AD ____________

MIPR NUMBER 95MM5524

TITLE: Use of Noninvasive Bone Structural Measurements to Evaluate Stress Fracture Susceptibility Among Female Recruits in U.S. Marine Corps Basic Training

SUBTITLE: Individual Profiles of Stress Fracture Susceptibility among Female Recruits in U.S. Marine Corps Basic Training

PRINCIPAL INVESTIGATOR: Richard A. Shaffer, CDR, MSC, USN

CONTRACTING ORGANIZATION: Naval Health Research Center
San Diego, CA 92186-5122

REPORT DATE: March 1996

19981029013

TYPE OF REPORT: Final

PREPARED FOR: Commander
U.S. Army Medical Research and Materiel Command
Fort Detrick
Frederick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for public release; distribution unlimited

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE March 1996	3. REPORT TYPE AND DATE COVERED Final (15 Nov 94- 31 Jan 96)

TITLE: Use of Noninvasive Bone Structural Measurements to Evaluate Stress Fracture Susceptibility Among...

5. FUNDING NUMBERS
95MM5524

6. AUTHOR(S)
Richard A. Shaffer

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Health Research Center

San Diego, CA 92186-5122

8. PERFORMING ORGANIZATION

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Commander
U.S. Army Medical Research and Material Command
Fort Detrick, Frederick, MD 21702-5012

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

Approved for public release; distribution unlimited

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
The objective of this study was to derive predictive models of stress fracture susceptibility in female military recruits by administering a questionnaire highlighting exercise and health habits prior to reporting to Marine Corps Recruit Depot (MCRD), Parris Island, and assess body composition and anthropometric measures immediately after reporting to MCRD, Parris Island. A second objective of this study was to establish enrollment procedures and begin enrolling subjects for a second phase of the study which will add femoral and tibial dual energy x-ray absorptiometry (DEXA) scans for each subject. The study population consisted of 1,054 (90%) of the 1,165 female recruits reporting to MCRD, Parris Island; 613 had anthropometric measures; 175 subjects had femoral and tibial DEXA scans. Fifty-two recruits (4.9% of the population) had 56 stress fractures. The most common sites were: metatarsal (n=19; 34%); pelvis (n=18; 32%); tibia (n=11; 20%); and femur (n=8; 14%). Previous injury history, fitness as measured by the 0.75 mile run, and late age at first menses were significantly associated with a higher incidence of stress fracture. Smoking cigarettes or alcohol use during the 6 months before reporting to MCRD were not significantly associated with stress fracture. Subjects will be continued to be enrolled using DEXA scanning and these results will be reports under another follow-on work unit. It is anticipated that these results will guide the design and implementation of preventive interventions.

14. SUBJECT TERMS
Defense Women's Health Research Program, human subjects, epidemiology, overuse injury, stress fracture incidence, military, morbidity, U.S. Navy, U.S. Marine Corps

15. NUMBER OF PAGES
51

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unclassified

FOREWORD

Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the US Army.

____ Where copyrighted material is quoted, permission has been obtained to use such material.

____ Where material from documents designated for limited distribution is quoted, permission has been obtained to use the material.

RKS Citations of commercial organizations and trade names in this report do not constitute an official Department of Army endorsement or approval of the products or services of these organizations.

____ In conducting research using animals, the investigator(s) adhered to the "Guide for the Care and Use of Laboratory Animals," prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Resources, National Research Council (NIH Publication No. 86-23, Revised 1985).

RKS For the protection of human subjects, the investigator(s) adhered to policies of applicable Federal Law 45 CFR 46.

____ In conducting research utilizing recombinant DNA technology, the investigator(s) adhered to current guidelines promulgated by the National Institutes of Health.

____ In the conduct of research utilizing recombinant DNA, the investigator(s) adhered to the NIH Guidelines for Research Involving Recombinant DNA Molecules.

____ In the conduct of research involving hazardous organisms, the investigator(s) adhered to the CDC-NIH Guide for Biosafety in Microbiological and Biomedical Laboratories.

RA Shaff 2/22/96

PI - Signature / Date

TABLE OF CONTENTS

INTRODUCTION

Stress fractures cause significant morbidity during recruit training, particularly in elite programs requiring intense physical conditioning, such as the US Marine Corps.[1-3] Estimates of the incidence of stress fractures in female military training populations range from 1.1% to as high as 34%.[4-12] Recent information from the Marine Corps Recruit Depot (MCRD), Parris Island, indicates that women suffer lower extremity stress fractures during basic training at a rate of 3.8%.[13] Further, discussion with Recruit Training Regiment staff suggests a significant increase in pelvic stress fractures in female recruits, with an incidence of up to 15% during the end of 1993 and the beginning of 1994.

Stress fractures, which occur predominantly in the lower extremity, are believed to result from bone structural failure caused by repetitive weight-bearing loads. Weight-bearing during training regimens exposes bones to repetitive axial compression, torsion, and bending stresses.[14] Within a bone exposed to a given load, stress magnitudes are determined by bone structural geometry, while the bone's ability to resist these stresses is defined by bone material properties.[15,16] Since bone material properties are much less variable than structural geometry, it is likely that most of the individual differences in bone strength can be explained by geometry.[17]

Work in progress at MCRD, San Diego, has developed a predictive model for musculoskeletal injury in male recruits. A number of intrinsic risk factors have shown promise for predicting stress fracture susceptibility in male recruits. The analysis of these risk factors indicates that as much as 60% of incident stress fractures during training can be predicted based on a profile composed of various measures of fitness, body structure, prior injury history, and exercise history. Many of these profile factors can be targeted for modification, with the ultimate goal of reducing stress fractures during training. For example, the data indicate that if male recruits were to exercise for endurance benefit more than twice a week for at least 2 months prior to arriving at MCRD, lower extremity stress fractures could be reduced by 44% during basic training. A number of other factors measuring fitness also demonstrate an association of pretraining fitness to likelihood of stress fracture. These predictors provide strong evidence for implementing physical training before a recruit begins Training Day 1. One can hypothesize that similar models, profiles, and modifications can be developed for females.

The general objective of this study was to derive predictive models of stress fracture susceptibility in female military personnel. This model was constructed from a questionnaire, which highlights exercise and health habits prior to reporting to MCRD, Parris Island, performance on an initial 0.75-mile run, and an assessment of body composition as a function of stress fracture incidence. Ultimately, an abbreviated profile can be constructed that can be utilized as a screening tool to identify high-risk female recruits. Further, those factors identified that are modifiable provide targets for the design of effective interventions to reduce the incidence of overuse injuries in female military training populations. In addition, the epidemiologic, anthropometric, and dual energy x-ray absorptiometry (DEXA) scan data collected in the current study will provide the basis for a follow-on stress fracture study being conducted by Johns Hopkins University collaborators. This subsequent study will define the statistical relationship between stress fracture and bone geometry as well as determine the effect of intensive training on bone remodeling through serial DEXA scanning during boot camp.

METHODS

Subjects were 1,054 female Marine Corps recruits, between the ages of 17 and 31, who arrived at MCRD, Parris Island, between 28 March and 20 September 1995 and volunteered to participate in the study. All subjects were administered a questionnaire and a subset of volunteers (613) had anthropometric measurements and DEXA scanning. Run times from the initial strength test (IST) 0.75-mile on Day 1 were recorded. Recruits were followed for the occurrence of injury, stress fractures, and graduation or separation.

Enrollment Procedures

All procedures were scheduled, without interference, during the first 4 days of recruit processing prior to training. Since MCRD processes incoming female recruits for basic training every 2 to 3 weeks, enrollment procedures were done in high volume cycles, with approximately 105 women enrolled over each 3- to 4-day processing period. The Information to Participants, California Experimental Subject's Bill of Rights, Voluntary Consent to Participate, Privacy Act Statement, and prospective questionnaire were administered on the first day of medical processing and required approximately 30 min to complete. All recruits were eligible for the study, and enrollment was performed without coercion. The questionnaire addressed recent physical activity and running practices, motivational factors, previous injuries, menstrual history, and tobacco and alcohol use. Anthropometric measurements and scanning, which were performed on a subset of recruits, took place on processing Days 2 to 4 and required approximately 20 to 30 min for completion.

Measurements

Anthropometry was performed on as many volunteers as the recruit processing schedule allowed. Height, weight, and body fat percentage were measured for a subset of 613 recruits. Body mass index (BMI) was calculated as weight/height^2, with weight in kilograms and height in centimeters. Several other anthropometric measurements of the lower extremities were taken to describe anatomical and mechanical variations. Bone lengths were used to identify DEXA scanning locations and to use as measurements of limb segment lengths.

DEXA Scanning

DEXA scanning was in place by 27 June 1995, and a total of 175 subjects, a subset of the 613 who were anthropometrically measured, were scanned midfemur and two-thirds distal tibia. Scanning was done with a conventional DEXA scanner (Norland XR26, Norland Inc., Fort Atkinson, WI). Subjects were positioned supine on the scanning table. Only the right side was scanned at both the midthigh (midfemur length) and at the distal third of the lower leg. Each 2 min scan involved a small amount of ionizing radiation (x-rays). Each scan exposed the subject to a total radiation equivalent of less than that received from normal background sources in one month (5 to 10 mrem). The instrument is approximately the size of an x-ray table, with an adjacent computer console. Because radiation levels outside the direct beam do not exist, the system does not require a shielded room.

Outcome Data

All subjects were followed throughout basic training for outcomes of injury, including stress fracture, and for graduation versus attrition ratio. The last platoon enrolled in September 1995 completed training in December 1995. Stress fracture data for the prospective phase were collected by reviewing each subject's medical record at the completion of training or at the time of separation from the Marine Corps. All stress fractures among subjects were routinely confirmed either radiographically or scintigraphically by the Branch Medical Clinic, according to standard case definitions. Data extracted from the medical record included date of visit, onset of injury, site of injury, specific final diagnoses, and the nature and duration of restricted duty due to injuries. Stress fracture was defined as partial or complete fatigue fracture of insidious onset in nondiseased bone. Diagnosis of stress fracture was based on (1) clinical presentation of localized pain of insidious onset, without prior acute trauma, aggravated by repetitive weight-bearing activities and relieved with rest; and (2) a confirmatory (+) radiograph and/or (+) bone scan at a site consistent with clinical presentation. A (+) radiograph was defined as presence of periosteal reaction, endosteal callus formation, and/or a fracture line in otherwise normal bone. A positive bone scan was defined as the presence of 3+ to 4+ intensity localized fusiform uptake at the site of pain.

Analysis

Incidence rates for injury were calculated as the number of recruits with at least one lower extremity stress fracture divided by the total number of study subjects. Univariate analysis was performed using chi-square to test the comparisons between the proportions of stress fractures in each applicable category of the questionnaire items. Analysis of shoe size, distance and duration of running during the last two months, age, height, weight, body fat percentage, BMI, and 0.75-mile run were performed using a comparison between means among those recruits with and without stress fractures.

For multivariate analysis, the measure of association was the adjusted odds ratio which was generated from multiple logistic regression analysis. Terms for the model were selected based on univariate analysis and items of interest.

RESULTS

Subjects

The 1,054 subjects had a mean age of 19 years, with a racial/ethnic distribution of 62.2% Caucasian, 17.3% Black, 14% Hispanic, and 6.5% other. The mean height, weight, body fat, and BMI are displayed in Table 1. The average IST run time was 6:19 min (range 4:03 - 8:57). Approximately one third of the recruits smoked cigarettes in the previous 6 months (Table 1). Of the 1,054 subjects, 808 graduated (77%), 227 separated (21.5%) and 19 are still in process (in medical rehabilitation platoon [MRP]) as of 29 February 1996. Twelve of the 19 recruits in MRP have stress fractures.

Injury

Five hundred twenty-six recruits (49.9%) suffered 914 injuries during basic training. A total of 52 recruits (4.9%) had 56 stress fractures. The most common site was the metatarsals (n = 19; 34%), followed by pelvis (n = 18; 32%), the tibia (n = 11; 20%), and femur (n = 8; 14%). The incidence of all injuries and stress fractures was compared between this cohort of female Marine Corps recruits and a cohort of male Marine Corps recruits at MCRD, San Diego (Table 2).

Risk Factors for Injury

Univariate analyses of 34 prospective health habit and exercise-related history questionnaire items, four anthropometric measurements, and the IST 0.75-mile run time are displayed in Table 3. Previous injury history and fitness as measured by the 0.75-mile run, were significantly associated with incidence of stress fracture as was menstrual history. Smoking cigarettes over the previous 6 months and alcohol use were not significantly associated with stress fracture.

Table 4 presents the adjusted odds ratio for selected risk factors in the logistic regression model of stress fracture susceptibility for female Marine Corps recruits. The adjusted odds ratios indicate an increased risk of stress fracture among recruits in poor or fair fitness compared to very good or excellent fitness. Recruits with slower running times on a 0.75 mile timed run were at increased risk of stress fracture during training. Later age of first menses was also a risk factor for stress fracture after controlling for incoming fitness. Variables not associated with stress fracture included cigarette smoking, alcohol use, and selected dieting methods.

CONCLUSIONS

This study documents that approximately 5% of all female Marine Corps recruits incur a stress fracture during 13 weeks of basic training. When compared to data from a recently completed study of male recruits at MCRD, San Diego, both the overall musculoskeletal injury rate (50% vs. 27.3%) and stress fracture rate (4.9% vs 3.7%) were higher in the female recruits. It is likely that the women's rate is conservative, since this study utilized stringent criteria for stress fracture diagnosis and a passive surveillance system. Preliminary work in male recruits demonstrated that active surveillance identified an additional 50% stress fracture occurrence rate than was reported at the medical clinic. In addition, the anatomical distribution of stress fractures in women resulted in more severe injuries, with pelvic and femoral fractures accounting for half of the stress fractures. In male recruits, femoral fractures were uncommon, and no pelvic fractures were documented.

Quantification of the readiness and fiscal impact in these female Marine Corps recruits is pending since some study subjects are still in process, primarily in the MRP for stress fractures. However, in male recruits, the stress fracture incidence rate of 3.7% in the 25,000 recruits in training results in projected cumulative costs of approximately $10 million annually, with associated readiness costs of approximately 53,000 lost training days.[13] Although the total number of female recruits is much lower at 2,000 in training annually, the per capita costs will be greater in women due to the increased severity of the injuries. Fractures of the pelvis and femur require 3-5 months for rehabilitation versus the 4-6 weeks required for metatarsal or tibial stress fractures.

In the current study, risk factors of poor fitness, prior injury, menstrual history, and perception of weight were significantly associated with subsequent occurrence of stress fracture. Specifically, women arriving at boot camp in poor fitness, as indicated by a 0.75-mile run and self-reported questions regarding fitness-related activities, were at increased risk for stress fracture. The incoming fitness association with stress fractures is further supported by a decreased risk of stress fractures in women with a history of a prior exercise-related injury. The history of exercise-related injury can be an indicator of more physically active individuals. In male Marine Corps recruits, a model for predicting stress fractures during training was developed using incoming fitness information and validated in subsequent classes of recruits.

Women who developed a stress fracture during boot camp reported a different menstrual history profile. Oligomenorrhea and estrogen supplementation previously have been identified as risk factors for stress fracture. Additional analyses of the menstrual history profile in this study population is in progress. Eating disorders have been shown to be associated with stress fractures in females. In the current study, we identified an association between women who perceived their weight to be too heavy or too low and stress fracture occurrence. The significance of this observation is unclear since the standard correlates for eating disorders (ie, diet pills, laxatives, vomiting, diuretics) were not significantly associated with stress fracture.

Approximately 30% of the incoming female Marine Corps recruits had a history of cigarette use, and 25% reported a history of alcohol ingestion 6 months prior to reporting to boot camp. Both univariate and multivariate analyses of the relationship between previous smoking history and alcohol ingestion and stress fractures were performed. Although another study in Army male trainees indicated a potential link between smoking and injuries in men, we found no such association in female Marine Corps recruits.[23] At this time, we can make no conclusions regarding anthropometric measures and stress fractures since analyses of this data set are pending.

Previous studies have documented women to be at greater risk of musculoskeletal injury during military training than men.[4-12] Stress fracture rates have been reported to be 2 to 12 times greater for women than men in similar training situations.[4-12] In a study of intrinsic risk factors for injury in men and women during Army basic training, gender was associated as a potentially important risk factor. Women had significantly more time-loss injuries than men. That study did not, however, permit conclusive evidence of gender as an independent risk factor because multivariate analyses controlling for other variables such as fitness were not done. In addition, the current study will help to determine if gender is an independent risk factor by multivariate modeling of data for both the males and females.

The identification of a risk profile for injury, and specifically stress fractures, is a necessary step toward the development of an effective intervention. In the current study, the modifiable intrinsic factor of poor incoming fitness was significantly associated with incidence of stress fractures. In the study of male Marine Corps recruits discussed previously, the physical conditioning component of basic training was modified to better accomodate the poor entry-level fitness. This intervention incorporated current principles of safe and effective physical training. It is anticipated that a similar approach could be taken with women Marine Corps recruits. The risk profile data developed in the current study could be an integral part of a future intervention study.

A follow-on study being conducted by Johns Hopkins University will study the association of rigorous physical conditioning to the rates and magnitudes of improvements in the structural rigidity of long bones, specifically the relationship between stress fracture incidence and initial bone geometry. Their research will emphasize the geometric properties of cross-sectional area (CSA) and the cross-sectional moment of inertia (CSMI) of the bending plane as measured by a commercial DEXA scanner.[18-22]

In summary, this prospective study of 1,054 female Marine Corps recruits during basic training documents stress fractures as a significant source of morbidity.

LIST OF ALL PERSONNEL RECEIVING PAY FROM THIS WORK UNIT

1. Daniel Trone, M.A.
2. Kelly Bettsinger, B.A.
3. Mary Durm, B.A.
4. Lonna Gelles
5. Tishaba Harris
6. Stephany Thoreson, B.S.
7. Elizabeth Lube, B.S.N.

TABLE 1. Characteristics of 613 Female Marine Corps Recruits, MCRD, Parris Island, 1995

	MEAN	**SD**
Age (years)	19.2	2.0
Height (cm)	163.3	6.7
Weight (kg)	58.6	7.1
Body Fat (%)	24.5	4.3
BMI (kg/m^2)	22.0	2.1
IST 0.75-mile run time	6:19	1:07
Smoked Past 6 Months	33% did smoke	

TABLE 2. Incidence of all Injuries and Stress Fractures for Female and Male Marine Corps Recruits

	ALL INJURIES	**STRESS FRACTURES**
females MCRD, Parris Island, 1995 (n=1054)	526 recruits had 914 injuries (49.9%)	52 recruits had 56 stress fractures (4.9%)
males MCRD, San Diego, 1993 (n=1136)	310 recruits had 503 injuries (27.3%)	42 recruits had 45 stress fractures (3.7%)

TABLE 3. Univariate Analyses (of questionnaire data, anthropometric measurements, and 0.75-mile run time) of Predictors of Stress Fracture in Female Marine Corps Recruits, 1995

VARIABLE		CHI-SQUARE	P VALUE
platoon number		16.99	0.591
handedness (left or right)		0.92	0.337
shoe size		1.25 (F stat)	0.262
sweat during exercise		5.63	0.228
exercise intensity		2.14	0.830
current physical fitness (self-rated)		8.46	0.076
exercise last 2 months		9.19	0.239
exercise change last 2 months		5.26	0.261
frequency of run last 2 months		9.80	0.200
duration of run last 2 months		9.05	0.171
distance of run last 2 months		4.92 (Kruskal-Wallis)	0.027
run time per workout last 2 months		2.05	0.153
previous injury below the waist		2.02	0.156
injuries prevent normal physical activities for at least one week		3.61	0.165
return to 100% normal physical activity sometime after the injury		5.19	0.075
previous stress fracture below the waist		0.10	0.747
regular medications		0.07	0.791
vitamin or mineral supplements		0.20	0.652
weight for height and build (self-perceived)		1.41	0.493
current weight satisfaction		0.48	0.490
dairy products		4.99	0.417
methods used to lose weight:	diet pills	0.02	0.889
	laxatives	0.00	0.970
	vomiting	2.63	0.268
	diuretics	0.39	0.534
age at first menses		2.90 (F stat)	0.085
number of menstrual cycles last 12 months		3.05	0.549
length of menstrual cycle last 12 months		0.02 (Kruskal-Wallis)	0.885
length of menstrual flow		4.19 (F stat)	0.038
birth control pills last 12 months		0.21	0.645
pregnancy last 12 months		0.12	0.728
cigarette use last 6 months		1.07	0.301
smokeless tobacco use last 6 months		1.14	0.285
alcohol use last 6 months		0.01	0.923
height		0.02 (F stat)	0.884
weight		0.77 (F stat)	0.616
body fat (%)		0.01 (F stat)	0.924
BMI (kg/m^2)		1.69 (F stat)	0.191
0.75-mile run time		16.15 (Kruskal-Wallis)	0.000

TABLE 4. Risk Factors for Stress Fractures With Adjusted Odds Ratios from Logistic Regression Model, Female Marine Corps Recruits, Parris Island, 1995

VARIABLE	β ESTIMATE	ODDS RATIO	95% CONFIDENCE INTERVAL
age (years)	0.0242	1.024	(0.89, 1.18)
current physical fitness (self-rated)			
very good, excellent		1.000	
good	1.0788	3.168	(0.99, 8.75)
poor or fair	1.1531	2.941	(1.00, 10.02)
0.75-mile run time			
< 5:58		1.000	
5:58 - 6:24	0.8875	2.429	(0.63, 9.41)
6:25 - 6:47	1.8989	6.679	(1.91, 23.37)
6:48 - 8:57	1.5752	4.832	(1.35, 17.23)
weight for height and build (self-perceived)			
normal		1.000	
too heavy	-0.0815	0.922	(0.41, 2.07)
too thin	0.9262	2.525	(0.96, 6.62)
age at first menses (years)	0.2119	1.236	(1.02, 1.50)
cigarette use last 6 months (yes)	-0.3899	0.677	(0.34, 1.34)
alcohol use last 6 months (yes)	0.0324	1.033	(0.54, 1.97)
prev injury below the waist	-0.5117	0.599	(0.32, 1.14)
yes to any methods to lose weight: diet pills, laxatives, vomiting, diuretics	0.0577	1.057	(0.47, 2.36)

REFERENCES

1. Gilbert RS & Johnson HA. Stress fractures in military recruits: A review of twelve years' experience. Military Medicine, 1966;131:716.

2. Greaney RB, Gerber FH, Laughlin RL, Kmet JP, et al. Distribution and natural history of stress fractures in U.S. Marine recruits. Radiology, 1983;146:339.

3. Milgrom C, Giladi M, Stein M, Kashtan H, Margulies JY, Chisin R, Steinberg R, & Aharonson Z. Stress fractures in military recruits: A prospective study showing unusually high incidence. J of Bone Jt Surg, 1985;67-B:732.

4. Pester S & Smith PC. Stress fractures in the lower extremities of soldiers in basic training. Ortho Rev, 1992;21(3):297-303.

5. Kowal DM. Nature and causes of injuries in women resulting from an endurance training program. Am J of Sports Med, 1980;8(4): 265-269.

6. Jones BH, Manikowski R, Harris JH, Dziados J, Norton S, Ewart T, & Vogel JA. Incidence of and risk factors for injury and illness among male and female Army basic trainees. US ARMY RIEM Tech Report, 1988;T19-88.

7. Jones BH. Overuse injuries of the lower extremities associated with marching, jogging and running: A review. Military Med, 1983;148:783-787.

8. Protzman RR & Griffis CG. Stress fractures in men and women undergoing military training. J of Bone Jt Surg,1977;59A:825.

9. Reinker KA & Ozburne S. A comparison of male and female orthopaedic pathology in basic training. Military Med, 1979;144:532-536.

10. Brudvig TJS, Gudger TD & Obermeyer L. Stress fractures in 295 trainees: A one-year study of incidence as related to age, sex, and race. Military Med, 1983;148:666-667.

11. Jones BH, Bovee MW, Harris JM & Cowan DN. Intrinsic risk factors for exercise-related injuries among male and female Army trainees. Am J Sports Med, 1993;21:705-710.

12. Shaffer RA, Brodine SK, Corwin C, Almeida SA & Maxwell-Williams K. Impact of musculoskeletal injury due to rigorous physical activity during U.S. Marine Corps basic training (abstract). Med Sci Sports Exerc, 1994;26: S141.

13. Kimsey CD. The epidemiology of lower extremity injuries in United States Marine Corps recruits. Unpublished doctoral dissertation, University of South Carolina, 1993.

14. Lanyon LE, Hampson WGL, Goodship AE, & Shah,JS. Bone deformation recorded in vivo from strain gauges attached to the human tibial shaft. Acta Orthopedica Scandinavica, 1975;46:256-268.

15. Frankel VH & Burstein AH. In RM Kenedi (Ed.), Biomechanics and related bioengineering topics. Oxford: Pergammon Press, 1965, pp. 386-96.

16. Martens M, Van Audekercke R, de Meester P, & Mulier JC. The mechanical characteristics of the long bones of the lower extremity in torsional loading. Biomechanics, 1980;13:667-676.

17. Martens M, Van Audekercke R, de Meester P, & Mulier JC. The geometrical properties of human femur and tibia and their importance for the mechanical behaviour of these bone structures. Archives of Orthopaedic and Traumatic Surgery, 1981;98:113-120.

18. Beck TJ, Ruff CB, Scott WW, Plato CC, Tobin JD, & Quan CA. Sex differences in geometry of the femoral neck with aging: A structural analysis of bone mineral data. Calcified Tissue International, 1992;50:24-29.

19. Cowin SC. The mechanical and stress adaptive properties of bone. Annals of Biomedical Engineering, 1983;11:263-295.

20. Giladi M, Milgrom C, Simkin A, Stein M, Kashtan H, Margulies J, Rand N, Chisin R, Steinberg R, Aharonson Z, Kedem R, & Frankel VH. Stress fractures and tibial bone width: A risk factor. J of Bone Jt Surg, 1987;69-B:326-329.

21. Milgrom C, Giladi M, Simkin A, Rand N, Kedem R, Kashtan H, Stein M, & Gomori M. The area moment of inertia of the tibia: A risk factor for stress fractures. Journal of Biomechanics, 1989; 22:1243.

22. Beck TJ, Ruff CB, Warden KE, Scott WW, & Rao GU. Predicting femoral neck strength from bone mineral data: A structural approach. Investigative Radiology, 1990;25:6-18.

23. Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, & Frykman PN. Epidemiology of injuries associated with physical training among young men in the Army. Med Sci Sports Exerc, 1993;25

Female Recruit Prospective Questionnaire (Rev. 6/28/95)

PRIVACY ACT STATEMENT: Authority - 5 USC 301. Information will be collected to enhance basic medical knowledge and aspects of clinical preventive services for research purposes only. Participation is voluntary. No rights or benefits will be affected by nonparticipation.

Your answers to the following questions will be used for the purpose of scientific research and will be read by the research staff only. Your answers will not be used for disciplinary purposes, nor will your answers affect your military training in any way.

PLEASE READ ALL DIRECTIONS AND QUESTIONS CAREFULLY.

ANSWER THE FOLLOWING QUESTIONS AS THEY APPLY TO YOU OR YOUR LIFESTYLE DURING THE 2 MONTHS BEFORE COMING TO PARRIS ISLAND (unless otherwise specified). ANSWER ALL QUESTIONS BY CIRCLING THE APPROPRIATE ANSWER AND/OR FILLING IN THE BLANK(S).

IT IS VERY IMPORTANT YOU ANSWER ALL QUESTIONS HONESTLY AND COMPLETELY, to the best of your recollection. Research staff are available to assist you. WE APPRECIATE YOUR TIME AND CARE IN COMPLETING THIS QUESTIONNAIRE.

1. Are you pregnant or do you THINK you might be pregnant?

1 - No 2 - Yes

2. Social security number: ___ ___ ___ - ___ ___ - ___ ___ ___ ___

3. Full name:

3a. Last name: ______________________

3b. First name: ______________________

3c. Middle initial: ___

4. Today's date: ___ ___ - ___ ___ - ___ ___
year month day

5. Platoon number: ___ ___ ___ ___

6. Handedness (circle one): 1 - Left 2 - Right

7. Shoe size: ___ ___ . ___

8. In your exercise or leisure activities, how often do you "work up a good sweat?" (circle one answer)

1	2	3	4	5
Never	Occasionally	Fairly often	Quite a lot	Most or all the time

9. How intensely do you usually exercise? (circle one answer)

0 - I don't usually exercise
1 - Very leisurely - breathing easy, as during a slow walk
2 - Leisurely - breathing and effort slightly greater than a slow walk
3 - Average - breathing increased but not uncomfortable
4 - Intense - breathing hard, have to 'push' to keep going
5 - Very Intensely - breathing labored, difficult to keep going

10. Compared to others your same age and sex, how would you describe your overall physical activity before reporting to PARRIS ISLAND?
1 - Inactive
2 - Not very active
3 - Average
4 - Fairly active
5 - Very active

11. How would you rate your current physical fitness compared to others your same age and sex? (circle one answer)

1	2	3	4	5
Poor	Fair	Good	Very good	Excellent

12. During the LAST 2 MONTHS before reporting to PARRIS ISLAND, how often did you exercise or play sports? (circle one answer)

0 - Never
1 - 1 time or less per week
2 - 2 times per week
3 - 3 times per week
4 - 4 times per week
5 - 5 times per week
6 - 6 times per week
7 - 7 or more times per week

13. In the 2 MONTHS prior to reporting to PARRIS ISLAND, on average, how intensely did you participate in sports or strenuous labor?

0 - None, I did not participate in sports or strenuous labor.
1 - Very leisurely - breathing easy, as during a slow walk
2 - Leisurely - breathing and effort slightly greater than a slow walk
3 - Average - breathing increased but not uncomfortable
4 - Intense - breathing hard, have to 'push' to keep going
5 - Very intense - breathing labored, difficult to keep going

14. How did your level of exercise or sports participation change in the LAST 2 MONTHS before reporting to PARRIS ISLAND; compared to your usual level in the previous year? (circle one answer)

1 - **Much less** exercise in the last 2 months
2 - **Less** exercise in the last 2 months
3 - **About the same** amount of exercise in the last 2 months
4 - **More** exercise in the last 2 months
5 - **Much more** exercise in the last 2 months

15. What were the most common sports or types of strenuous labor that you participated in, other than running/jogging? Please write in "1" for the most frequent, "2" for the second most frequent and "3" for the third most frequent. If there were none, please check the first line, "None".

Also, please tell us how many years of VARSITY level participation you have had in any of the sports. Include HIGH SCHOOL and COLLEGE participation. Please read all before answering.

Rank		Varsity Participation
____	None, I did not participate in sports or strenuous labor.	
____	Basketball	1A - ____ (years)
____	Football	2A - ____ (years)
____	Baseball/Softball	3A - ____ (years)
____	Hockey	4A - ____ (years)
____	Field Hockey	5A - ____ (years)
____	Track (running events)	6A - ____ (years)
____	Track (field events)	7A - ____ (years)
____	Volleyball	8A - ____ (years)
____	Soccer	9A - ____ (years)
____	Lacrosse	10A - ____ (years)
____	Cross Country	11A - ____ (years)
____	Rowing	12A - ____ (years)
____	Gymnastics	13A - ____ (years)
____	Swimming	14A - ____ (years)
____	Wrestling	15A - ____ (years)

____ Racket Sports 16A - ____(years)
____ Aerobics 17A - ____(years)
____ Walking 18A - ____(years)
____ Rugby 19A - ____(years)
____ Bicycling 20A - ____(years)
____ Tennis 21A - ____(years)
____ Roller Blading 22A - ____(years)
____ Weight Lifting 23A - ____(years)
____ Farming
____ Furniture moving
____ Construction
____ Other Sports (please specify sports): ____________
27A - ____(years)
____ Other types of strenuous labor(please specify sports): ____________
28A - ____(years)

Questions #16-19 refer to running or jogging as a separate and distinct activity. Do not include running or jogging during another kind of sports activity unless you consistently ran or jogged to warm-up or train for that activity.

16. During the 2 MONTHS BEFORE coming to PARRIS ISLAND, on average, how many times per week did you run or jog?
0 - Never
1 - 1 time or less per week
2 - 2 times per week
3 - 3 times per week
4 - 4 times per week
5 - 5 times per week
6 - 6 times per week
7 - 7 or more times per week

17. If you ran or jogged during the LAST 2 MONTHS, for how long in total had you been CONSISTENTLY (2 or more times per week) running or jogging before coming to PARRIS ISLAND? (circle one answer) (*If you did not run or jog during the last 2 months, circle "0".)

0 - Does not apply. I did not run or jog during the 2 months before coming to PARRIS ISLAND.
1 - 1 month or less
2 - 2 months
3 - 3 months
4 - 4-6 months
5 - 7-11 months
6 - 1 year or more

18. During the 2 MONTHS BEFORE coming to PARRIS ISLAND, how far did you usually run or jog per workout? (*If you did not run or jog during the last 2 months, circle "000".)

___ ___ . ___ ___ (number of) miles
000 - I did not run or jog during the 2 months before coming to PARRIS ISLAND.

19. During the 2 MONTHS BEFORE coming to PARRIS ISLAND, how much time did it usually take you to complete a single running or jogging workout? (*If you did not run or jog during the last 2 months, circle "000".)

___ ___ ___ minutes
000 - I did not run or jog during the 2 months before coming to PARRIS ISLAND.

20. On days, that you participated in sports or strenuous labor activities, on average, how many minutes did you participate in sports or strenuous labor activities?

___ ___ ___ average number of minutes of sports or strenuous labor.

000 None, I did not participate in sports or strenuous labor.

21. In your life, have you ever injured bone, muscle, tendon, ligament, and/or cartilage in one or both of your lower limbs (hip to toe)? (for example, broken bone, pulled muscle, tendinitis, sprain or strain, tear, stress fracture) (circle one answer)

1 - No [if NO then also circle "0" for questions 22 and 23]
2 - Yes

22. Did any of these injuries prevent you from fully participating in your normal physical activities for at least a week? (*If you have never been injured, circle "0".) (circle one answer)

0 - Does not apply (I have never injured bone, muscle, tendon, ligament or cartilage in one or both of my lower limbs.)
1 - No
2 - Yes

23. Following these injuries, were you able to return to 100% of the level of physical activity you had maintained prior to the injury? (*If you have never been injured, circle "0".) (circle one answer)

0 - Does not apply (I have never injured bone, muscle, tendon, ligament or cartilage in one or both of my lower limbs).
1 - No, as a result of at least one injury, I have never been able to perform at 100% of the level of physical activity I had maintained before I was injured.
2 - Yes, I have been able to return fully (100%) to the level of physical activity I had maintained before I was injured.

24. In your life, have you ever been told by a medical provider that you had a stress fracture in one or both of your lower limbs (hip to toe)? (circle one answer)

1 - No [go to question #25]
2 - Yes, please specify:
   a. How many total stress fractures have you had? ____

   b. How long ago did the most recent stress fracture occur? ____ months/years (circle either months or years)

   c. In what location(s) have you had a stress fracture? (circle all that apply)
      1 - Hip
      2 - Upper leg (below hip, above knee)
      3 - Knee
      4 - Lower leg (below knee, above ankle)
      5 - Ankle
      6 - Foot

   d. Were you able to return to 100% of the level of physical activity you maintained prior to any of these stress fractures?
      1 - No, I have never been able to perform at 100% of my previous level of physical activity.
      2 - Yes, I have been able to return fully (100%) to my previous level of physical activity.

25. Have you had a heat injury before coming to PARRIS ISLAND?

1 - No
2 - Yes - specify year:
   The year was 19____.

26. Have you ever had a urinary tract infection (UTI, infection of bladder or kidneys)? For women, this does not include vaginal infections like yeast, trich, etc.

1 - No   2 - Yes

27. Have you ever had a wound infection (infection in a cut or surgical wound)?

1 - No   2 - Yes

28. Have you ever had an infection of your uterus or uterine tubes (sometimes called PID or pelvic inflammatory disease)? This does not include vaginal infections like yeast, trich, etc.

1 - No   2 - Yes

29. Has your appendix been removed?

1 - No [If no, skip to question 32]   2 - Yes

30. Why was your appendix removed?

1 - I definitely had appendicitis.
2 - I think I had appendicitis.
3 - They thought I had appendicitis, but after it was removed, they found my appendix was normal.
4 - My appendix was removed because I had surgery for another reason and they simply decided to take my appendix out because the surgeon had opened my stomach.
5 - I don't know why my appendix was removed.

31. Did you have a ruptured appendix?

1 - No, I had appendicitis but my appendix was definitely not ruptured.
2 - Unlikely, I had appendicitis and I think my appendix was not ruptured.
3 - Possibly, I had appendicitis and I think my appendix was ruptured.
4 - Yes, I had appendicitis and my appendix was definitely ruptured.

32. Do you take any medications (including birth control) on a regular basis?

1 - No
2 - Yes: If yes, please list: ____________________

____

33. Do you take any vitamin or mineral supplements?

1 - No
2 - Yes: If yes, please list: ____________________

____

34. For your height and build, do you consider your current weight to be:

0 - Too heavy   1 - Normal   2 - Too thin

35. Are you happy with your current weight?

1 - No   2 - Yes

36. How many meals do you usually eat per day? (circle one answer)

0   1   2   3   4   5 or more

37. How many snacks do you usually eat per day? (circle one answer)

0   1   2   3   4   5 or more

38. How many servings of milk, cheese, and/or other dairy products do you have per day? (circle one answer)

0   1   2   3   4   5 or more

39. Are there certain foods you avoid for any reason (e.g. meats, breads, etc.)?

1 - No
2 - Yes: If yes, please circle all that apply:
  1 - milk/dairy products
  2 - fruits
  3 - vegetables
  4 - breads/grains/cereals
  5 - red meats
  6 - pork
  7 - fish
  8 - chicken/poultry
  9 - fats
  10 - other (specify) ____________________

40. Have you ever been on a calorie-restricted diet?

1 - No   2 - Yes

41. Have you ever used any of the following methods to lose weight:

a.	Diet pills	1 - No	2 - Yes
b.	Laxatives	1 - No	2 - Yes
c.	Vomiting	1 - No	2 - Yes
d.	Diuretics	1 - No	2 - Yes

42. At what age did you start to menstruate (have periods)?

__ __ years old
001 - does not apply, I have not started menstruation.

43. How many periods did you have during the last 12 months? (circle one answer)

1 - 10-12
2 - 7-9
3 - 5-6
4 - 1-4
5 - None

44. In the last 12 months, how long was your usual menstrual cycle (from the start of one period until the start of the next period)? (For most women, a cycle is 25-35 days).

__ __ days

45. When you had a period during the last 12 months, how many days did the flow usually last? (For most women, the flow usually lasts 2-5 days.)

__ __ days

46. Were you ever pregnant during the last 12 months?

1 - Yes   2 - No

47. In the last 12 months, have your menstrual periods been irregular?

1 - Yes   2 - No

48. In the last 12 months, have you gone more than six months between any menstrual periods (other than for pregnancy)?

1 - Yes   2 - No

49. During the last 12 months, did you ever use birth control pills or any other hormonal therapy?

1 - Yes   2 - No

50. In the six months before reporting to PARRIS ISLAND, on the average, how many cigarettes did you smoke per day?

0 - None, I did not smoke.
____ average number of cigarettes smoked per day. (There are 20 in a pack.)

51. How many years have you regularly smoked cigarettes?

0 - I have not regularly smoked cigarettes.
____ number of years I have regularly smoked cigarettes.

52. What is the maximum number of cigarettes you have smoked per day on a regular basis?

0 - I have not regularly smoked cigarettes.
____ maximum number of cigarettes smoked per day on a regular basis. (There are 20 in a pack.)

53. In the six months before reporting to PARRIS ISLAND, on average, how many times (DIPS) per week did you use smokeless tobacco?

0 - None, I did not use smokeless tobacco.
____ average number of times (DIPS) per week.

54. How many years have you used smokeless tobacco?

0 - None, I have not regularly used smokeless tobacco.
____ number of years I have regularly used smokeless tobacco.

55. What is the maximum number of times (DIPS) per week you have used smokeless tobacco on a regular basis?

0 - None, I have not regularly used smokeless tobacco.
____ maximum number of times (DIPS) per week I used smokeless tobacco.

56. In the six months before reporting to PARRIS ISLAND, what is the most number of alcoholic drinks that you consumed in one 24 hour period? (one shot of whiskey, one glass of wine, or one 12 ounce beer represent one drink.)

0 - None, I did not consume any alcoholic drinks in the six months prior to reporting to PARRIS ISLAND.
____ most number of alcoholic drinks consumed in a 24 hour period.

57. In the six months before reporting to PARRIS ISLAND, what is the most number of alcoholic drinks that you consumed in any 7 day period?

0 - None, I did not consume any alcoholic drinks in the six months prior to reporting to PARRIS ISLAND.
____ most number of alcoholic drinks consumed in any 7 day period.

58. How many years have you regularly consumed one or more alcoholic drinks per week?

0 - None, I do not regularly drink alcohol.
____ number of years I have regularly consumed one or more alcoholic drinks per week.

59. What is the maximum number of alcoholic drinks you have consumed per week on a regular basis?

0 - None, I do not regularly drink alcohol.
____ maximum number of alcoholic drinks consumed per week on a regular basis.

60. Have you ever cared for farm animals like horses, cows, chickens, pigs, etc.?

1 - No
2 - Yes

61. How long did you care for farm animals?

____ No, I have not cared for farm animals.
____ number of years I cared for farm animals.

This booklet was generated as part of the
Defense Women's Health Research Proposal study entitled

Use of Noninvasive Bone Structural Measurements to Evaluate Stress Fracture Susceptibility Among Female Recruits in U.S. Marine Corps Basic Training

Principal Investigator
Richard A. Shaffer, PhD, MPH, LCDR, MSC, USN

By

Janet Buttermore, P.T.
Motion Analysis Laboratory, Children's Hospital and Health Center, San Diego

Chrisanna Weech-Johnson, MPH
Management Assistance & Concepts Corporation

Karen Maxwell, MS
UNIBAND

Daniel Trone, MA

Naval Health Research Center
P.O. Box 85122
San Diego, CA 92186-5122

(619)553-8400
DSN 553-8400

DATA SHEET
MCRD - PARRIS ISLAND
Demographics and Anthropometrics

I. DEMOGRAPHICS

1. Are you pregnant or do you think you could be pregnant?

   1 - NO
   2 - YES

2. Name Last ______________________ First ________________ MI ___

3. Social security number ___ ___ ___ - ___ ___ - ___ ___ ___ ___

4. Today's date ___ ___ - ___ ___ - ___ ___ (month-day-year)

5. Gender (circle one):
   1 - Female
   2 - Male

6. Race (circle one):
   1 - Caucasian (White), not Hispanic
   2 - Asian
   3 - Black
   4 - Hispanic
   5 - Pacific Islander
   6 - Native American
   7 - Other (specify) ________________

7. Have you ever had a lower extremity surgery (below the waist)?

   0 - No
   1 - Yes (specify) ____

II. ANTHROPOMETRICS

STANDING

8. Height ___ ___ ___ . ___ inches

9. Weight ___ ___ ___ . ___ pounds

10. Neck circumference: ___ ___ . ___ cm

11. Waist circumference: ___ ___ ___ . ___ cm

12. Hip circumference: ___ ___ ___ . ___ cm

13. Pelvis width: ___ ___ . ___ cm

14. Trochanteric width: ___ ___ . ___ cm

15. Knee varus/valgus 1 - valgus 2 - varus 3 - neutral 4 - both

    a. Medial malleoli distance (valgus) ___ ___ . ___ cm

    b. Femoral condyle distance (varus) ___ ___ . ___ cm

16. Height of navicular (navicular to floor)

    a. Right ___ . ___ cm

    b. Left ___ . ___ cm

17. Length of foot (tuber calcanei to first MP joint)

    a. Right ___ ___ . ___ cm

    b. Left ___ ___ . ___ cm

SITTING (on exam table)

18. Thumb to forearm? 0 - No 1 - Yes

19. Sit and reach ___ ___ . ___ cm 1 - positive (past toes) 2 - negative (lacks toes)

20. Elbow hyperextension
   a. Right ___ ___ degrees 1 - positive 2 - negative (hyperextension)
   b. Left ___ ___ degrees 1 - positive 2 - negative (hyperextension)

SUPINE (on back)

21. Upper leg length (ASIS to the medial knee joint space)
   a. Right ___ ___.___cm
   b. Left ___ ___.___cm

22. Tibial length (medial knee joint space to the medial malleolus)
   a. Right ___ ___.___cm
   b. Left ___ ___.___cm

23. Q angle (ASIS to center of patella to tibial tubercle)(toes pointing to the ceiling)
   a. Right ___ ___degrees 1. - valgus 2. - varus 3. - neutral
   b. Left ___ ___degrees 1.- valgus 2. - varus 3. - neutral

24. Knee range of motion (heel on top of the other foot)
(greater trochanter to lateral knee joint space to lateral malleolus)
   a. Right extension ___ ___degrees 1. - positive 2. - negative (hyperextension)
   b. Left extension ___ ___degrees 1. - positive 2. - negative (hyperextension)
   c. Flexion symmetric? (both knees to buttocks) 100-Yes 0-No ___ ___degrees difference

25. Straight leg raise (hold heel to tightness)(opposite knee flat on table)(hips flat on table)
   a. Right ___ ___ ___degrees
   b. Left ___ ___ ___degrees

26. Ankle dorsiflexion (knee extended)(90 degrees is neutral (0))
   a. Right ___ ___degrees 1. - positive (plantar flexion) 2. - negative (dorsi flexion)
   b. Left ___ ___degrees 1. - positive (plantar flexion) 2. - negative (dorsi flexion)

27. Ober Test (ilio-tibial band)(measurer should describe)
   a. Right 1. - positive (above horiz.) 2. - negative (below horiz.) 3. - intermediate (horiz.)
   b. Left 1. - positive (above horiz.) 2. - negative (below horiz.) 3. - intermediate (horiz.)

PRONE (on stomach)

28. Ankle dorsiflexion (knee flexed)(axis of rotation is the lateral malleolus)(knee to lateral aspect of the foot)
   a. Right ___ ___degrees 1.-positive (plantar flexion) 2.-negative (dorsi flexion)
   b.. Left ___ ___degrees 1.-positive (plantar flexion) 2.-negative (dorsi flexion)

29. Internal hip rotation (knees together, 90 degree flexion, both legs flare out at the same time)
   a. Right ___ ___degrees
   b. Left ___ ___degrees

30. External hip rotation (knees together, 90 degree flexion, one leg at a time)(crosses the midline)
   a. Right ___ ___degrees
   b. Left ___ ___degrees

31. Hindfoot inversion (feet at the end of the table)(axis of rotation is the Achilles insertion of the calcaneus)
(grab foot, pull toward midline of lower leg)
   a. Right ___ ___degrees
   b. Left ___ ___degrees

32. Hindfoot eversion (similar to #31, grab foot pull away from midline of lower leg)
   a. Right ___ ___degrees
   b. Left ___ ___degrees

SKIN MARKINGS by order of appearance in the data sheet/protocol.

1. Navicular: (standing) locate and place a mark along the lower edge of the navicular (figures D, 1,2) on both feet.

2. First M-P joint of feet: (standing) locate and place a mark at the first M-P (metatarsophalangeal) joint on the medial side of both feet (figures D, 3).

3. Medial knee joint space: (supine) locate the patellar tendon (figures B, 4) and place thumb in depression just medial to it (figure 5). Slide thumb medially while flexing and straightening the subject's knee until a groove is felt between the medial tibial and femoral condyles (figures A, 6-8). Mark this spot on both knees.

4. Lateral knee joint space: (supine) locate the patellar tendon (figures B, 4) and place thumb in depression just lateral to it (figure 5). Slide thumb laterally while flexing and straightening the subject's knee until a groove is felt between the lateral tibial and femoral condyles (figures A, 6-8). Mark this spot on both knees.

5. Medial malleolus: (supine) locate and place a mark at the distal end of the tibia, at the bottom edge of the medial malleolus of both legs (figures D, 9).

6. Lateral malleolus: (supine) locate and place a mark at the distal end of the tibia, at the bottom edge of the lateral malleolus of both legs.

7. Center of patella: (supine) locate and mark the center of the patella (knee cap) on both legs (figures A, B).

8. Tibial tubercle: (supine) locate the patellar tendon at the bottom of the patella (kneecap), follow it to the tibial tubercle. Mark the tubercle on both legs (figures A, B, 11, 12).

9. Midline of calcaneus (heel): (prone)
   a. place subject in the prone position.
   b. flex subject's knee and raise the lower leg until the sole of the subject's foot is facing up.
   c. facing the heel, grasp the heel on either side with thumb on one side and forefingers on the other, firmly delineating the calcaneus (heel bone) (figures 13, 14).
   d. place a line along the midline of the heel on both feet (figure 15).

10. Insertion of Achilles tendon: (prone) Place subject in prone position. Place thumb or forefinger on subject's heel and, while flexing the subject's ankle back and forth, move thumb/forefinger towards lower leg to locate the top of the calcaneus at the insertion of the Achilles tendon. Mark this spot centrally on both heels (figure 15).

11. Midline of distal calf: (prone) Place subject in prone position. Lay subject's leg down on the table and locate the midline of the calf. Extend a line along the midline of the distal calf on both legs, approximating the long axis of the tibia (figure 15).

II ANTHROPOMETRICS

STANDING

8. Height.
Materials - hospital grade counterbalance scale with measuring slide rule.
Subject should stand with shoes off, in light PT gear, on a hospital grade counterbalance scale facing outward with heels together. Subject should inhale maximally, hold the head with chin up to a height a little lower than the bottom of the earlobe. Subject should step out. Measure the height to the closest 0.1 inches.

9. Weight.
Materials - hospital grade counterbalance scale.
Subject should stand with shoes off, in light PT gear, on a hospital grade counterbalance scale facing forward with heels together. Measure weight to the closest 0.1 pounds.

10. Neck circumference.
Materials - metric nylon tape measure.
Require the subject to look straight ahead, with the chin slightly up so that the head is in a neutral position. Place the tape measure around the neck at a level just below the larynx. Because of the shape of the neck, the tape will usually slope downward to the front.

11. Waist circumference.
Materials - metric nylon tape measure.
The subject should lift clothing in order to expose the midsection. The level of the abdominal circumference is located about halfway between the umbilicus and the xiphoid process. Record the measurement at the end of a normal expiration.

12. Hip circumference.
Materials - metric nylon tape measure.
The subject should stand with heels together. While facing the subject's side, place the tape around the hips so that it is level with the floor and passes over the greatest protrusion of the gluteal muscles. Because the tape passes over clothing, extra tension should be applied so that the tape conforms closely to body contours.

13. Pelvis width.
Materials - caliper.
A. Have subject stand with feet slightly apart and toes pointed straight ahead.
B. Place arms of caliper firmly on either side of subject's pelvis (figure 16).
C. Measure and record the width of the pelvis girdle (pelvis width) at its widest point (iliac tubercle, figures 17, 18).

14. Trochanteric width.
Materials - caliper.
A. Have subject stand with feet slightly apart and toes pointed straight ahead.
B. Place arms of caliper firmly on both sides of subject's hips at the level of the greater trochanters (figure 19).
C. Measure and record the width of the hips at the greater trochanters to the nearest 0.1 cm.

15. Knee varus/valgus.
Materials - triangle caliper or tape measure.
A. Ask subject to stand with knees locked and feet shoulder width apart.
B. Then, ask subject to slowly move one leg toward the other until either the ankles of knees come together.
C. Place the triangle or tape measure between the subject's knees (femoral condyles) or ankles (medial malleoli) and press firmly against the subject to delineate interfemoral or intermalleoli width.
D. Measure and record the distance between the medial malleoli (valgus) or between the medial femoral condyles (varus) to the nearest 0.1 cm (figure 20). If valgus, record medial femoral condyle distance as zero; if varus, record medial malleoli distance as zero. If knees and ankles come together as the same time, record both distances as zero and circle "neutral". If there is measurable distance between both the femoral condyles and the medial malleoli, record both measurements and circle "both".

16. Height of navicular (navicular to floor).
Materials - skin marker, metric ruler with demarcations beginning precisely at the edge of the ruler.
A. Ask subject to take weight off left leg, bend the left leg at the knee, and extend it slightly to the rear. Subject should be braced against a table or wall (figure 21).
B. Measure and record the vertical distance between the floor and the lower edge of

the navicular of the right foot (previously marked) to the nearest 0.1 cm (figures D, 22).
C. Repeat height of the navicular for the left foot.

17. Length of foot (tuber calcanei to first MP joint).
Materials - skin marker, metric ruler.
A. Using the line of tile on the floor or a preestablished straight line (such as tape, or clip board at the rear of the foot), align the subject's medial side of the right foot along the line.
B. Ask subject to take weight off left leg, bend left leg at the knee, and extend left leg backward slightly, thus keeping weight balanced and evenly distributed on right foot with knee locked (figure 21).
C. Measure and record the distance from the tuber calcanei (heel edge) to the first MP joint (previously marked) on the floor along the medial edge of the foot to the nearest 0.1 cm (figures D, 23).
D. Repeat length of foot measurement for the left foot.

SITTING
18. Thumb to forearm?
Materials - none (actually, a thumb and a forearm)
A. Ask subject to flex wrist as if shooting a basketball.
B. Ask if subject can push thumb with other hand down to the forearm.

19. Sit and reach.
Materials - metric ruler or tape.
A. Ask subject to sit with legs straight out in front of them, and with toes and feet pointed straight up toward the ceiling.
B. Ask subject to slowly bend from the waist toward the toes, with arms outstretched as far as possible.
C. Measure and record the distance from the middle fingertip to the great toenail. If the middle fingertip is past the toes, circle "positive"; if it doesn't reach the toes, circle "negative".

20. Elbow hyperextension.
Materials - goniometer.
A. Ask subject to outstretch right arm forward, with the palm up toward the ceiling.
B. Ask subject to extend the right elbow (push upward toward the ceiling) as far as possible.
C. Place axis of goniometer in the center of the lateral side of the right elbow. Line up stationary *arm* of goniometer with midpoint of the right shoulder, and the moveable *arm* of goniometer with radial styloid process (figures 24, 25).
D. Measure and record the angle of the elbow (figure 25). If the elbow is flexed (elbow points toward floor), circle "positive". If the elbow is hyperextended (elbow points toward ceiling), circle "negative" (figure 25).
E. Repeat the measurement for the left elbow.

SUPINE (on back)
21. Upper leg length (ASIS to medial knee joint space).
Materials - skin marker, metric tape.
A. Locate anterior superior iliac spine (ASIS) on the pelvis of the right leg (figures 17, 18).
B. Place and hold the zero end of the metric tape at the slight concavity just below the ASIS.
C. Tautly extend the measuring tape to the medial knee joint space mark and record the upper leg length to the nearest 0.1 cm (figure 26).
D. repeat the measurement on the left leg.
The following steps are to be taken only when immediately scanning afterward
E. While holding the tape in place, mark 1/2 the total distance of the subject's right thigh.
F. Using a ruler, extend this mark into a line mediolaterally across the thigh (femoral scan site and mid thigh girth)(figure 26).
G. Draw two other lines: one 0.5 cm above the first line, and one 0.5 cm below the first line (scan length)(figure 26).

22. Tibial length (medial knee joint space to medial malleolus).
Materials - skin marker, metric tape.
A. Place the zero end of metric tape at the medial knee joint space mark on the right leg.
B. Tautly extend the measuring tape to the medial malleolus mark and record the tibial length to the nearest 0.1 cm (figure 27).
C. Repeat the measurement on the left leg.
The following steps are to be taken only when immediately scanning afterward
D. While holding the tape in place, mark 2/3 the total distance (1/3 distal tibia) of the subject's right lower leg.

E. Using a ruler, extend this mark into a line mediolaterally across the lower leg (tibial scan site)(figure 27).
F. Draw two other lines: one 0.5 cm above the first line, and one 0.5 cm below the first line (scan length)(figure 27).

23. Q Angle.
Materials - goniometer.
A. Position the subject's right leg with toes pointed toward the ceiling.
B. Position the subject vertically. Have the subject place his/her forefinger on the ASIS (figure 18) of the subject's right leg as a visual aid.
C. Place the axis of the goniometer on the mark at the midpoint of the patella (central kneecap) on the right leg (figures A, B, 28). Line up the stationary arm of the goniometer with the ASIS, and line up the movable arm of the goniometer through the tibial tubercle (figure A, B).
D. Measure and record the angle between the stationary arm (ASIS-midpatella) and the movable arm (midpatella-tibial tubercle) to the nearest degree (figure 28). Indicate valgus (><), varus (<>), or neutral (neither valgus nor varus) alignment of the knee (figure 28).
E. Repeat Q angle measurement and indication of valgus, varus, or neutral alignment for the left leg.

24. Knee range of motion.
Materials - goniometer.
Right and left knee extension.
A. Ask the subject to place the right heel on the left foot, and to extend or relax the right knee down toward the table as far as possible. The foot and toes should be pointing toward the ceiling. Or have the recorder hold the right heel about 8 inches off the table and tell the subject to relax.
B. Place the axis of the goniometer at the center of the lateral joint space of the knee (figures 29, 30). Line up the stationary arm of the goniometer with the right greater trochanter (figure 19). Line up the movable arm of the goniometer with the lateral malleolus (figures C, 31).
C. Measure and record the angle of the knee extension (figure 32). If the knee is flexed (bent - with knee pointed up toward the ceiling), circle "positive". If the knee is hyperextended (knee pointed down toward the table), circle "negative" (figure 32).
D. Repeat the measurement on the left leg.
E. Flexion symmetric? Grab the subject's ankles and push both heels toward the buttocks. If both ankles stop the same distance from the buttocks, then circle "100-Yes". If not symmetric, then measure each inflexion using the same landmarks as used for the extension measurement (the axis of rotation is the lateral joint space, and the arms of the goniometer are in line with the greater trochanter and the lateral malleolus). Record only the degree difference between the two knees.

25. Straight leg raise.
Materials - goniometer.
A. Position the subject's left leg straight down on the table. Lift the right leg up by holding the ankle and slowly moving toward the ceiling (figure 33). The subject must relax the leg while the examiner lifts the leg. At the point where either knee begins to bend, or where the examiner feels tightness or resistance, the leg is stopped and the assistant holds the leg in this position.
B. Place the axis of the goniometer at the right greater trochanter (figure 19). Line up the stationary arm of the goniometer parallel to the table, pointing toward the foot. The movable arm of the goniometer lines up with the right lateral malleolus (figures C, 31).
C. Measure and record the angle (figure 33).
D. Repeat the measurement on the left leg.

26. Ankle dorsiflexion (knee extended).
Materials - goniometer.
A. Ask the subject to pull the right foot up <u>maximally</u> keeping the knee straight (figure 34).
B. Place the axis of the goniometer on the lateral malleolus with the stationary arm of the goniometer parallel to the fibula. Line up the movable arm of the goniometer parallel to the lateral midline of the fifth metatarsal.
C. Measure and record the angle between the stationary arm (parallel to fibula) and the movable arm (parallel to plane of the foot) at maximal flexion to the nearest degree. Indicate whether motion is dorsiflexion and is measured in negative degrees, plantar flexion and measured in positive degrees, or without flexion and measured in neutral degrees (zero-neither dorsiflexion not plantar flexion) (figure 34).
D. Repeat ankle dorsiflexion measurement for the left ankle.

Note: The neutral point is 90 degrees on the goniometer, but this is recorded as 0 degrees

27. Ober test.
Materials - table and a body.
A. Ask the subject to lie on the left side with both knees slightly bent. The examiner (you) stands behind the subject.
B. Support the right leg in your right arm. Hold the upper side of the subject's pelvis with your left hand to prevent truck motion.
C. Lift the leg up toward the ceiling maximally, then pull the leg firmly back toward you maximally (figure 35). At this point, allow the leg to slowly lower toward the table, keeping the hip in maximal extension (figure 36).
D. The assistant will determine if the leg is horizontal (intermediate), above the horizon (positive), or below horizontal (negative). Record.
E. Repeat measurement sequence on the left leg.

PRONE (on stomach)

28. Ankle dorsiflexion (knee flexed).
Materials - goniometer.
A. Ask the subject to bend the right knee to approximately 90 degrees. Ask the recorder to pull the subject's foot toward the knee (dorsiflex) maximally (figure 34).
B. Place the axis of the goniometer on the lateral malleolus with the stationary arm of the goniometer parallel to the fibula. Line up the movable arm of the goniometer parallel to the lateral midline of the fifth metatarsal.
C. Measure and record to the closest degree the angle between the stationary arm (parallel to the fibula) and the movable arm (parallel to plane of the foot) at maximal flexion. Indicate whether the motion is dorsiflexion (measured in negative degrees), plantar flexion (measured in positive degrees), or without either dorsi or plantar flexion (measured as neutral). If neutral, place zeros in both data lines. (figure 34).
D. Repeat ankle dorsiflexion measurement for the left ankle.
Note: The neutral point is 90 degrees on the goniometer, but this is recorded as 0 degrees

29. Internal hip rotation.
Materials - goniometer.
A. Flex the subject's right knee to 90 degrees and perpendicular to the transverse line across the ASIS of the pelvis, midway between external and internal rotation (figures 37, 38).
B. Place the axis of the goniometer over the central patella of the right leg with the stationary arm of the goniometer parallel to the axis of the tibia and perpendicular to the floor and exam table. Line up the movable arm of the goniometer along the midline of the tibia (figure 38).
C. Press one hand firmly down onto the pelvis in order to prevent it from rocking, while the other hand rotates the leg away from the midline of the trunk (with thigh as axis of rotation) until resistance is felt (figure 38).
D. Measure and record to the closest degree the angle between the stationary arm (perpendicular to floor and exam table) and the movable arm (along midline of tibia) at maximal rotation (figure 38).
E. Repeat the internal hip rotation measurement for the left leg with the left knee flexed and the right knee extended.

30. External hip rotation.
Materials - goniometer.
A. Flex the subject's right knee to 90 degrees and perpendicular to the transverse line across the ASIS of the pelvis, midway between external and internal rotation (leaving left leg extended) (figures 37, 38).
B. Place the axis of the goniometer over the central patella of the right leg with the stationary arm of the goniometer parallel to the axis of the tibia and perpendicular to the floor and exam table. Line up the movable arm of the goniometer along the midline of the tibia (figure 38).
C. Firmly press down on the pelvis in order to prevent it from rocking, while the other hand rotates the leg toward the midline of the trunk (with thigh as axis of rotation) until resistance is felt (figure 38).
D. Measure and record to the closest degree the angle between the stationary arm perpendicular to floor and exam table) and the movable arm (along midline of tibia) at the central patella during maximal rotation (figure 38).
E. Repeat external hip rotation measurement for the left leg with the left knee flexed and right knee extended.

31. Hindfoot inversion.
Materials - goniometer.
A. Subject is positioned with legs extended and feet off the edge of the exam table.
B. Place the axis of the goniometer on upper heel mark of right leg at the insertion of the Achilles tendon (figure 15). Line up the stationary arm of the goniometer parallel to the axis of the tibia, and line up the movable arm of the goniometer parallel to the long axis of the heel along the midheel mark (figures 15, 39).

C. Firmly grasp the right heel in the cup of your hand with your thumb on the lateral side of the subject's heel and your forefingers on the medial side of the subject's heel.
D. Passively turn the subject's heel inward, while focusing on movement of only the subtalar joint (figures 40, 41).
E. Measure and record to the closest degree the angle between the stationary arm (midline of the lower leg) and the movable arm (midline of the calcaneus) at the upper heel during maximal inversion (figure 41).
F. Repeat hindfoot inversion measurement for the left subtalar joint.

32. Hindfoot eversion.
Materials - goniometer.
A. Position the subject with legs extended and feet off the edge of the table.
B. Place the axis of the goniometer on the upper heel mark of the right leg at the insertion of the Achilles tendon. Align the stationary arm of the goniometer parallel to the long axis of the tibia, and align the movable arm of the goniometer parallel to the long axis of the heel along the midheel mark (figure 15).
C. Firmly grasp the right heel in the cup of your hand with your thumb on lateral side of the subject's heel and your forefingers on the medial side of the subject's heel.
D. Passively turn the subject's heel outward, while focusing on movement of the subtalar joint only (figures 40, 42).
E. Measure and record to the closest degree the angle between the stationary arm (midline of the lower leg) and the movable arm (midline of the calcaneus) at the upper heel during maximal eversion (figure 42).
F. Repeat hindfoot eversion measurement for the left subtalar joint.

ILLUSTRATIONS

Figures A, B, C, D, and 1 through 43.

Use of goniometer - figure 43.

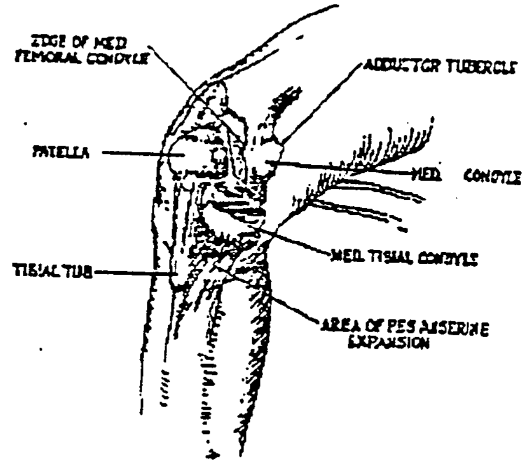


Figure A - General orientation of medial knee landmarks.

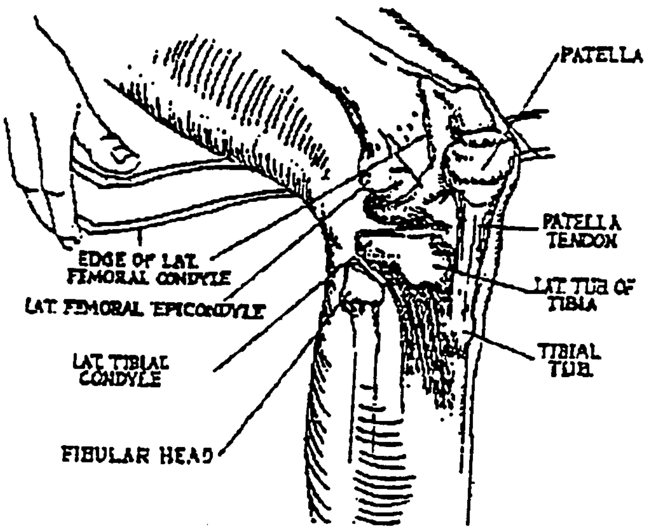


Figure B - General orientation of lateral landmarks.

Figure C - General orientation of foot.

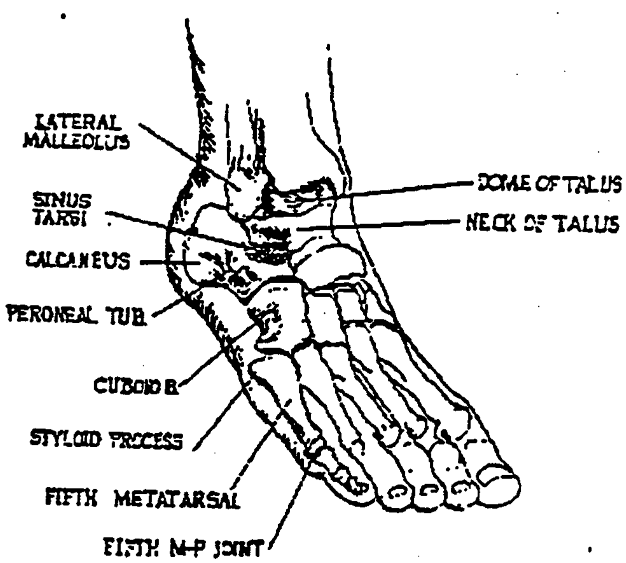
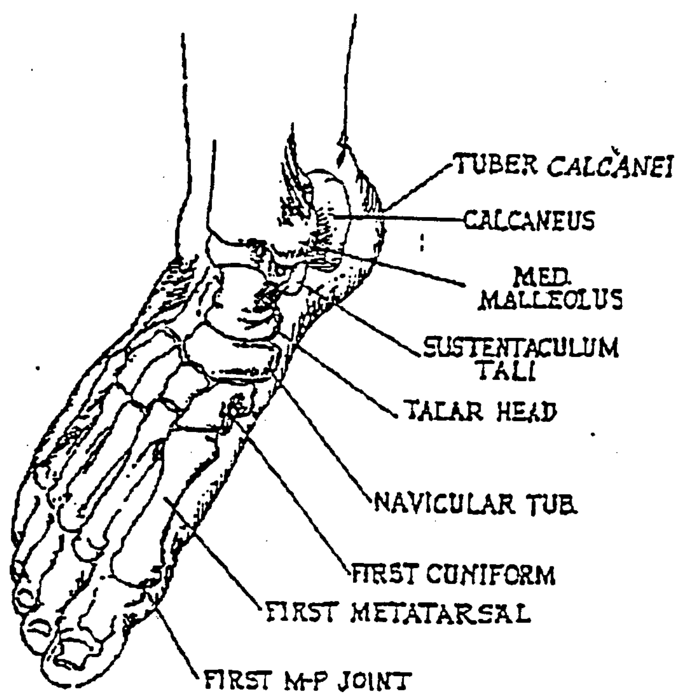


Figure D - General orientation of foot.



Figures 1 through 3 - Locating navicular and first MP joint.

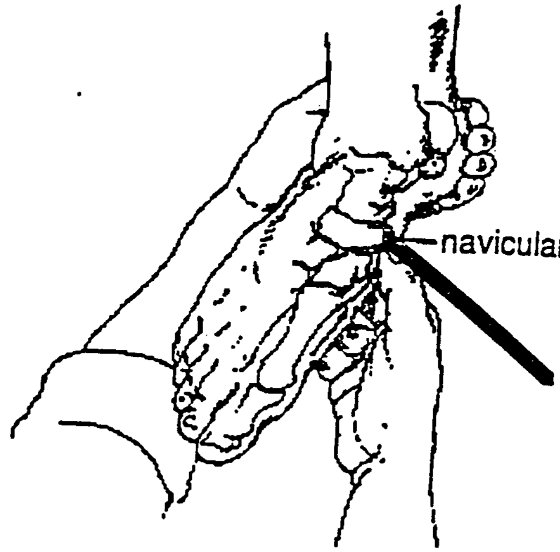


Figure 1

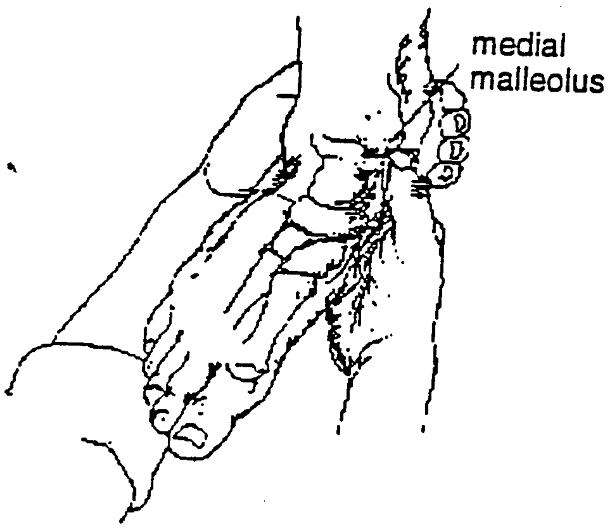


Figure 2

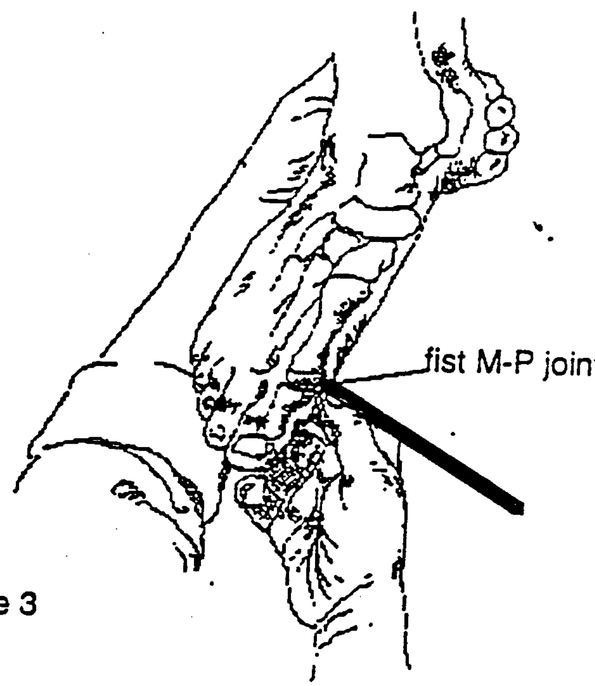


Figure 3

Figures 4 through 8 - Orientation points for locating medial knee joint space.

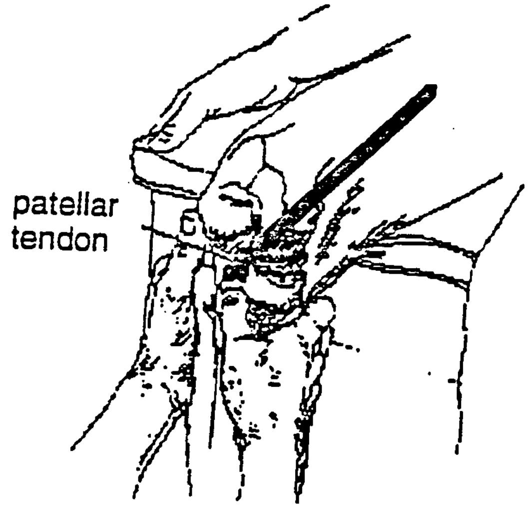


figure 4

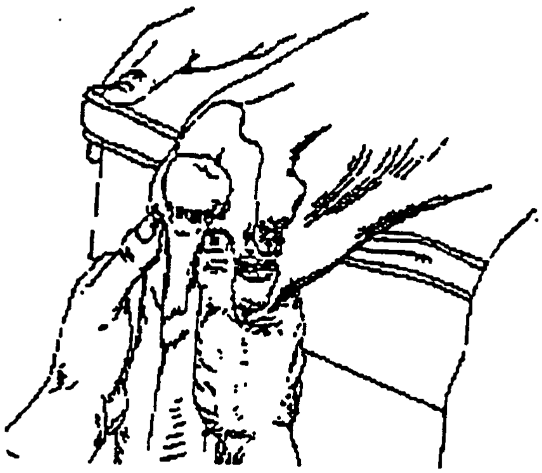


figure 5

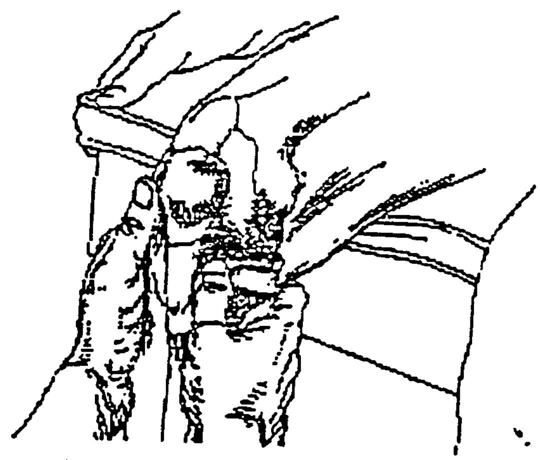


figure 6

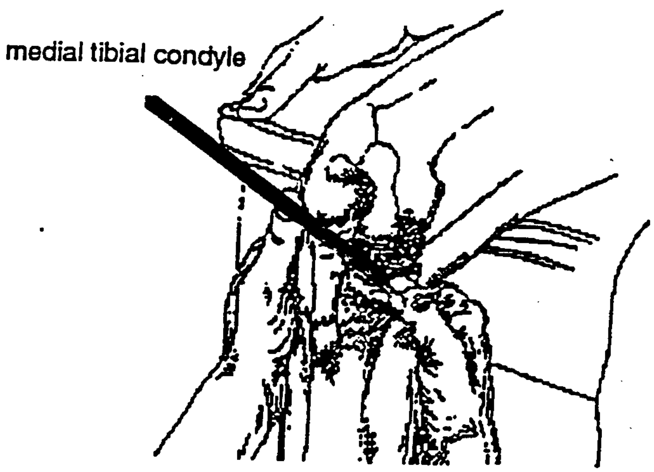


figure 7

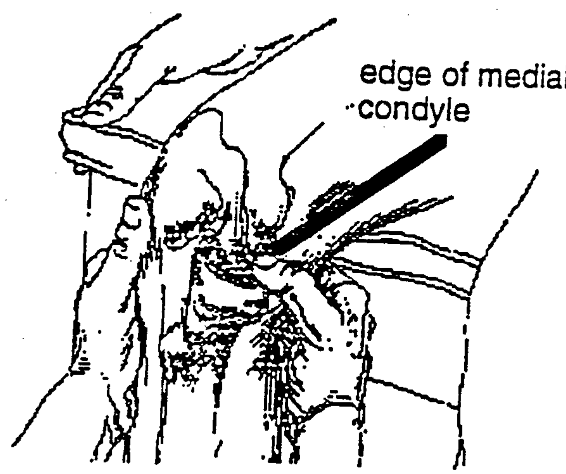


figure 8

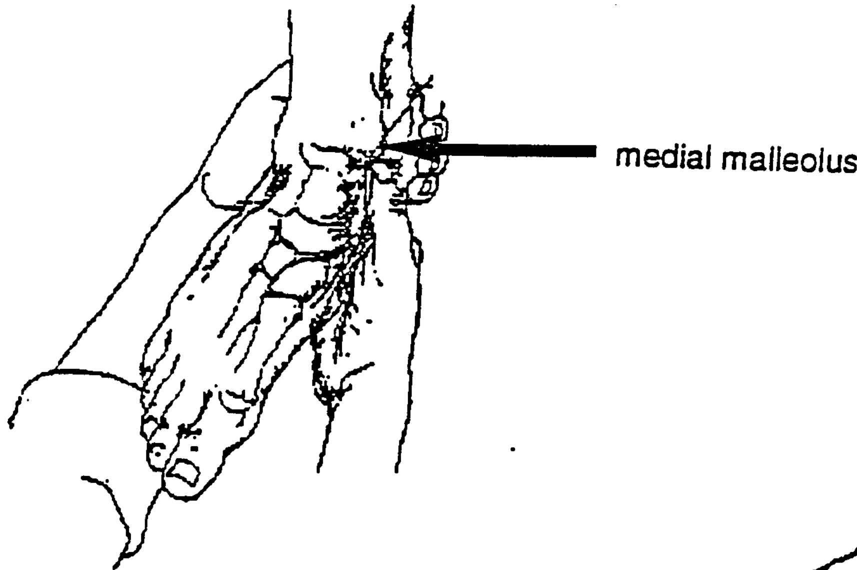
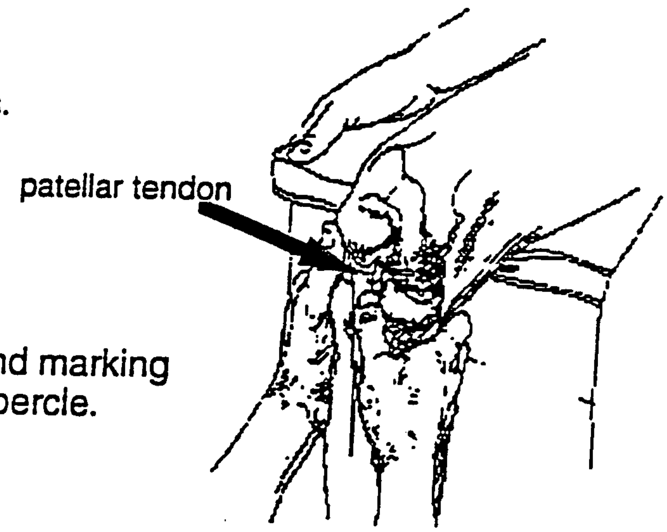


figure 9 - Locating medial malleolus.



Figures 10 through 12 - Locating and marking the tibial tubercle.

figure 10

tibial tubercle

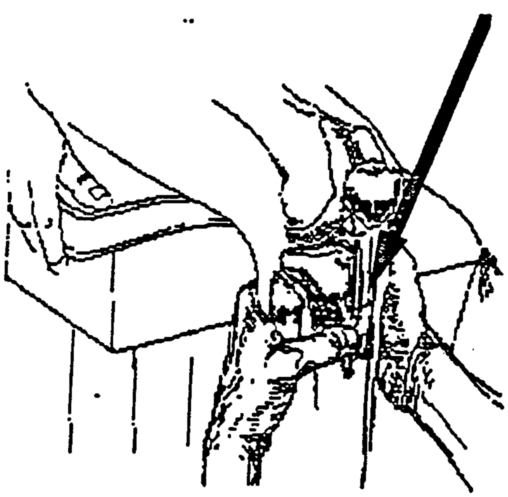


figure 11

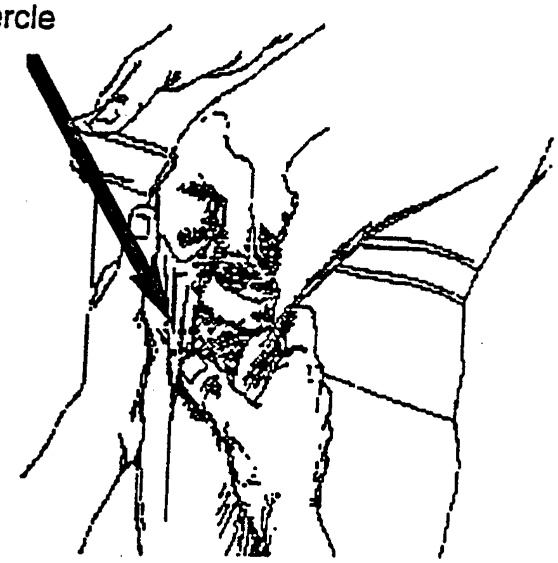


figure 12

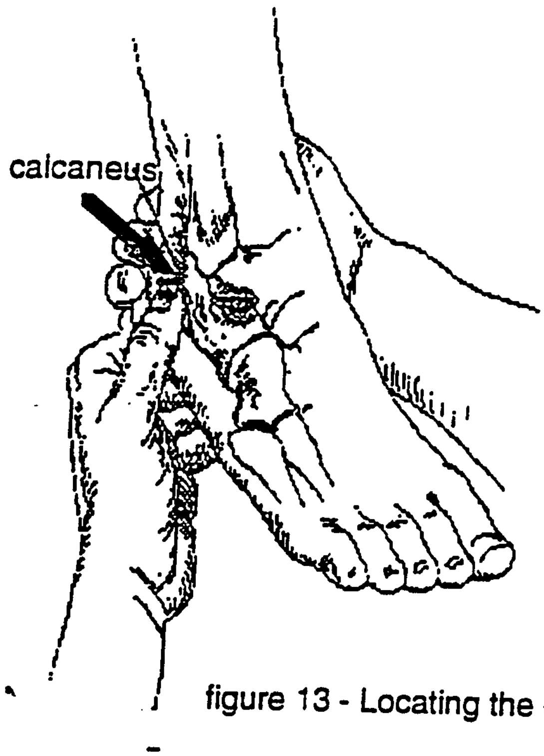


figure 13 - Locating the calcaneus.

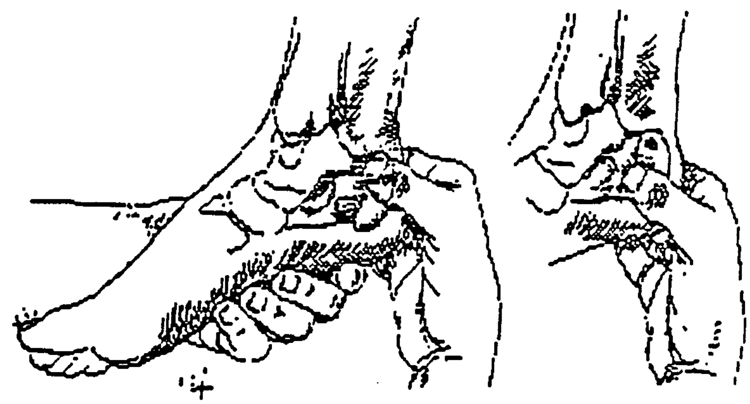


figure 14 - Delineating the calcaneus.

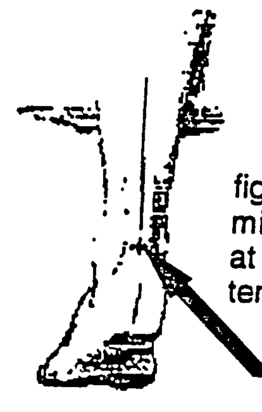


figure 15 - Skin markings: midline heel, upper heel at insertion of Achilles tendon, midline distal calf.

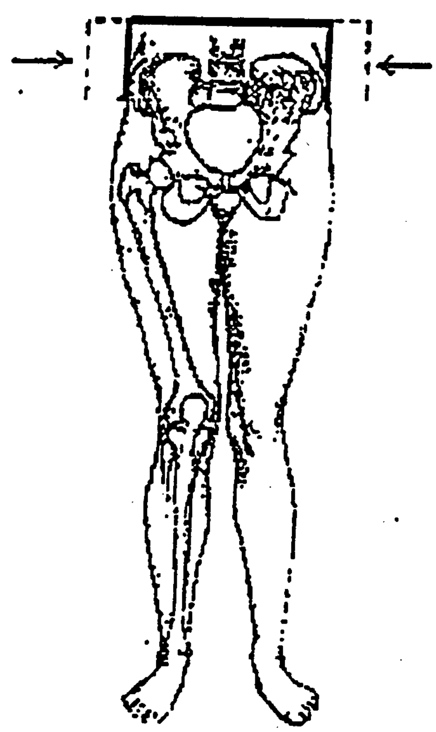


figure 16 - Pelvis width measurement at widest point on pelvic girdle.

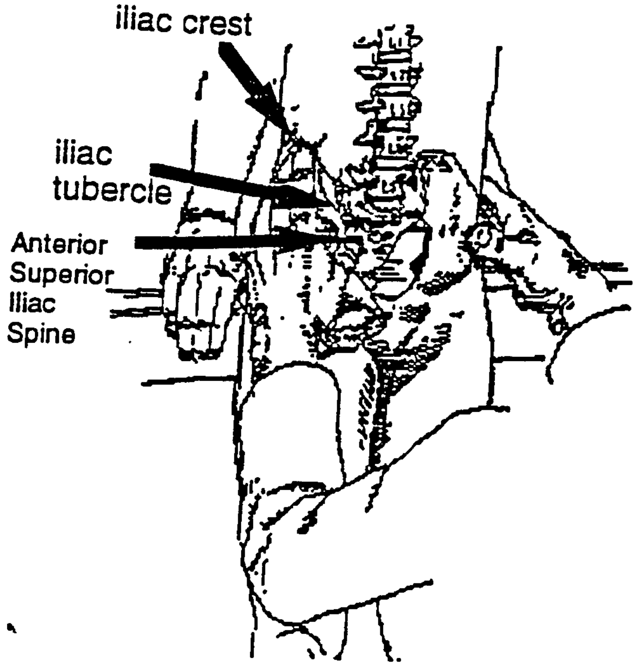


figure 17 - Orientation of pelvis for locating ASIS and iliac tubercle.

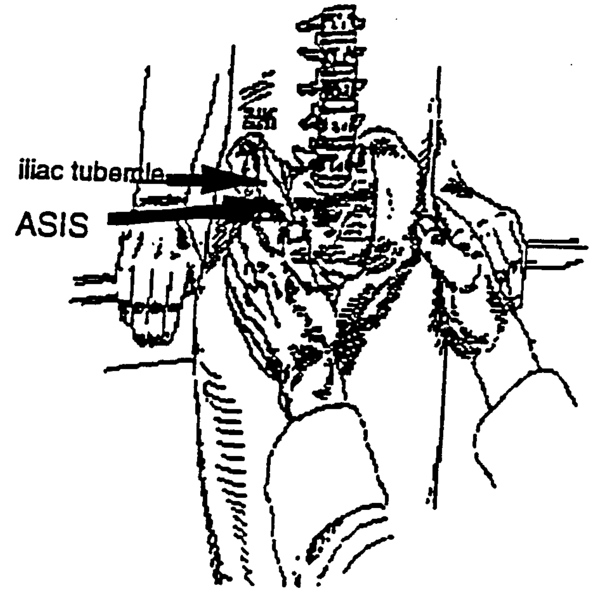


figure 8 - Orientation of pelvis for locating ASIS and iliac tubercle.

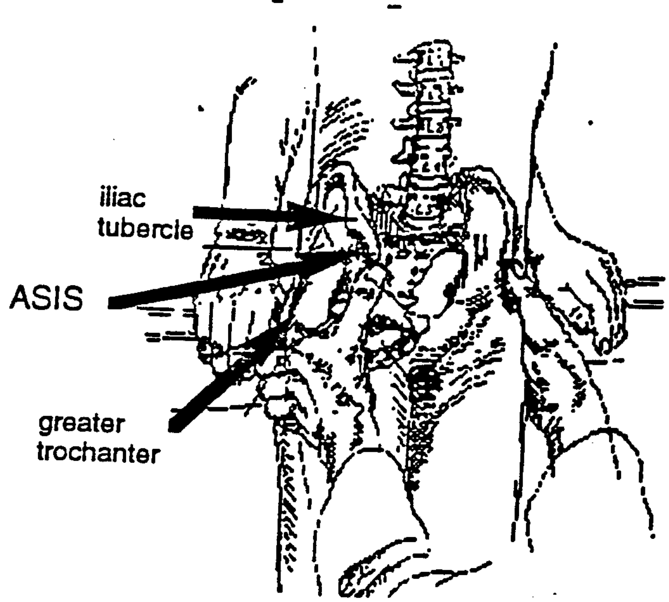


figure 19 - Locating the greater trochanters.

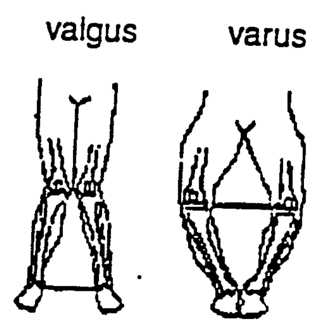


figure 20 - Knee valgus/varus measurement: distance between medial malleoli or femoral condyles.

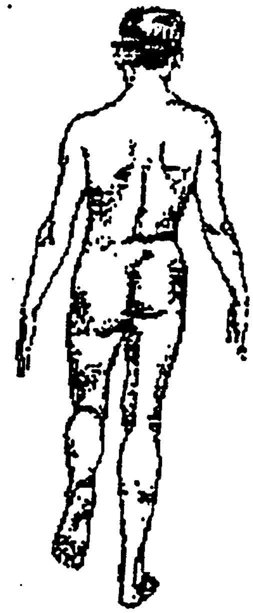


figure 21 - Positioning of subject for lower leg-heel alignment and longitudinal foot-arch measurements.

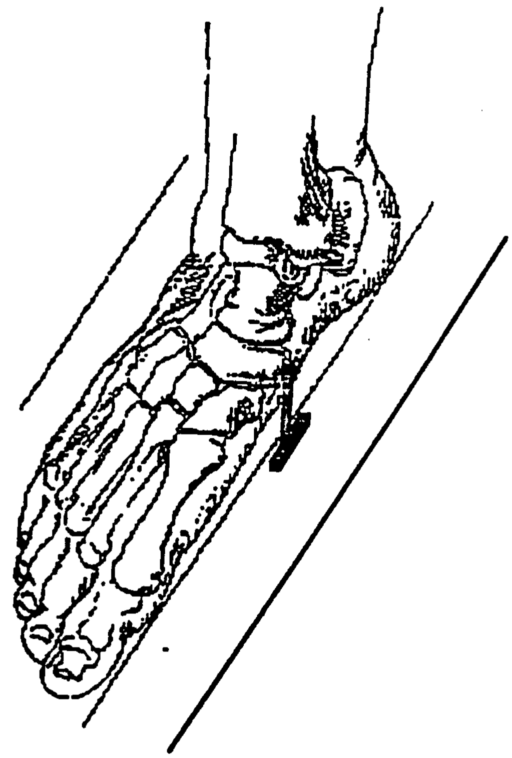


figure 22 - Height of navicular positioning and measurement (navicular-floor).

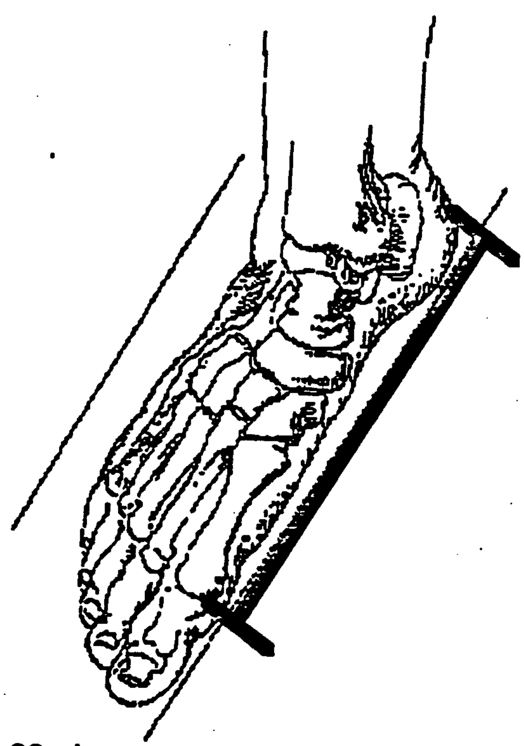


figure 23 - Length of foot positioning and measurement (tubercle calcanei-first MP joint).

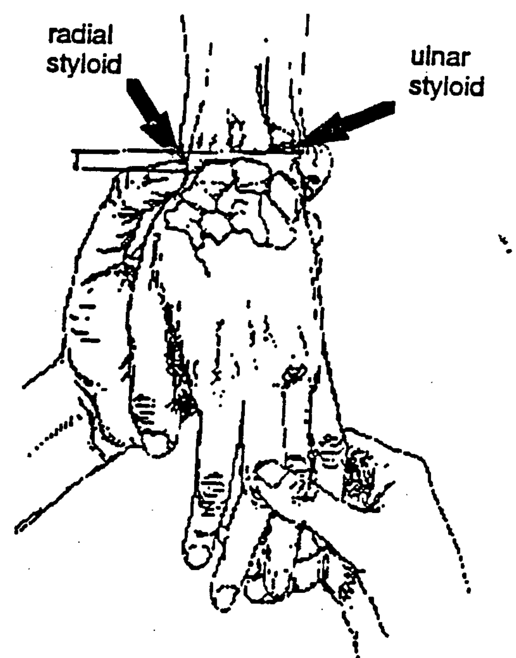


figure 24 - Locating the radial styloid process.

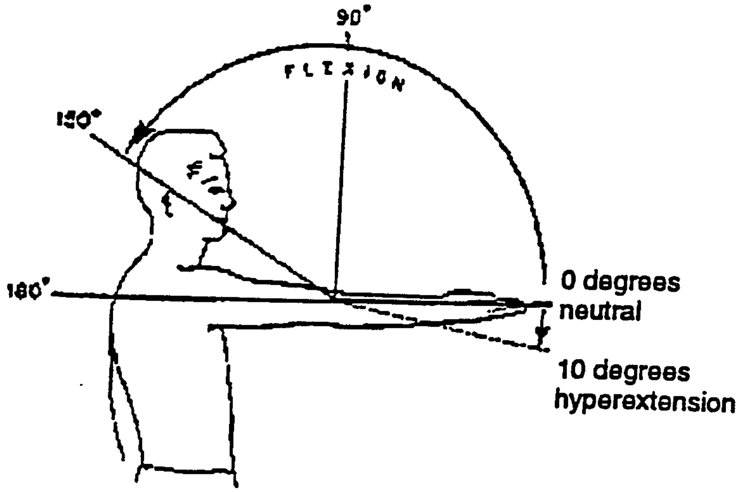


figure 25 - Measurement of elbow extension.

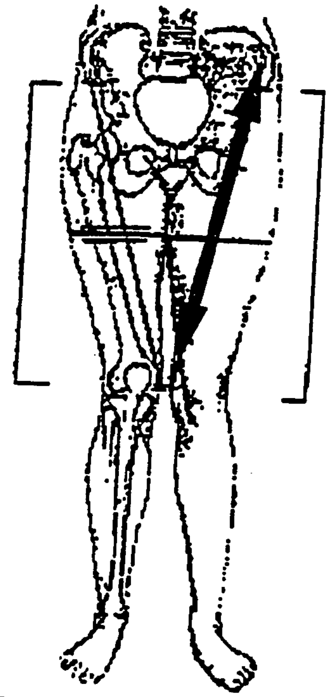


figure 26 - Upper leg length measurement and skin markings (ASIS-medial knee joint space).

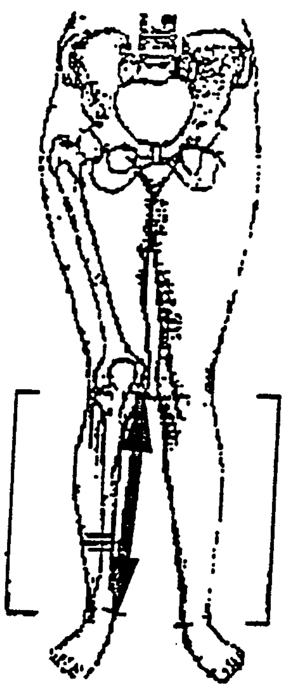


figure 27 - Tibial length measurement and skin markings (medial knee joint space-medial malleolus).

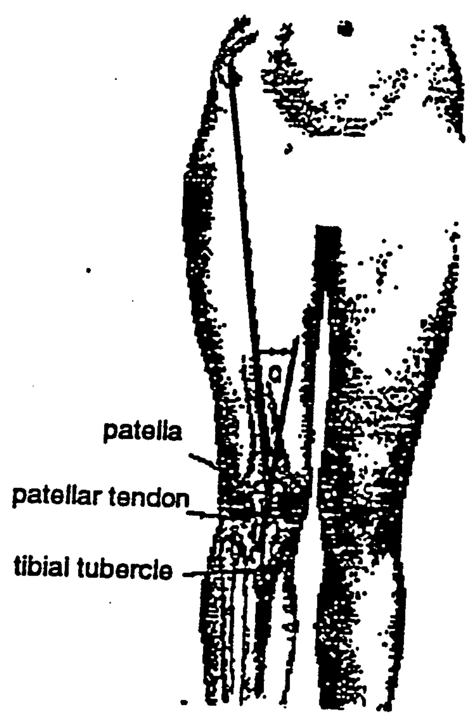


figure 28 - Q angle measurement (ASIS-central patella-tibial tubercle).

Figures 29 and 30 - Orientation points for locating lateral knee joint space.

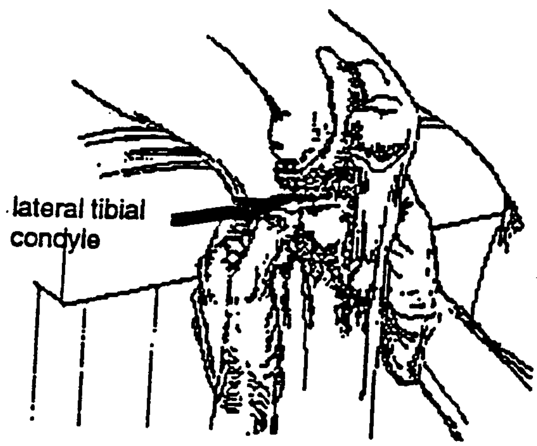


figure 29

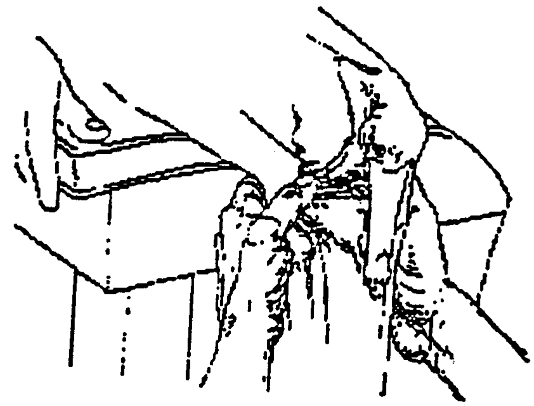


figure 30

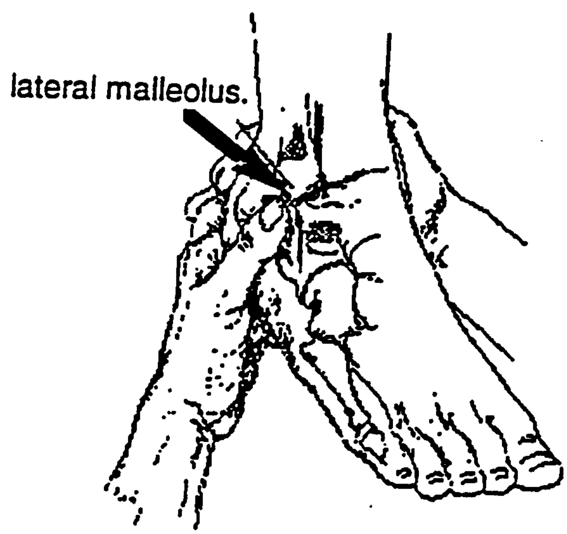


figure 31 - Locating the lateral malleolus.

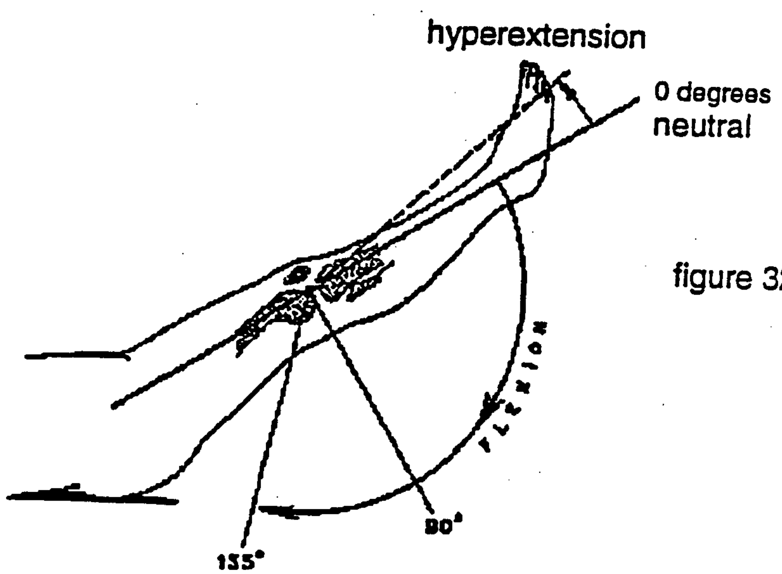


figure 32 - Measurement of knee extension and flexion.

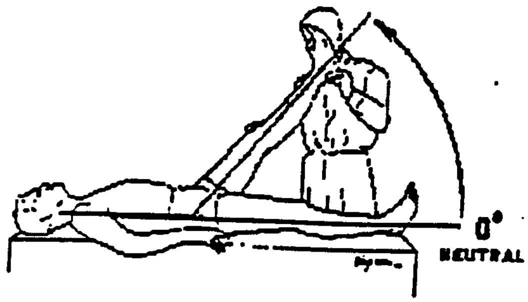


figure 33 - Measurement of straight leg raise.

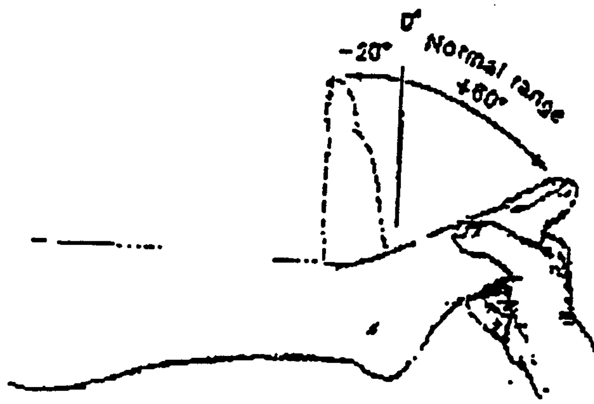


figure 34 - Ankle dorsiflexion measurement.

Figures 35 and 36 - Demonstration of the Ober Test.

figure 35

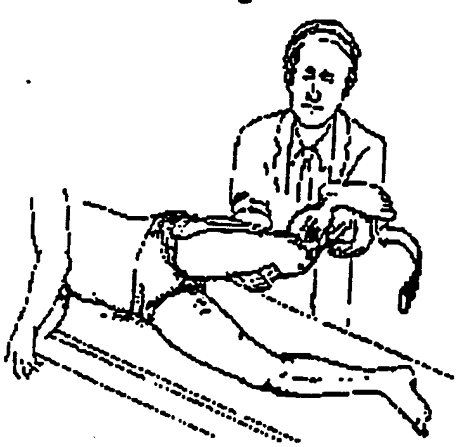
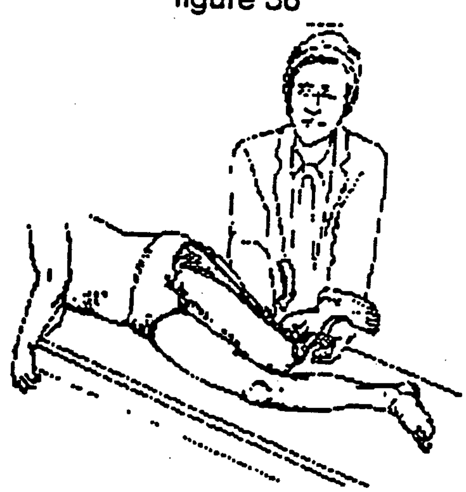


figure 36



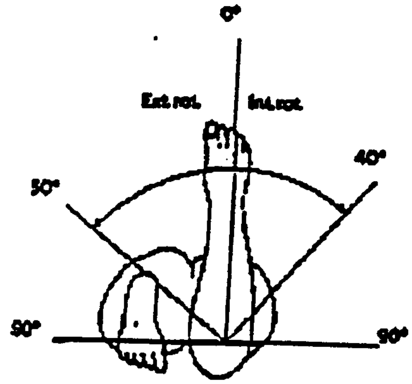


figure 37 - Positioning of subject for internal and external hip rotation measurements.

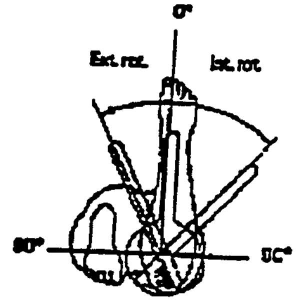


figure 38 - Aligning goniometer and axis of rotation for internal and external hip rotation measurement.

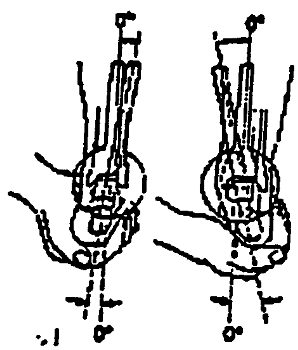


figure 39 - Aligning goniometer for hindfoot inversion and eversion measurements.

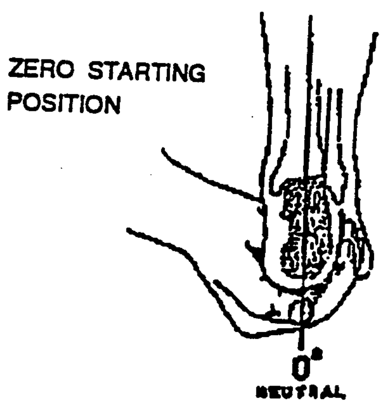


figure 40 - Neutral zero starting position for hindfoot inversion and eversion measurements.

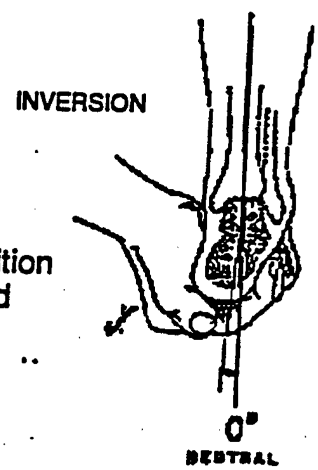


figure 41 - Passive motion of subtalar joint for hindfoot inversion measurement.

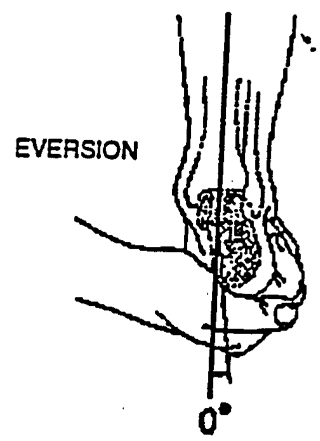


figure 42 - Passive motion of subtalar joint for hindfoot eversion measurement.

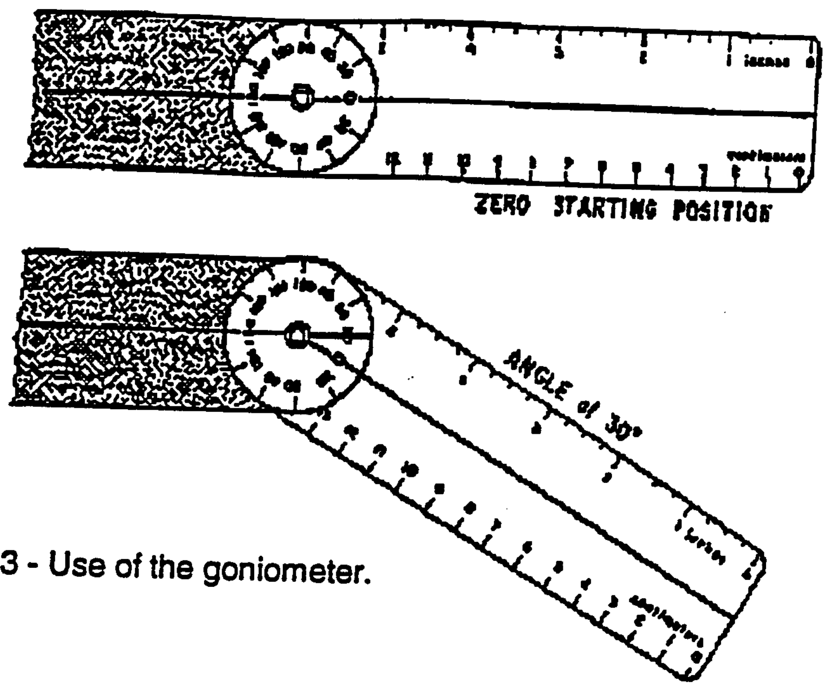


figure 43 - Use of the goniometer.

References for Anthropometric Protocol and Illustrations

American Academy of Orthopaedic Surgeons. Joint motion: Method of measuring and recording . Chicago: American Academy of Orthopaedic Surgeons, 1965.

Brody, D.M. Running Injuries. Clinical Symposia , 32(4):2-36, 1980.

Hoppenfeld, S. Physical examination of the spine and extremities . Norwalk: Appleton-Century-Crofts, 1976.

Russe, O., ed. Atlas of examination. Standard measurements and diagnosis in orthopedics and traumatology . Bern: Hans Huber, Publishers, 1972.