, whereas the unilateral deficit (UD) may be attributed to limb dominance. This study examined the relationship between UD and BD. Twelve women (mean age 34.9 ± 8.2 yrs, height 160.7 ± 2.3 cm, weight 59.2 ± 3.3 kg) performed three concentric isokinetic knee flexion reps at 60 and 120° sec using unilateral dominant, nondominant, and coupled bilateral limbs. The BD (100 [bilateral total/unilateral total] - 100) and UD (100 [nondominant/dominant] - 100) were calculated on peak torque data at each velocity. Pearson product-moment correlation coefficients (r) revealed a positive relationship between knee flexion UD and BD:

<table>
<thead>
<tr>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.53</td>
<td>0.07</td>
</tr>
<tr>
<td>0.45</td>
<td>0.14</td>
</tr>
<tr>
<td>0.40</td>
<td>0.19</td>
</tr>
<tr>
<td>0.53</td>
<td>0.07</td>
</tr>
<tr>
<td>0.49</td>
<td>0.10</td>
</tr>
</tbody>
</table>

These results suggest that a strength imbalance between limbs may play an important limiting role in bilateral flexion activity. Therefore, individuals interested in augmenting bilateral flexion performance should consider reducing the unilateral deficit.

Generality of Measurement for 1-RM Bench Press Strength Following Nautilus Resistance Training
Lee Bates, Jack Boven, Jerry Mayhew, and Paul Visich. Northeast Missouri State University, and Kirkville College of Osteopathic Medicine

The purpose of this study was to determine the generality of training on maximal bench press strength evaluation. Male (n = 98) and female (n = 101) members of a college fitness class were evaluated prior to training for 1-RM bench press strength using free weights (FW) and a plate-loaded Nautilus bench press machine (BPM). After 8 weeks of progressive resistance training using the BPM, each subject was reevaluated for 1-RM on FW and BPM. The training program consisted of 2 sets of 8 to 12 reps. At pre- and posttraining testing, both men and women had 18 to 22% higher 1-RM values (p < 0.05) using the BPM. Correlations between the two methods at pre- and posttraining tests were high for men (r = 0.84 and 0.88) and moderate for women (r = 0.65 and 0.71). Both groups made significant gains (p < 0.05) in 1-RM strength on both testing methods. The percent increase for BPM was significantly greater (p < 0.05) than FW for men (BPM 19.0 ± 12.8%, FW 12.1 ± 31.2%) but not for women (BPM 21.0 ± 20.0%, FW 16.8 ± 16.4%). The correlations between pre- and posttraining 1-RM values on FW (men, r = 0.84; women, r = 0.78) were high and similar to those on BPM (men, r = 0.87; women, r = 0.74). Therefore, despite the significantly higher strength values registered on a BPM, there appears to be significant carryover from training on BPM to FW bench press evaluation to indicate a generality component in measuring strength development.

Relationship of Pullup and Lat-Pull Performances to 1-RM Lat-Pull Strength
T.G. Chandler, S.C. West, R.B. Larkin, B.J. Crady, and J.L. Mayhew. Northeast Missouri State University, and Kirksville College of Osteopathic Medicine

The purposes of this study were (a) to determine the relationship of pullup and lat-pull performances to 1-RM lat-pull strength and (b) assess the use of repetition exercises to estimate 1-RM strength. Thirty college baseball players (age 20.0 ± 1.7 yrs, weight 82.3 ± 10.6 kg) were evaluated for 1-RM lat-pull (LPmax) using a standard lat-pull machine. Subsequently, each player performed repetitions to failure in the lat-pull using 60% 1-RM (LPR) and in deadhand pullups (PU). A pronated grip with hands slightly wider than shoulder width was used for all testing. Subjects performed significantly more LPR (19.5 ± 5.0) than pullups (6.3 ± 2.9), and the two were not significantly related (r = -0.04). LPMax was equivalent to 103.3% (±14.4%) of body mass and significantly related to lat-rep work (r = 0.74) and body mass (r = 0.72), but not significantly related to PU (r = 0.35) or LPR (r = 0.01). LPmax/kg body mass was significantly related to pullups (r = 0.80) but not to lat pullups (r = 0.12). LPmax predicted from LPR and load lifted significantly underestimated actual LPmax by -11.4% (±3.1%), while LPmax predicted from PU and body weight significantly overestimated LPmax by 19.0% (±8.4%). Lat-pull work was nonsignificantly related to pullup work (r = 0.37) but highly related to predicted (r = 0.86) and actual LPmax (r = 0.74). Subjects who pulled <100% of their body mass in LPmax were able to do 4.3 pullups (±1.9). In conclusion, it appears that PU and LPR do not reflect LPmax and that each exercise is sufficiently different to invalidate using one to predict the other.

Accuracy of Predicting Bench Press and Squat Performance From Repetitions at Low and High Intensity
M.D. Arnold, J.L. Mayhew, D. LeSueur, and M. McCormick. Clark College: Northeast Missouri State University; Kirkville College of Osteopathic Medicine; and Washburn University

To evaluate the validity of 6 equations for predicting 1-RM in the bench press (BP) and squat (SQ), 47 college men and women
were measured for repetitions to failure (RTF) using low (65% 1-RM) and high (85% 1-RM) intensity. Each subject was assessed at the end of a 10-wk weight training course after instruction in proper technique for both lifts. RTF for each exercise were randomly assigned the week following 1-RM determination. At 65% 1-RM, 4 equations significantly overpredicted BP by an average of 15.4% and 2 significantly underpredicted BP by an average of 6.4%. The correlations between predicted and actual BP ranged from \( r = 0.58 \) to \( 0.99 \). At 85% 1-RM, 5 equations significantly overpredicted BP by an average of 5.0%, with all validity correlations above \( r = 0.96 \). In the SQ at 65% 1-RM, 3 equations significantly underpredicted by 11.1%, 2 nonsignificantly underpredicted by 1.3%, and 1 nonsignificantly overpredicted by 5.1%. At 85% 1-RM, 5 equations significantly overpredicted SQ by an average of 3.6% and 1 nonsignificantly underestimated by 0.2%. Generally, predictions with RTF at 85% 1-RM produced higher correlations and smaller percent differences with actual strength measurements than RTF at 65% 1-RM. The O'Connell prediction equation was best for estimating BP (\( r = 0.99 \), \( SEE = 3.6 \) kg) and SQ (\( r = 0.98 \), \( SEE = 6.7 \) kg).

**Parallel Dips as a Predictor of 1-RM Bench Press Strength**

T.E. Ball, J.L. Mayhew, and J.C. Bowen. Northern Illinois University; and Northeast Missouri State University

Calisthenic exercises offer an appealing approach for training and evaluation of strength activities. Parallel dips are a commonly used training exercise, and because of their biomechanical nature might offer an excellent means of predicting upper body strength. This study assessed the potential of dips for predicting 1-RM bench press strength. Men (\( n = 246 \)) enrolled in a general fitness course gave their informed consent to be evaluated during the first week of class for 1-RM bench press, maximum parallel dips to failure, and several anthropometric variables. Relative body fatness was estimated from the Jackson-Pollock equation, and arm cross-sectional area (CSA) was determined from flexed arm circumference corrected for triceps skinfold. In a validation sample (\( n = 200 \)), dips were significantly related to 1-RM bench press (\( r = 0.49 \)) but ineffective for prediction (\( SEE = 17.3 \) kg). The addition of body mass to the equation improved prediction (\( R = 0.82 \), \( SEE = 11.5 \) kg). Further addition of arm CSA increased prediction only slightly (\( R = 0.84 \), \( SEE = 10.8 \) kg). A randomly selected cross-validation sample (\( n = 46 \)) indicated that both multiple regression equations predicted 1-RM values that were highly correlated with \( r = 0.82 \) and not significantly different from actual 1-RM (\( r < 1.08 \)). Therefore, dips in conjunction with body mass are a satisfactory method for predicting 1-RM bench press strength.

**Development of a Prediction Equation for Assessing VO\(_{2}\)max Based on Performance Time During Graduated Exercise on the ClimbMax 200 Stairclimber With Older Adults**

Tony Grice, HSU Station, Abilene, TX

Valid methods of predicting maximal oxygen consumption (\( VO_{2}\)max) using the stairclimber are needed for the health-fitness market. With previous exercise tests featuring bicycle and treadmill protocols, the more recent advance of stairclimbers as popular forms of exercise has encouraged new test development. The use of a prediction equation for determining \( VO_{2}\)max based on performance time during treadmill exercise has become an attractive alternative to direct measurement. Although there are many protocols available for use with either the bicycle ergometer or treadmill, only recently have protocols been developed for specific use with a mechanized stairclimbing device (Dickson, Grice, and Bell, 1992). The primary purpose of this study will be to develop a prediction equation using the ClimbMax 200 for predicting \( VO_{2}\)max in selected older adults of varying levels of physical fitness when compared to \( VO_{2}\)max values measured directly from the Bruce treadmill test. Fifty adults (25 women and 25 men) ages 35 to 58 performed three graded exercise tests to exhaustion. The Aerospot Test 100 system was used to analyze expired air for determination of \( VO_{2}\)max during the Bruce treadmill test and one graded exercise test using the Climbinax 200 stairclimber (Tectrix Fitness Equipment, Irvine, CA). A third stairclimb test without gas analysis was performed as a means of cross-validation. Each was performed with a minimum of 48-hrs rest between tests. All testing was to be completed within 2 wks. This stairclimber was computer interfaced and programmed for a user-specific exercise protocol with a Polar heart rate monitoring device, and a printout of the workload/heart rate/time relationship was produced. Multiple regression analysis to estimate \( VO_{2}\)max from the stairclimber performance data resulted in the following prediction equations: Female: \( 86.7639 + (-0.7103 \cdot \text{Age}) + (0.2824 \cdot \text{W35HR}) + (-0.4537 \cdot \text{W40HR}) \). This equation is significant at the 0.001 level with a standard error of 4.05 \text{ ml/kg/min} and a cross-validation correlation of 0.6106. Male: \( 104.0012 + (-0.6399 \cdot \text{Age}) + (0.7458 \cdot \text{W40HR}) + (1.0583 \cdot \text{W45HR}) + (-1.9803 \cdot \text{W50HR}) \). This equation is significant at the 0.001 level with a standard error of 5.99 \text{ ml/kg/min} and a cross-validation correlation of 0.6541. Because of the increased interest in the stairclimbing device as a training method, a practical means of estimating \( VO_{2}\)max across a wider range of age and fitness levels would seem beneficial. Therefore the use of a prediction equation for assessing \( VO_{2}\)max based on performance time during graded exercise on a stairclimbing device is an attractive alternative to the more expensive and time-consuming direct measurement of expired air samples. The margins of error previously reported when predicting \( VO_{2}\)max from submaximal heart rates have acceptable predictive validity for screening and classification in terms of aerobic fitness.