timated by having the cyclists coast through the timed section with an erect stance. For racing bicyclists at 15 MPH, the required power was reduced 23, 26, and 27% for positions two, three, and four in the pace line respectively. At 30 MPH, it was reduced 29, 33, and 33%. By contrast, for runners, the range of reduction of required power was only 4-9% for speeds from 12 to 17 MPH respectively. Using these results, a simple method of predicting the speed increase of racing bicyclists was devised (e.g., four-man team time trial), knowing only the individual performance times (one man time trial). Predicted and actual race performances were compared to show the utility of the method for team selection and tactics. Application to running may require development of special skills, tactics, and training methods.

CHAPTER 8
Caf. State Univ.
Long Beach, CA 90840

9:30 a.m.
A BIOMECHANICAL ANALYSIS OF LOWER LIMB ACTION
DURING CYCLING AT FOUR DIFFERENT LOADS
R. J. Gregor and P. R. Cavanagh. Biomechanics Laboratory, The Pennsylvania State University, University Park, Pennsylvania

The purpose of this investigation was to describe the varying force patterns produced at the pedals and evaluate net muscular torques about the hip, knee and ankle joint of five experienced bicyclists performing at four separate workloads. 56, 65 and 80 per cent of each subject's maximal aerobic capacity as well as a constant workload of 1400 kpm were the conditions employed. Special pedals designed to measure two components of force at each foot were placed on a standard road racing bicycle and utilized throughout the investigation procedure. Cinematographic records (100 fps) were also taken to ensure the values recorded were needed for input to the equations of motion. A peak force of approximately 62 lb. recorded normal to the surface of the pedal at the constant workload was the mean for all subjects and agreed well with values presented in previous literature. Results also indicated the subjects were quite asymmetrical in their patterns of force application regardless of workload. They worked a disproportionate amount of the time with their right leg but "pulled up" on the pedal with each leg during its recovery phase of the cycle (180-300 degrees). Almost all subjects displayed patterns of force which could be classified as efficient and this appeared to vary with the subjects' ability.

Robert J. Gregor
Dept. of Kinesiology
UCLA
Los Angeles, CA 90024

9:45 a.m.
MUSCLE FORCE AND POWER-VELOCITY RELATIONSHIPS
UNDER ISOKINETIC LOADING
J. J. Perrine and V. R. Edgerton. Neuromuscular Research Laboratory, U.C.L.A., Los Angeles, California

While several well known experiments have been conducted to determine the relationship between the amount of isotonic (constant) load presented, and the maximum velocity attainable by human skeletal muscle in vivo, it can easily be shown that this procedure would not necessarily demonstrate the actual maximal force potential of a muscle at given loading velocities. This latter relationship can, however, be readily determined by isokinetic loading. Fifteen healthy males and females between 18 and 38 years of age, and representing varied activity patterns from sedentary to athletic, performed maximal dynamic knee extensions on an isokinetic dynamometer. Maximal torque output at a specific point in the range (30° before full extension) and at seven velocity settings from 0 (isometric) to 285°/sec was determined. The data showed that absolute maximum 30° torque output for these individuals, as measured at the particular optimal loading velocity, ranged from 3 to 25 kgm. The optimal loading velocity varied with the individual from 0 to 144°/sec, and at no test velocity within this range was torque potential below 85% of absolute maximum for any subject. Maximal 30° power output ranged from 9 to 68 kgm/sec, and in all 15 subjects was developed at, and remained essentially con-

stant over the 3 or 4 highest test velocities. Distinct and possibly significant differences are apparent between this data and available data on animal muscles that are isolated from the body, maximally stimulated, and loaded in an essentially equivalent manner.

James J. Perrine
28412 Onward St.
Woodland Hills, CA 91364

10:00 a.m.
ISOMETRIC AND ISOTONIC EXERCISE EFFECTS UPON
FRACTIONATED REFLEX COMPONENTS
A. F. Morris, Moltor Integration Research Laboratory, University of Mass., Amherst

Despite intensive efforts to explain the mechanisms underlying neuromuscular fatigue, this phenomenon remains largely unexplained. The purpose of the present study was to examine fractionated reflex responses after local fatigue by isotonic and isometric muscular exercise of the quadriceps musculature. The fractionation procedure enables the researcher to subdivide total reflex time into peripheral and central components. The central component is termed reflex latency and constitutes the time for the monosynaptic reflex arc. Reflex motor time is the peripheral component and this time represents the total time for muscular contraction. Severe isotonic exercise produced a strength decrement of 57% while the isotonic exercise task produced strength decreases in the order of 35% in 12 male university students. Although differential strength decrements were shown, both exercise types significantly lengthened total reflex time. In addition, both the central component (reflex latency) and the peripheral component (motor time) were increased. Attempts to synthesize these reflex time results with strength decrements will be discussed.

A. F. Morris
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Atlanta, GA 30306

SECTION C-3
Thursday, May 6
2:00 p.m. to 3:30 p.m.
Chairperson: Frank Katch
Queens College
Flushing, NY

2:00 p.m.
PROPORTIONALITY CHARACTERISTICS OF BLACK AND
WHITE OLYMPIC RUNNERS AND JUMPERS
J. E. L. Carter, Dept. of Physical Education, San Diego State University, San Diego, California

The purpose of this study was to assess the proportionality of 109 Black and 84 White runners and jumpers from the Mexico Olympics. Subgroups were sprint, 400m, middle distance, and long distance runners, and long, triple and high jumpers. Weight, biacromial and bifacial breadths, arm, leg and trunk lengths were examined. Total and event groups were analysed by means of the "phantom" strategy for proportion analysis which involves adjusting measures to a standard height. Phantom z-values were calculated and proportionality profiles constructed for each event by race. Profiles showed that for all events Blacks had narrower bifacial breadth and longer arms and legs than Whites, while races were similar on weight, biacromial breadth and trunk length. There was a tendency for weight and biacromial breadth for both races, and leg length for Whites, to decrease with the distance run. When compared to phantom values both Blacks and Whites were light, had small bifacial breadth and trunk length, and similar biacromial breadth; Whites were similar and Blacks long for arm and leg.
length. In biomechanical terms, the differences suggest an advantage for Black in running and jumping.

Supported by Faculty Grant #263-029-913.

J. E. L. Carrier
Dept. of Phys. Ed.
San Diego State Univ.
San Diego, CA 92182

2:15 p.m.
SOMATOTYPE OF CANADIAN FIGURE SKATERS
W. D. Ross, S. R. Brown, J. W. Yu, R. A. Faulkner. Department of Kinesiology, Simon Fraser University, Burnaby, B.C., Canada and Department of Physical Education, University of British Columbia, Vancouver, B.C., Canada

Anthropometric data was assembled on 46 top-rated Canadian male and female figure skaters to derive Heath-Carter somatotypes which revealed the following mean values: senior-junior men 1.7-5.5-2.9; novice men 1.7-5.4-2.7; senior-junior ladies 2.6-4.2-3.0; and novice ladies 2.1-3.3-3.3. Somatotype dispersion indices (SDI) which show mean dispersion of somatotypes about sample mean plots revealed the novice ladies to be the most homogeneous with a SDI of 2.22, followed by novice men 2.58, senior-junior men 2.79 and senior-junior ladies 3.02. Compared with 1969 Olympic Athletes, the senior-junior skaters of both sexes most closely resembled the gymnasts being relatively small, lean and muscular.

Supported by NRC Grant (711-007).

William D. Ross
13342 83th Ave.
Surrey, B.C., Canada

2:30 p.m.
ANTHROPOMETRIC ESTIMATION OF BODY DENSITY AND LEAN BODY WEIGHT IN WOMEN GYMNASTS
W. E. Sinning, Springfield College, Springfield, Massachusetts

Measurements from 44 college women gymnasts were used to evaluate previously derived equations for estimating body composition and develop new equations by stepwise linear regressions. True composition values were computed from body density (DB). Measures were taken of skeletal diameters (D), circumferences (C) and skinfolds (S). Equations evaluated were those by Sloani et al. (J. Appl. Physiol. 17:967), Katch and Michael (J. Appl. Physiol. 25:92) and Wilmore and Behnke (Am. J. Clin. Nutr. 33:87). Correlations between true and estimated (LBW's) were high (0.91 to 0.95) but underestimated true LBW (1.13 to 0.58 kg). New equations for estimating DB and LBW were derived using D, C and S alone or in combination. Two equations that have practical value are: LBW = .7028 D + .8938 C - .3815 S; and LBW = .458 + .7980 Weight + .0590 right elbow D - .4459 suprailiac S [R=.98, SEE 1.34]. It was concluded that women gymnasts comprise a distinct population and estimates of body composition must be made from appropriate equations.

Wayne E. Sinning
Springfield College
Springfield, MA 01109

2:45 p.m.
DIFFERENCES AND CHANGES IN VO2 AMONG YOUNG RUNNERS, 10 TO 18 YEARS OF AGE
J. Daniels, P. F. Kagen, N. Oldridge and B. White, University of Wisconsin, Madison

Twenty young males, all active in middle-distance running, were studied between January 1968 and May 1974 for the purpose of gathering longitudinal data regarding VO2 during treadmill running. VO2submax (measured during the last 2 min of a 6-min run at 202m/min) and VO2max values (measured during a 5-8 min increasing-speed run to exhaustion) were collected approximately every 6 months for 6 yrs. Different groups, starting at ages of 10, 12 and 13 yrs were followed for periods of 2 to 3 yrs continuously. In all longitudinal comparisons, VO2max (ml/min) changes paralleled changes in body weight; consequently, VO2max (ml/kg) never showed a significant change. In every group VO2submax (ml/kg) dropped significantly over time. All data were also pooled by 1-yr age groups, providing cross-sectional data for active boys 10-18 yrs of age. VO2max ranged from 1933ml/min for 10-yr olds to 4082 for 18-yr olds. Concurrent changes in weight resulted in no significant differences in VO2max (ml/kg) from the overall mean of 6.5. VO2submax (ml/kg) was highest among 10-yr olds (53.3) and lowest among 18-yr olds (42.5). Based on these findings and significant improvements in times for 1- and 2-mile races, it was concluded that VO2max (ml/min) increases no faster than does body weight among moderately active growing boys and that both age and training contribute to a change in VO2submax: a factor, which along with possible anesthetic adjustments, account greatly for improvements in middle-distance race performance.

Jack Daniels
Dept. of HPER
Univ. of Texas
Austin, TX 78712

3:00 p.m.
RESTING AND EXERCISE RESPIRATORY FUNCTION IN WELL TRAINED CHILD SWIMMERS
P. Vaccaro and C. W. Zaunder, University of Florida, Gainesville, Florida

The purpose of this study was to describe resting and exercise pulmonary diffusing capacities and oxygen uptake of well trained child and adolescent swimmers and to evaluate the relationships among these parameters. Furthermore, the relationships among pulmonary diffusing capacity, oxygen uptake, age, height, weight, body surface area, and physical working capacity were determined. December members of a competitive swim team served as subjects. Each subject was measured on two separate days, about one hour following ingestion of breakfast. On Experimental Day One the swimmers were assessed for resting Dlco, resting VO2, FWC150, exercise Dlco, and exercise VO2, and on Experimental Day Two they were measured for height (cm), weight (kg), and VO2max (ml/kg/min). Results of the analyses indicated that: (1) the best predictors of resting Dlco in order are age, BSA, weight and height; (2) the best predictor of exercise Dlco was FWC150; (3) mean resting Dlco in well trained child swimmers is significantly higher (P<0.05) than the predicted mean resting Dlco one would expect to see in normal children of the same age and body dimensions; and (4) mean max VO2 in well trained child swimmers as measured by treadmill running is not significantly greater (P>0.05) than mean VO2predicted for normal children of the same age and body dimensions.

Paul Vaccaro
Dept. of Phys. Ed.
Univ. of Maryland
College Park, MD 20742

3:15 p.m.
EXERCISE PERFORMANCE IN 6-11 YR. OLD BOYS WITH DUCHENNE MUSCULAR DYSTROPHY
Ronald Sockolov and B. Irwin, Human Performance Laboratory, University of California, Davis

An incremental bicycle ergometer test and isokinetic limb strength measurements were made on 13 dystrophic and 27 normal untrained boys to determine the effects of severe muscular dystrophy on cardiorespiratory responses during exercise. Results for the dystrophic group (D) were compared to 13 normals (N) matched for age, 8.4 ± 0.4 yr (mean ± SE); height 49.5 ± 1.0 in.; and weight 23.7 ± 1.3 kg. At rest, D had significantly higher (P<0.05) heart rate (HR) 89 vs 102 (means for N vs D), and lower stroke volume (SV), (determined by impedance cardiography) 39 vs 31 ml, with no difference in oxygen uptake (VO2), calculated cardiac output (Q), pulmonary ventilation (Ve); or respiratory exchange ratio (R). For a given submaximal VO2, SV, Q, and Ve, were lower in D. During maximal work, D had significantly lower peak oxygen uptake (watt/kg) than N; 27.9 vs 32.7; VO2peak 135 vs 37.1 ml/min; HR 186 vs 136 b/min; SV 60 vs 41 ml; and Q 11.0 vs 5.01 l/min. Arm and leg strengths (4 flexion and 4 extension motions) were significantly lower in D, but muscle girths were not smaller. In summary, exercise performance in D