437 THE INJURY PATTERN IN VOLLEYBALL. A COMPARATIVE STUDY. 
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The aim of this study was to analyze the pattern of injuries in volleyball players, by comparing elite (EV) and non-elite (NEV) players, female (F) and male (M) players. Furthermore, comparisons were made between players of indoor (IV) and beach (BV) volleyball - a new and rapidly growing activity. Questionnaires were distributed to 32 teams in four different competition leagues before the beach season 1993 and the indoor season 1993/94. Replies were received from 205 players with a mean age of 27.6 years (range 18-40) and with a volleyball experience of 10.6 years (range 2-29). A total of 310 injuries were reported; 194/116 in EV/NEV, 131/79 in F/IV and 26/24 in BV/IV. Most injuries in BV were in the upper extremity (38%), whereas lower extremity injuries (51%) were dominant in IV. There was a higher risk of shoulder and neck injuries in EV, whereas a lower risk of ankle injuries (p<0.05) in BV. In BV most injuries occurred in field defence (32%), which were more than expected (p<0.001), while most injuries in IV occurred during spiking (34%). Spiking was the cause of most injuries in EV and in NEV, in F and in MV. There was a higher risk of ankle injuries (p<0.001) in NEV compared to EV. We conclude, that the injury pattern is different in IV compared to BV, while there are only minor differences between EV and NEV and no evident differences between F and MV. The injury risk is higher in NEV than in EV.

438 ADVERSE RESPIRATORY HEALTH EFFECTS OF COMPETITIVE SWIMMING: THE PREVALENCE OF SYMPTOMS AND ILLNESSES IN A COHORT OF 738 SWIMMERS. 
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The purpose of this study was to estimate the prevalence of respiratory symptoms and illnesses in a cohort of 738 competitive swimmers. Each of the swimmers was asked a respiratory health questionnaire that was modified to ask specific information about their medical history, the occurrence of respiratory symptoms during exercise, and the amount of training they did. The overall prevalence of asthma among the 738 swimmers was 13.4%. There was, however, a significant difference among the three groups of competitive swimmers that we identified. This included 10.6% of Age Group Swimmers, 12.0% of National Qualifiers, and 20.6% of International Level Swimmers. The prevalence of swimming-related symptoms included sneezing (45.0% of participants), difficulty breathing (39.4%), coughing (36.4%), sore eyes (36.6%), headaches (35.9%), sore throats (31.9%), wheezing (24.3%), chest tightness (24.8%), and chest congestion (22.8%). All of the symptoms, besides fatigue, were more common in older swimmers. Older swimmers were more likely to feel congested, sneeze, experience headaches, experience chest tightness, chest wheeze, have chest tightness, or difficulty breathing, sore throats, and headaches. A majority of the swimmers reported that their symptoms were less severe, last noticeable, or absent if they spent several days away from the swimming pool.

439 PREDICTING STRESS FRACTURES DURING RIGOROUS PHYSICAL TRAINING USING SIMPLE MEASURES OF PHYSICAL FITNESS AND ACTIVITY. 
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Predicting stress fractures (SF) in military trainees is the first step in reducing the significant impact of these injuries on military training programs. The purpose of this study was to provide preliminary evidence to quantitatively estimate the ability to predict subsequent SF based on the following indices of fitness: body fat, percentage of fat-free weight, and muscular endurance. 437 recruits undergoing basic training during a two week period all entering basic training (April 1993) were asked to participate; 1163 consented. A short 10 item questionnaire was administered querying the recruits about their exercise history and answers were used to assign recruits to fat-free weight. Psychological testing using the MMPI, 43 subjects (incidence 3.8%) developed SF as diagnosed by clinical presentation and confirmed by radiograph and/or magnetic resonance. Of these 43 recruits, 9 were subsequently assigned to prior to entering basic training. Based on this information as well as the recruits SF risk category, the results were assigned a priori to high (18.7%) or low (81.3%) risk for SF. Following 11 weeks of training, 437 recruits were assigned a priori to high (18.7%) or low (81.3%) SF risk category. SF incidence among the high risk recruits was 16.9% compared to 2.8% in the low risk recruits (RR=2.52, 95% CI 1.62-3.47). Our data suggest that the risk of SF during rigorous physical training is increased by poor physical fitness and low levels of physical activity prior to training.

C-19 POSTER MUSCLE FATIGUE 

440 DIFFERENTIAL MUSCLE FATIGUE DURING CONTINUOUS AND REPEATED CONTRACTIONS. 

The importance of the caffeine kinase (CK) reaction lies in the buffering of the ATP concentration in active skeletal muscles. Skeletal muscle of mice lacking CK-M and CK-II still showed a normal level of ATP at the series level after a series of isometric twitch contractions (1 Hz). However, twitch force dropped quickly to 75% after 9 twitches (1 Hz) or to 55% after 9 contractions (3 Hz), whereas force stabilized and even slightly increased (Van Den Eunen et al., Cell 74: 621-631, 1993). To test the need for buffering of ATP by the CK-system in the present study control and CK-M and CK-II deficient skeletal muscles were fatigued in situ using different types of exercise (one continuous maximal voluntary contraction) or series of repeated maximal contractions within 5s, either isometric (150 s) or dynamic (60 s). Surprisingly, the force of the force decay during the 5s continuous contraction seemed similar in the control and CK-deficient mice. In the series of repeated contractions the force of the control muscles decreased slowly (90 s) during the first 10 s and the 20th contraction in 85% (isometric) and 55% (dynamic). In contrast in the CK-deficient mice the force decay during the 10th and the 20th contraction was up to 25% lower. The CK-system seems important in maintaining a high level of contractile output during the start of exercises.

441 FATIGUE IN MALIGNANT HYPERTHERMIC (MH) AND NORMAL (N) PORCINE SKELETAL MUSCLES. 
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Excitation-contraction coupling (ECC) of MH muscles is abnormal in that function of the sarcoplasmic reticulum Ca2+ release channel is altered by a mutation in the ryanosidine receptor gene. Since impaired ECC may play a role in skeletal muscle fatigue, we compared the fatigue characteristics of MH and N pig muscles. Small bundles of intact fibers were fatigued using: 1) high frequency stimulation to induce action potential failure, and 2) lower frequency stimulation to induce metabolic alterations. In response to high frequency (100 ms trains, 200 Hz, 1/sec) both N and MH muscles fatigued in a similar manner (time for peak tetanic tension (T) to fall to 75% of control: 1.64±0.19 min in N and 1.32±0.13 min in MH). Full recovery of both twitch and tetanic in both N and MH muscles occurred in 1 sec. Frequency stimulation (100 ms trains, 100 Hz, 1/sec) suspended both MH and N bundles into two groups: 1) bundles that fatigued in >4 min, and 2) bundles that required <15 min. In the fast fatiguing bundles, time to 25% decrease in P, for MH (2.5±3 min) was significantly shorter than for N (4.9±1.11 min). Times to 25% decrease in P, in the fast fatiguing bundles were not different for MH (5.6±1 min) and N (10±2.5 min). Full recovery in <15 min. The possibility that the basis for the difference in time to fatigue of the fast and slow fatiguing groups was a difference in fiber type composition of bundles is being investigated. The more rapid fatigue in MH muscles may be due to differences in cellular Ca2+ regulation. Supported by NIH AR41720.

442 SURFACE EMG MEDIUM FREQUENCY IS DECREASED IN WEAKENED QUADRICEPS MUSCLES. 
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Needle EMG studies have documented a decreased firing rate of all motor units in skeletal muscle following immobilization. Surface EMG (SEMG) analysis of muscle weakened by injury or surgery can be utilized for its frequency content via the Fast Fourier Transformation (FFT). The median frequency (MF) obtained describes shifts in firing rates of recruited motor units. Therefore, we examined the SEMG in 8 pain-free patients who had quadriceps weakness (strength deficit 22% of normal, P<0.01) prior to maximal voluntary contraction (MVC). In the series of maximal isometric contractions, in addition, 7 control subjects without weakness (-2%) were tested to examine the effect of dominance. The MF of the SEMG of the vastus lateralis (VL) and medialis (VM) was computed for second 2-3 s (so chosen for peak tension without fatigue) during 3 maximal contractions. The means of the three trials were analyzed statistically. The injured group had a significant lower MF in the VM (94±6 vs 44±4 Hz, P<0.05) with a similar trend in the VL. The control group提高了 lower MF of both VL and VM in the dominant leg. The injured group had a 44% decrease in the non-dominant injured leg. There was a significant interaction between weakness and dominance (P<0.05), so that weakness and dominance were both associated with a lower MF during maximal contraction. In the injured leg, this may reflect loss of recruitment of high frequency motor units or a generalized decrease in firing rate of all motor units and parallels the findings in other muscle groups using needle electrodes.