DESIGN OF MACHINE TO EVALUATE ANKLE JOINT UNDER VARIABLE INVERSION-EVERSION TORQUES AND DEGREES OF PLANTAR FLEXION-DORSIFLEXION

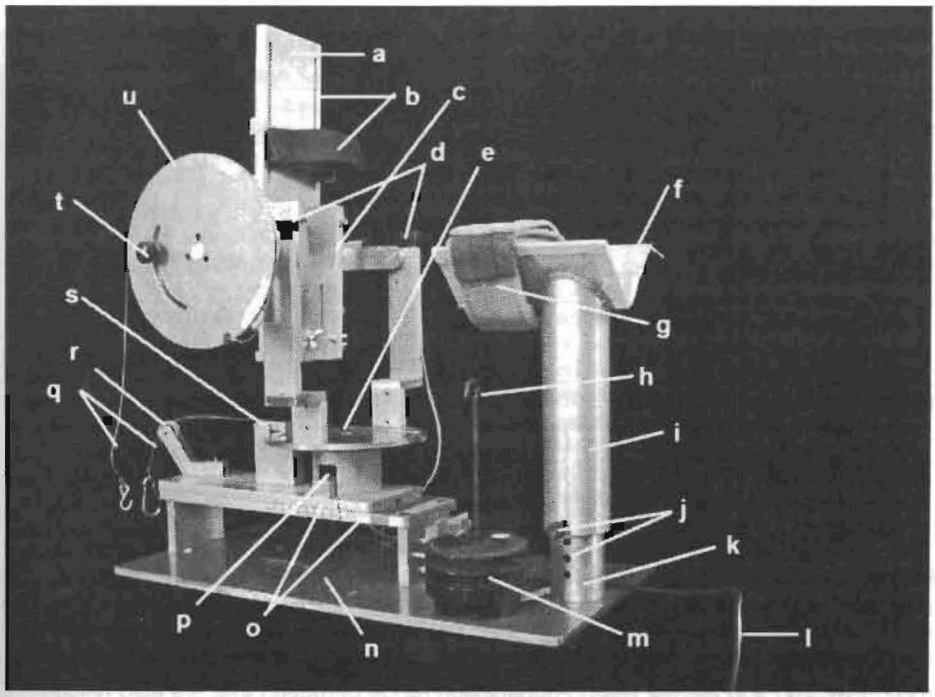
Eugene W. Brown, Miguel Narvaez, Toru Tanaka, Kris Kotrla, and Adam Breunger
Department of Kinesiology, Michigan State University, East Lansing, Michigan, U.S.A.

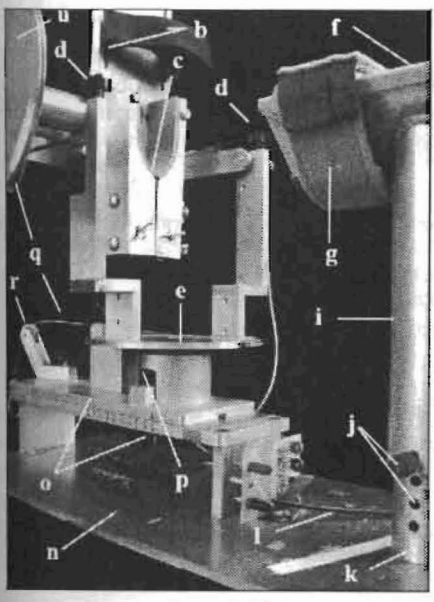
In sport, injury to the ankle is the most common joint trauma (Garrick & Requa, 1988). The purpose of this project was to design a machine that could be used to obtain valid, reliable, and objective measures of the position of the ankle when exposed to various inversion-eversion torques. The establishment of these types of data sets on various populations will permit many subsequent comparisons (e.g., gender and age differences in ankle range of motion relative to the incidence of ankle injury, influence of ankle injury on the range of motion of the ankle joint).

KEY WORDS: ankle, testing, inversion, eversion, machine, torque.

INTRODUCTION: Because the ankle is the most commonly injured joint in sport, it is valuable to understand typical joint architecture, biomechanics of joint motion, and normal range and variability of motion by age and gender. This information may provide a basis for understanding the potential for injuryin different subject groups.
One problem that exists in establishing this type of comparative angular data is that the architecture of the ankle complex, consisting of the ankle and subtalar joints, is intimately related to the midtarsal (calcaneocuboid and talonavicular) joints and movements of the foot.
Another problem has been uniformity in methods of measuring the range of motion of the ankle complex. The plantar flexion-dorsiflexion position influences the expected range of inversion-eversion. Similarly, the variability of the method and magnitude of application of external torque (e.g., actively induced by the subject, manual application by researcher, and static loading) will impact the range of inversion-eversion.
The researchers' goal in this project was to design a valid, reliable, and objective machine to measure inversion-eversion movements of the ankle complex.

METHOD: Inman (1976) reported the design of a wooden mechanical testing device to measure the ankle range of motion for inversion-eversion under different conditions of plantar flexion-dorsiflexion. The primary difficulties of this device were a) bracing the foot and shank iin devices designed to measure range of motion without interfering with the measurements being made, b) accommodating subjects with anthropometry of the shank-foot-ankle complex that differed in size, and c) using mechanical goniometers to measure range of motion.
Initially, an aluminum machine, that eliminated all but the problem of bracing the foot and shank without interfering with ankle range of motion, was constructed. Subsequently, one of the current authors modified Plummer's (1991) designed of a wooden heel clamp to eliminate the final difficulty in obtaining valid measures of the ankle range of motion under incremental application of various torques. The current machine is shown in Figure 1.





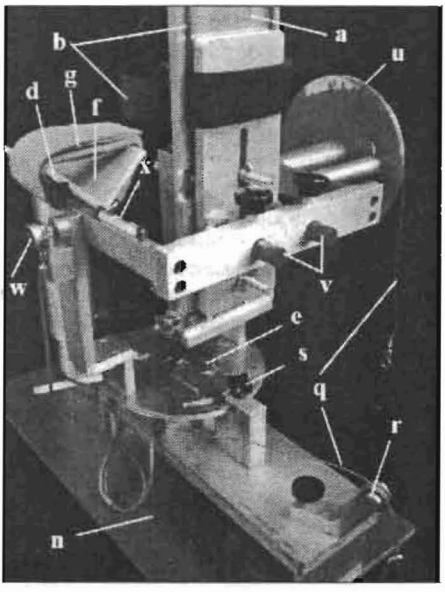


Figure 1: Three views of ankle testing machine.

Key to Figure 1:

a foot plate	**l** shank support outer cylinder	**q** torque cables
b forefoot keyway and elcro strap	**j** shank support adjustment pin and holes	**r** torque alignment pulley system
c padded adjustable heel clamp system	**k** shank support inner cylinder	**s** inversion-eversion lock system
d plantar flexion-dorsiflexion lock knobs	**l** analog output cable from goniometers	**t** plantar flexion-dorsiflexion lock system
e inversion-eversion torque plate with perimeter groove for torque cable	**m** slotted weight set	**u** plantar flexion-dorsiflexion torque plate with perimeter groove for torque cable
f padded shank support	**n** base plate	**v** ankle centering adjustment system and lock knobs
g elcro shank strap	**o** shank length adjustment plates and lock knob	**w** plantar flexion-dorsiflexion electrogoniometer
h weight hanger	**p** inversion-eversion electrogoniometer housing	**x** level

RESULTS AND DISCUSSION: The current ankle testing machine has been used in preliminary tests to evaluate the range of motion of the ankle of male and female university subjects under inversion and eversion torques ranging from 1 to 5.1 Nm and 15 degrees of ankle plantar flexion. The machine has face validity. Its electrogoniometer provides objective measures of inversion-eversion and plantar flexion-dorsiflexion range of motion that are also reliable.

CONCLUSION: The ankle testing machine has the potential to establish baseline information about the range of motion (means and standard deviations) of ankle joints of a broad population of males and females of various ages. This type of information could subsequently be used to conduct comparative studies on the a) incidence of ankle sprains in populations with differing ankle range of motion (e.g., males versus females, young versus old subjects, injured versus non-injured), b) influence and lasting effect of ankle taping and reusable ankle braces on joint range of motion, and c).lasting effect of ankle injury on ankle range of motion.

REFERENCES:

Garrick, J.G., & Requa, R.K. (1988). The epidemiology of foot and ankle injuries in sports. Clinics in Sports Medicine, 7, 29.

Inman, V.T. (1976). The joints of the ankle. Baltimore, MD: Williams and Wilkins.

Plummer, P.E. (1991). A comparison of athletic ankle taping techniques with respect to ankle inversion. Unpublished master's thesis, Michigan State University, East Lansing, Michigan.