AN ORTHOPEDIC EXAM FOR ATHLETIC INJURY RISK FACTORS

F.R.T. Nelson, L.C. Montgomery, J.P. Norton, P.A. Deuster
The Human Performance Laboratory
Department of Military Medicine
Uniformed Services University of the Health Sciences
Bethesda, MD 20814-4799

Introduction

Athletic injuries, in particular stress fractures, are common among U.S. Navy SEAL trainees during their extensive program of upper and lower body physical training. Between 1980 and 1986 there were over 200 stress fractures, accounting for almost half of all medical dropouts from the program. Most of the injuries are overuse related, and potentially preventable. In an attempt to identify physical risk factors that could be used in a pre-selection process, a simple reproducible physical exam emphasizing biomechanical factors was devised and used to evaluate men about to begin training.

Methods

Informed consent was obtained from 505 trainees in five successive classes at the Basic Underwater Demolition/SEAL (BUD/S) School in Coronado, CA. The subjects were all male, ranging in age from 18 to 35 years with an average age of 22 years. The complete orthopedic exam was conducted on four classes whereas only the knee and ankle exam was completed on the fifth class. The examination was conducted the week before training began. A record of course completion or reason for failure or transfer to a subsequent class was kept on all trainees.

Specific risk parameters were measured for the hips, knees, ankles, and feet. To improve reproducibility, the use of angular measurements was eliminated when possible; rather, absolute distances were measured with a centimeter ruler. The same examiner conducted all of the evaluations.

Hip extension (HE) was measured in the supine position by having the trainee flex one knee to his chest with enough force to reverse the lumbar lordosis; the hip was fully extended and the knee was flexed at 90 degrees over the edge of the exam table. The distance from table surface to popliteal fossa was then measured in the opposite leg. The higher the number, the more limited the hip extension.

Hip internal and external rotation was measured in hip extension with the subject prone. The knees were placed together, being careful that the pelvis was not rotated. Hip internal rotation (HIR) was measured on both sides simultaneously with knees flexed at 90 degrees. Hip external rotation (HER) was measured in the same position but with the knees a fist-width apart and the knee on the side not being measured extended slightly so that the two sides could be internally rotated at the same time. Again, care was taken to make sure that the pelvis was level. A goniometer was held perpendicular to the table, and the angle formed by the tibia and the arm of the goniometer was recorded.

Knee extension (KE) was measured with the subject in the supine position. The examiner pressed the thigh firmly on the table surface and then lifted the calf such that the heel would lift off the table. The subject held the ankle in a neutral position and the distance from table surface to heel was then measured. A few heels were within a centimeter of the table or could not be raised, and those were recorded as zeros. There were no subjects with a measurable contracture.

Knee flexion (KF) was measured while the subject was supine and able to flex the hip. The distance in centimeters from the heel to the posterior thigh was measured while the knee was held fully flexed.

Knee varus or valgus was measured with the trainee standing. The legs were brought slowly together until either the medial femoral condylar area or malleoli touched. Because of the physical condition of the subjects, body fat did not play a significant role in this measure. If the medial malleoli touched first, the intercondylar distance was measured. If the condylar surface touched first, the intermalleolar distance was measured in centimeters. If both malleoli and condyles touched at the same time a zero was recorded. The relative degree of knee varus or valgus (KVV) was computed by subtracting the condylar distance from the malleolar distance. A positive number indicated knee varus whereas a negative number indicated knee valgus.

Ankle dorsiflexibility (ADF) was measured with the trainee standing on a measuring device. The measuring device had a heel plate so that all subjects would bring the heel to a precise location. The foot was carefully arranged to a fore and aft position. The knee was held in full extension as the trainee moved his weight over the ankle with the heel remaining on the surface. At the point at which the subject could move no further forward over the ankle without lifting the heel the vertical distance from the intrapatellar region perpendicular to the line was measured. At the same time the horizontal distance from the heel to the vertical line was also measured. ADF was calculated as the ratio of the horizontal versus vertical measure, a combination of the ability to dorsiflex the ankle as well as to accommodate with foot pronation. No attempt was made to determine the contribution of foot pronation to the overall flexibility.

Foot profiles, which were entirely subjective, were categorized as cavus, neutral, or planus.

Results

Ninety-six trainees were dropped or carried over to another class for medical reasons. Of these, 32 had stress fractures; 27 stress fractures involved the tibia, 4 the femur and 1 a metatarsal bone. Only 9 trainees were dropped due to back injuries. Other orthopedic overuse injuries included iliotibial band syndrome and tendonitis of the ankle, accounting for 14 medical drops or carry overs.

Hip extension was limited in 10% of the population. The definition of limitation of hip extension was a popliteal distance of 10 cm or greater from the exam table surface. There was no statistically significant difference in the occurrence of stress fractures in this group. There were also no apparent or significant variations in injury rate based on hip internal or external rotation.

Over half (60.7%) of the subjects had relative knee varus by the standing measure. Only 1.2% had knee valgus greater than 4 cm and 10.5% had knee varus greater than 4 cm. There were no statistically significant differences in the stress fracture rate based on this measure. Further, there were no significant variations in knee flexion or knee extension.

The ratio of patellar height to the heel-vertical line distance was 1.2 + 0.2 (mean + standard deviation) with a range of 0.9 (very flexible) to 1.8 (very tight). However, there was no statistically significant relation with stress fractures. For the foot profiles, 5.4% of the population had pes cavus and 11.8% had pes planus. There was a statistically insignificant increase in stress fracture rate in the pes planus group.

No combination of physical findings that would act as a predictor for stress fractures was identified by discriminant analysis.

Discussion

When examining hip extension we were interested in the incidence of back injuries and stress fractures. However, in this population the back injury rate was so low that a statistical evaluation was not practical. Hip flexion tightness will cause hyperlordosis, particularly in running activities. It should be noted that this population is so highly trained in the abdominal and iliopsoas muscle groups that there appears to be an element of protection, as demonstrated by the unusually low back injury rate.

Although a majority of the subjects had knee varus by our measure, only a tenth of the population had more than a 4 cm intercondylar distance with the ankles touching while standing. A casual observer would envision that this knee posture would be important in abnormal tibial loads. However, there was no statistically significant risk of stress fractures in either the varus or valgus group. It is recognized that this is a static measurement and in no way reflects the actual position of the femoral tibial impact load with heel strike, stance, and push off in running. Thus, as a static measure it proved to be of no predictive value.

The most surprising "negative" findings occurred with the modified ankle dorsiflexion measurement. It would appear that increased forces on the tibia or matatarsals would occur with a limited ankle dorsiflexion and foot pronation complex. There were enough individuals in the tight group (ratio > 1.4) that we should have seen a statistically significant number of stress fractures if this measure was very important. Although there was a higher incidence of stress fracture with tighter ankle measures, it was not statistically significant. No effort was made to study the degree to which pronation contributed to this flexibility. In future studies, the two components (actual ankle dorsiflexion and foot pronation) should be measured.

Although the orthopedist in our group was initially surprised at the absence of any statistically significant physical risk factors, further consideration of this population adds some insight. These are self-selected individuals; of 475 subjects questioned, 279 ran 4 or more miles per week, including 100 men who ran over 25 miles per week. This level of activity is obviously much greater than the average population.

Hence, this is a population that has already demonstrated an implied combination of biomechanical features that should support a high level of activity.

Summary

A simple orthopedic exam was designed to identify physical factors which might predispose an individual to athletic injury. 505 male trainees were evaluated by this exam prior to an extensive period of training. The occurrence of stress fractures and other injuries were recorded. Results showed that 10.5% had limited hip extension, 19.0% had limited ankle dorsiflexion, and 60.7% had relative knee varus. No single or combined physical trait was found to be significantly related to overuse injuries.