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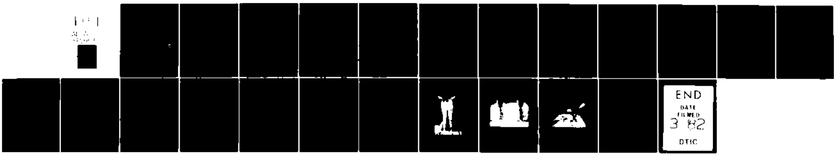

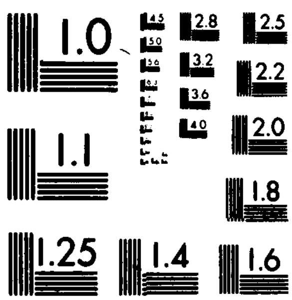

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Anatomic Perspective of the Female Athlete:

An Approach to Musculoskeletal Profiling of Women in Sports

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An approach to musculoskeletal profiling of women in sports

Introduction

Women's sports did not begin to grow and gain public recognition until the early 1970's. Since then, the number of women participating in intercollegiate sports has doubled and the number of girls participating in interscholastic sports programs has increased almost threefold. As women flood the sports arena, many questions arise regarding the female athlete. Their performance capabilities are constantly compared with male athletic records and standards, and explanations for the difference in their level of performance are being sought [1].

As well as differences in performance, it has also been suggested that there are differences in susceptibility to injury between males and females. Because of suspected differences, many questions arise concerning the medical care of the female athlete. Should women and men be trained in the same way if injury is of concern? Does the female anatomical structure predispose her to certain types of injuries? Are there distinct patterns of injury for women athletes? Can potential injuries be detected prior to their occurrence through a comprehensive musculoskeletal profile screening system? These are questions which should be addressed in order to reduce the number and severity of injuries incurred by women in sports competition.

This paper will focus on women and the injuries they incur as a result of physical training and athletic competition. First the literature pertaining to training injuries in both males and females will be reviewed. Next a musculoskeletal profiling system presently used in a study of women athletes at Wellesley College will be outlined. Then the potential applications of such a system will be explored.

Review of the literature

It has been speculated that peculiarities of female anatomy may account for their different propensity for certain types of injuries. Anatomically, it has been stated [1,2] that the female has a wider pelvis, and therefore, the angle of the femur to the pelvis is more acute than in the male. Albohm [3] and Haycock [4] feel that the wider pelvis contributes to the potential problem of subluxation or dislocation of the patella, which can ultimately result in chondromalacia. It has been shown [3] that women have somewhat slighter bone structure and a smaller proportion of muscle to adipose tissue than the male. Females also possess a greater degree of elasticity in the connective tissue which increases flexibility and many contribute to a greater susceptibility to ligamentous injury [3].

The two major sources of information on injuries to women resulting from physical activity are the military and interscholastic athletic programs. More women have been entering the military in the last ten years and as a result, their physical aptitudes and injury rates have been more closely scruitinized. Several studies have been conducted involving male and female basic trainees. Reinker and Ozburne [5] noted that in basic training, the injury rate for women was twice that of the men. The incidence of stress fractures was 10 percent in women as compared with 1 percent for men. Stress fractures accounted for an alarmingly high number (one-third) of the total injuries sustained by women. Other significant injuries which involved time loss from training were chondromalacia of the patella, achilles tendinitis, and sprains.

In an attempt to decrease the incidence of injury a company of 280 females was placed on a revised exercise program [5] during basic training at Fort Jackson. The strategy was to introduce physical stresses gradually and to avoid known pathogenic varieties of training. As a result, the incidence of stress fractures alone was reduced markedly from over 10 percent to 1.5 percent and lower extremity musculoskeletal injuries as a whole were decreased by approximately 50 percent.

In another study, Kowal [6] found that approximately 25 percent of males, and almost 60 percent of females suffered overuse injuries to the lower extremities during the 8 week basic training cycle. The injury data was correlated with prior fitness measures, suggesting that the major causes of injury in women might be attributed to the lack of conditioning, greater percent body fat, and to the rapid introduction of heavy training, which does not allow for a progressive exposure to stress. It appeared that women in the military were not in condition to perform to male standards at the onset of training and needed additional time for their bodies to respond to the stresses of a vigorous training program.

Thus, nearly all of the military studies to date [5,6,7] clearly demonstrate that female trainees are highly susceptible to stress related injuries in basic training. However, it is interesting to compare the similarities and dissimilarities in injury patterns between women in the military and women in sport. The National Athletic Injury/Illness Reporting System (NAIRS) is a national surveillance system that compiles intercollegiate and interscholastic injury data submitted by athletic trainers or other health care personnel. A preliminary overview [8] of injuries among collegiate women athletes during its first three operational years (1975-78) indicated that injuries to women athletes are essentially sport related; not gender related. The data reveals that matched sports demonstrated similar patterns of injury for men and women and that the major differences of injury patterns were between sports. It appeared from this study that there are more dissimilarities between women's sports than between comparable men and women's sports.

A study which supports the NAIRS findings [9] was conducted to compare injury rates between male and female high school athletic participants in eight similar sports. The study revealed that sprains and strains were the most frequent injuries. Females had a significantly greater number of knee injuries and major ankle injuries than males, but the pattern of injury for other major anatomical sites was similar. There were no significant differences in overall incidence of injury between males and females, however, it was interesting to note that females had a greater number of serious injuries.

Graham [10] conducted an injury survey among 29 colleges in Virginia involving 129 female athletic teams during the 1974-75 school year. The study indicated that the most common injuries in all sports were sprains, strains, contusions, and simple fractures. Of these injuries, 44 percent were reinjuries and nearly twice as many injuries occurred to the right side of the body as opposed to the left side. The results of the survey support previous findings [9] which indicate that the most common injuries involve the lower extremity, specifically the ankle and knee.

Another study reviewing the clinical records of two sports physicians [11] identified 1819 injuries in 1650 running patients during 1978-80. The records revealed that both sexes had a similar distribution of injuries by major anatomical sites (hips, thigh, knee, leg, ankle, foot), but certain specific conditions were observed more frequently in one sex or the other. The knee was the most common site of complaint accounting for 42 percent of all injuries and patello-femoral pain syndrome was the most frequent disorder, accounting for 26 percent of all injuries. This study found that men sustained more achilles tendinitis and patellar tendinitis, while women suffered more from "patellar pain syndrome" and "tibial stress syndrome".

Pagliano [12] found that the knee accounted for 30 percent of the 1077 injuries among runners in a ten month study of running related injuries. Chondromalacia was the most common diagnosis, accounting for almost one third of those complaining of knee pain. The clinical diagnosis of chondromalacia patella is a matter of debate and there are no specific criteria which are agreed upon. Nevertheless, it appears that women are subject to more patello-femoral complaints (which are construed to be chondromalacia) than men. Pagliano [12] stated that women outnumber men two to one in the general population in terms of having symptomatic "chondromalacia." Brody [13] claims that the typical patient complaining of "chondromalacia" is one who possesses a wide pelvis, knock-knees and hyperpronated feet. Therefore, it may be that the anatomic structure of women which is more like this may predispose them to patello-femoral complaints when subject to the stress of competition and weight bearing physical training.

In summary, the data from civilian studies shows some differences in the distribution and incidence of injuries to males and females competing in the same sports. However, these differences are not as marked as those noted in military studies of basic training populations. What this contrast may suggest is that when women are expected to train and perform with men, as they are in the military, they are more likely to suffer injuries than when allowed to train and compete at their own level (at least initially).

A system of musculoskeletal profiling

It would certainly be advantageous to the athlete if potential injuries could be predicted prior to their occurrence. A pre-season musculoskeletal examination could identify abnormal physical characteristics and the athletic trainer could then prescribe a preventive conditioning program to help decrease the possibility of future injury.

In an effort to establish a selective musculoskeletal athletic profile system, a collaborative four year longitudinal study was launched in 1980 by Wellesley College and the US Army Research Institute of Environmental Medicine (USARIEM). The study involves ten female intercollegiate varsity teams. The purpose of the study is to determine whether any relationship exists between various physical characteristics and the occurrence of injury and if so to attempt to develope a battery of tests that would help predict injury.

The pre-season screening exam involves many components: medical history, anthropometry, muscle strength, orthopedic alignment, joint laxity, and flexibility. These components are measured and recorded to provide a baseline for each student athlete. Injuries sustained during the season are documented by the athletic trainer and then appropriate follow-up care is administered by the College infirmary, athletic trainer, or the team orthopedic physician.

1. Medical History

Biographical information is recorded concerning age, sport, years of participation and injury history.

2. Anthropometry

The subjects height and weight are recorded. Skinfold measurements are taken from the subscapular, tricep, bicep, and suprailiac areas. Percent body fat is estimated from skinfold thicknesses according to the formulas of Durnin and Womersley (20).

3. Muscle Strength

Maximal isometric strength of the upper torso, the legs and back are measured on a static strength machine designed and used extensively by

USARIEM (21). The Cybex II dynamometer is used to measure maximal dynamic strength of both the left and right knee flexors and extensors at both 30 degrees/second and 180 degrees/second. On all strength tests three maximum voluntary contractions are performed with at least 30 seconds rest between contractions. If the strength values are not within ± 10% of each other they are repeated up to a maximum of five contractions. The mean of the three highest values is recorded as the criterion strength score.

4. Orthopedic Alignment

The purpose of orthopedic alignment measures is to construct a lower body model as a means of individual comparison. Our plan is to eventually have sufficient data for a computer to generate a lower body structural profile for each athlete to permit comparisons between injured and uninjured subjects and thus identify predisposing structural differences.

For most of the following measurements of the lower extremities, subjects are measured while standing with their feet in 5 degrees of external rotation. Body length and width measurements are recorded in centimeters while angular measurements are recorded in degrees. The measurements taken are as follows (16,17):

a. The anterior superior iliac spine (ASIS) is identified and designated with a marking implement. Leg length is determined by measuring each leg from the ASIS to the shelf of the medial malleolus.

b. The Q-angle is measured with a long arm goniometer. The axis of the goniometer is centered on the mid-patella and the arms aligned with the ASIS and the center of the tibial tuberosity (figure 1-1).

c. An anthropometer is used to measure the distance between the ASIS.

d. Obstetric calipers are used to compress the adipose tissue and measure the distance between the right and left greater trochanters.

e. Obstetric calipers are placed on the right and left outer femoral condyles and the distance measured and recorded.

f. The distance between the right and left inner femoral condyles is measured.

g. The distance is measured between the right and left medial malleoli.

h. The distance is measured from the greater trochanter to the lateral malleolus.

i. The distance is measured from the greater trochanter to the outer femoral condyle.

j. The distance is measured from the outer femoral condyle to the lateral malleolus.

k. Foot pronation/supination is measured with the subject standing with toes pointing straight ahead. The insertion of the achilles tendon into the calcaneous and the midline of the calcaneous are identified and marked. The heel is then placed against a plexiglas grid and the angle measured with a protractor (figure 1-2).

5. Joint Laxity

Joint laxity varies throughout the population of normal healthy adults (22). It has been suggested that "supple" individuals are more likely to suffer dislocations than tight or less flexible individuals. Four hypermobility tests are administered to determine overall joint laxity. Individuals who demonstrate excessive joint mobility in 3 out of 4 of the following tests are suspected to have an increased susceptibility toward joint related injuries.

a. The subject attempts to touch the thumb to the ventral forearm with the wrist flexed and the thumb extended.

b. The subject attempts to apply gentle pressure with the non-tested hand in order to extend the fingers so that they are parallel to the dorsal aspect of the forearm.

c. Elbow hyperextension is measured with the athlete's arm extended and hand supinated. The goniometer is centered on the lateral epicondyle and the goniometer arms are aligned with the long axis of the humerus and the radial styloid, and degrees of deviation from 180° are noted.

d. Hyperextension of the knee joint is measured while the subject is supine with the knee extended and the heel resting on a three inch platform. The goniometer is centered at the knee on the lateral femoral condyle with the arms aligned with the greater trochanter and the lateral malleolus, and deviation from 180° is recorded.

6. Flexibility

Flexibility below a certain level is suspected to predispose a muscle to injury when stressed. In order to test this assumption, flexibility measurements are obtained from 7 major muscle groups of the lower extremity, so that injury rates in "flexible" and "inflexible" athletes may be compared [18]. A goniometer is used to measure active flexion in each joint, as follows:

a. Hamstring flexibility is measured with the subject lying in a supine position with legs extended. The leg being tested is actively flexed at the hip with the knee locked. The axis of the goniometer is placed on the greater trochanter with one arm aligned with the lateral midline of the thigh (parallel to the femur) and the other arm parallel to the measuring surface.

b. Adductor flexibility is measured with the subject lying supine with the tested leg extended and the non-tested flexed and hanging over the side of the table to stabalize the pelvis. One arm of the goniometer is placed on a line across the right and left ASIS, and the other arm placed on the anterior midline of the thigh. The leg is actively abducted with the toes and knees pointing up to avoid lateral rotation of the hip.

c. Quadricep flexibility is measured with the subject in a prone position with leg extended. The knee is actively flexed and measured with one goniometer arm aligned with the greater trochanter and the other arm aligned with the lateral malleolus (parallel to the crest of the tibia).

d. Hip extension flexibility is measured with the subject in a prone position with the knee flexed at 90 degrees. The thigh is actively extended with the goniometer arms aligned with the lateral midline of the thigh and an imaginary line which parallels the table surface.

e. Gastrocnemius flexibility is measured with the subject in a long sitting position with knees extended. The foot is actively dorsiflexed with one goniometer arm placed parallel to the fifth metatarsal and the other arm aligned with the lateral midline of the leg (parallel to the shaft of the tibia).

f. Soleus flexibility is measured with the subject in a long sitting position with the knee flexed at 90 degrees. The foot is actively dorsiflexed with goniometer arms aligned parallel to the fifth metatarsal and the lateral midline of the leg (parallel to the shaft of the tibia).

g. Hip rotation is measured with the subject in a prone position with the knee flexed to 90 degrees and the midpatella resting against the axis of a large plexiglas protractor. As the lower leg externally rotates, internal hip rotation takes place and is measured (figure 1-3). Care is taken to keep the subject's hips on the table. The procedure is repreated allowing the leg to fall into internal rotation, so external hip rotation can be measured.

Practical use of musculoskeletal profiling

The intent of the collaborative study between Wellesley College and USARIEM is to examine the possible value and utility of developing a musculoskeletal profile which could identify biomechanical abnormalities as well as strength imbalances, and to see if these may predispose women to certain types of injuries. We are particularly interested in identifying physical characteristics which either exceed or fall short of the accepted norms and determining if certain characteristics or combinations of characteristics are predictive of specific injuries.

Musculoskeletal profiling may be useful as other than a research tool. For instance, historical information can alert the trainer to potential sources of future injury. When a history of injury dictates, a preventive conditioning program can be prescribed with the aim of reducing the chances of reinjury. Also, if particular muscle groups are found to be relatively inflexible during preseason screening a remedial static stretching program may be prescribed.

In regard to the characteristics of muscles, Klafs and Arnheim [14] have stated that imbalances in muscle strength and inflexibility are precipitating factors leading to muscle strains. Burkett [14] in a prospective study found that 67% of athletes with a muscular strength imbalance of 10% or greater between the right and left knee flexors suffered hamstring strains. But, Laird [15] was unable to show that knee flexor or knee extensor strength imbalances predisposed athletes to muscle strains. Despite the contradictory literature at this point, however, it is felt that athletes who demonstrate a 10 percent or greater muscle imbalance between flexors and/or extensors should be placed on a strength conditioning program. It is hoped that a reduction of strength imbalance will be useful in the prevention of potential muscle strains. Nevertheless, it is important to recognize that 10 percent only represents a guideline and that strength imbalance is not always solely responsible for the occurrence of a muscle strain. There are athletes with a muscle imbalance of 10 percent or greater who will not sustain a muscle strain. The type of sport, position, motivation, and intensity of effort may be important factors to consider when looking at muscle strains and all injury statistics in general.

A musculoskeletal profile can also be important insurance that an athlete is not returned to competition before she (or he) is fully rehabilitated. Preseason screening establishes objective norms for a particular athlete and the decision regarding when the athlete may return to practice can be based on these norms. It is important that the athlete be tested prior to the competitive season to insure test scores that are not confounded by injuries. Sapega and Nicholas [19] have stated that the common practice of assuming that physical symmetry is the norm and using the athletes opposite side as a comparative standard is not always desirable.

Summary and conclusions

It has been suggested that women athletes sustain similar types of injuries as their male counterparts. The mechanisms responsible for injury are similar for both sexes and it appears that injuries are more sport related, than sex related. But there is a continued need to focus on the patterns of injury, and to determine whether there is a causal relationship between measurably aberrant musculoskeletal variables and injury. Also, there is a further need to ascertain whether susceptibility to injury is indeed similar in males and females. By using the precompetition examination outlined above, we hope to develop a system for predicting with some certainty predisposition to injury. If predisposing factors can be identified, precompetition training and equipment can be individualized where practical to minimize the chance of injury.

REFERENCES

1. Harris, V. Physical sex differences: A matter of degree. The Counseling Psychologist 6:9-11, 1976.

2. Haycock, E., Gillette, J. . Susceptibility of women athletes to injury. JAMA 236:163-165, 1976.

3. Albohm, M. How injuries occur in girls' sports. Phys. and Sportsmed. 5:44-48, Feb., 1976.

4. Haycock, E. Health concerns of women in sports. Athletic Purchasing and Facilities 62-65, March, 1981.

5. Reinker, A., Ozburne, S. A comparison of male and female orthopedic pathology in basic training. Military Medicine 532-536, August, 1979.

6. Kowal, D.M. Nature and causes of injuries in women resulting from an endurance training program. Am. J. of Sports Med. 8:265-269, 1980.

7. Protzman, R. Can women be overextended in physical conditioning programs? Am. J. of Sports Med. 7:145-146, 1979.

8. Clarke, K.S. Women's injuries in collegiate sports. Am. J. of Sports Med. 8:187-191, 1980.

9. Shively, R.A., Grana W.A., Ellis, D. High school sports injuries. Phys. and Sportsmed. 9:46-49, 1981.

10. Graham, F.P., Bruce, J. Survey of intercollegiate athletic injuries to women. Res. Quart. 48:217-

11. Clement, D.B., Taunton, J.E., Smart, G.W., McNicol, K.L. A survey of overuse running injuries, Phys. and Sportsmed. 9:47-48, 1981.

12. Pagliano J., Jackson D. The ultimate study of running injuries. Runner's World 42-50, Nov., 1980.

13. Brody, D., Konecke, S., Day, S.W., Kryder, S. A study of 4,000 running injuries. Running Times 22-29, July, 1981; 20-27 Sept., 1981.

14. Burkett, L.N. Causative factors in hamstring strains. Med. Sci. Sports 2:39-42, 1970.

15. Laird, D.E. Comparison of quad to ham strength ratios of an intercollegiate soccer team. Athletic Training 66-68, Spring, 1981.

16. Enneking, W.F., Brower, T.D., Ralston, E.L., American Orthopaedic Association. Manual of Orthopaedic Surgery, United States of America, 1979.

17. Heck, C.V., Hendryson, I.E., Rowe, C.R. Joint Motion: Method of Measuring and Recording. Chicago, Illinois: American Academy of Orthopaedic Surgeons, 1965.

18. ports Medicine Section, American Physical Therapy Association. Guidelines for Pre-season Athletic Participation Evaluation. Columbus, Georgia: Diversified Printing Services, 1979.

19. Sapega, A.A., Nicholas, J.A. The clinical use of musculoskeletal profiling in orthopedic sportsmedicine. Phys. and Sportsmed. 2:39-42, April, 1981.

20. Durnin, J.V.G.G., Wormersley, J. Body fat assessment from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Brit. J. Nutr. 32:77-97, 1974.

21. Knapik, J.J., Wright, J.E., Kowal, D.M., Vogel, J.A. The influence of US Army Basic Initial Entry Training on the muscular strength of men and women. Aviat. Space Environ. Med. 51:1086-1090, 1980.

22. Marshall, J.L., Johanson, N., Wickiewicz, T.L., Tischler, H. M., Koslin, B.L., Zeno, S., Meyers, A. Joint loosness: a function of the person and the joint. Med. Sci. Sports 12:189-194, 1980.

BIBLIOGRAPHY

Buchbinder, M.R.; Napora, N.U., Biggs, E.W. The relationship of abnormal pronation to chondromalacia of the patella in distance runners. Podiatric Sports Medicine 69:159-162, February 1979.

Eggold, James F. Orthotics in the prevention of runners overuse injuries. Phys. and Sportsmed. 9:125-128, March, 1981.

Glick, James M. Muscle strains: prevention and treatment. Phys. and Sportsmed. 8:73-77, November, 1980.

Godshall, Richard W. The predictability of athletic injuries: an eight year study. J. of Sports Med 3:50-54, 1975.

Hayes, Don. Risk factors in sport. Human Factors 16:454-458, 1974.

Krissoff, W.B., Ferris, W.D. Runners' injuries. Phys. and Sportsmed. 7:55-64, 1979.

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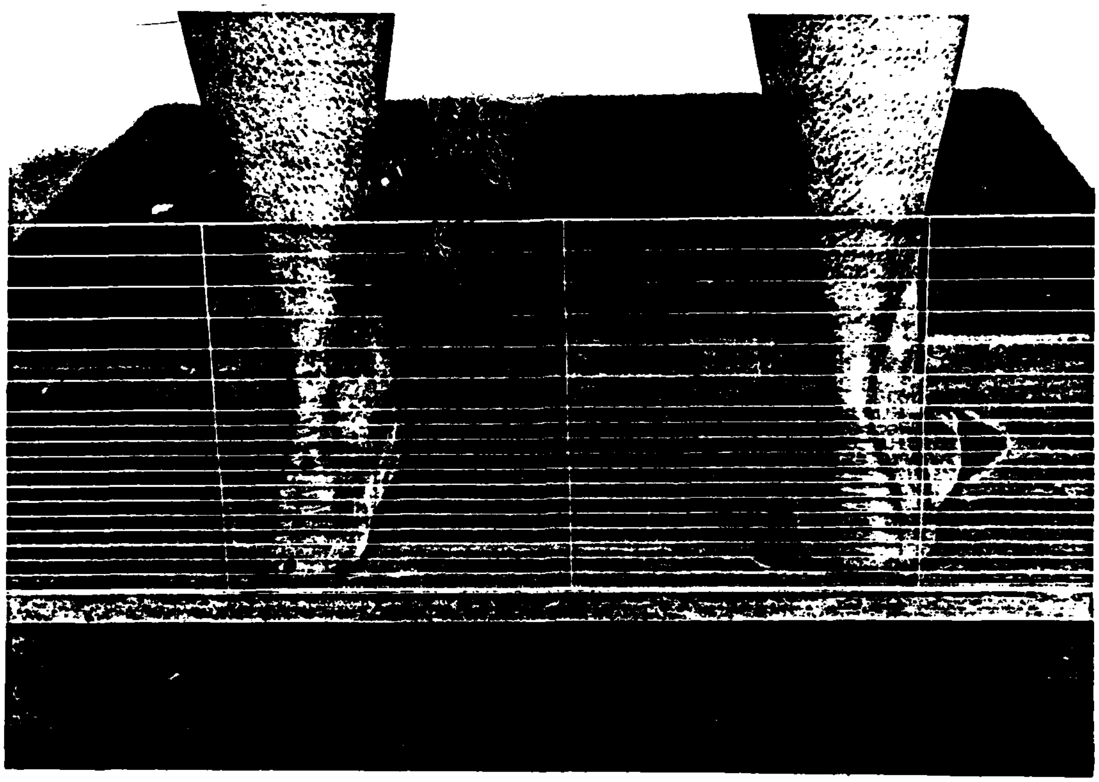
Figure 1-2



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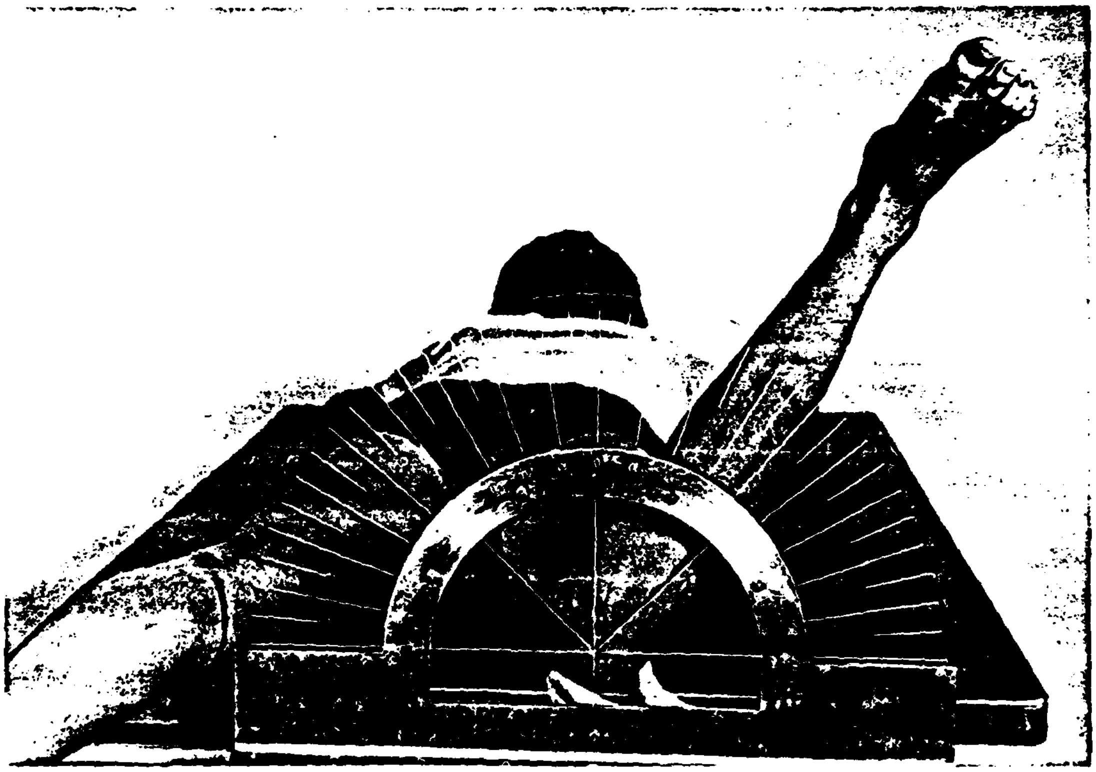

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

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