ACES - History

By

Gideon Ariel, Ph.D.

Thailand, December 2007
Figure 2. Contractile Force Apparatus for Isometric Contraction
Isometric muscular effort under study in the Motor Integration Laboratory
FIGURE 1.  LEG PRESS: TOTAL MUSCULAR INVOLVEMENT (in percent)

☐ = LEG PRESS ON VARIABLE RESISTANCE MACHINE (CENTURION)
△ = LEG PRESS WITH EXERCISE APPARATUS
▽ = SQUAT WITH CONVENTION BARBELL

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RAISING BAR

POSITIONS 1/8 SEC
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Biomechanical analysis of the knee joint during deep knee bends with heavy load

B. G. Ariel
University of Massachusetts, Amherst

The knee joint, the largest and most complex synovial joint in the human body, is an anatomical region subject to injuries from activities in various fields including athletics, industry, and recreation. Because this joint is between the longest bones in the body, the femur and the tibia, the forces and moments of force around this joint produce torques of such magnitude that injuries ensue. In athletics, various injuries may occur by overloading the knee joint (Nicholas, 1970; Peterson, 1970). In several studies (Kennedy and Fowler, 1971; Marshall and Olsson, 1971; Newman, 1969; Slocum and Larson, 1968), it was found that the instability of the knee joint was the result of the application of excessive external rotation and abduction forces to a flexed, weight-bearing knee.

The knee joint, described as a hinge joint, is much more complex. It consists of three articulations, the surfaces of which are not mutually adapted to each other, so that movement is not simply gliding (Gray, 1954; Lockhart, Hamilton, and Fyfe, 1959). The quadriceps femoris muscle group is responsible for extension of the knee joint. The four muscles of this group pull through a common tendon and insert via the ligamentum patella, which continues from the patella to the tuberosity of the tibia. The movements of the knee joint are primarily flexion and extension and, in certain positions of the joint, internal and external rotation (Dick, 1969).

The purpose of the present study was to investigate the forces and moments of force acting about the knee joint during a deep knee bend exercise with a heavy load.

METHODS

Twelve experienced weightlifters, ranging in age from 21 to 25 years, served as subjects. Their mean height was 181.5 cm and their mean weight was 90.5
TRACING OF SAMPLE X-RAY USED TO DETERMINE KNEE JOINT MODEL

F1 = F2
MOMENT = F x X

K = Knee joint angle
L = Angle between tibia and lig. patella
e = Distance from joint center to tuberosity of tibia (4.4 cm)
d = Distance from mechanical axis of tibia to the tuberosity of tibia (3.2 cm)
b = Distance of the bi-sector of the knee joint angle to the apex of the patella (5.7 cm)
X = Perpendicular distance from knee joint center to the ligamentum patella line of force (F1)
Table 1. Knee joint angle, forces, and moments of force for selected subjects in the deep knee bend with heavy load

<table>
<thead>
<tr>
<th>Position</th>
<th>Knee angle (degrees)</th>
<th>Moment (kg/m)</th>
<th>Horizontal force (kg)</th>
<th>Vertical force (kg)</th>
<th>Bone-on-bone force (kg)</th>
<th>Shear force (kg)</th>
<th>Compression force (kg)</th>
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COMPUTERIZED
EXERCISE
EQUIPMENT
Fig. 1. The programmable variable resistance exerciser flow chart.
Gideon Ariel, Computernik-Biomechanist

Gideon Ariel is a single-minded problem-solver, calling on the disciplines of exercise science (in which he received his doctorate at the University of Massachusetts), computer science, mechanics, and engineering to provide solutions for the problems of athletic performance. As biomechanics and computer science chairman for the U.S. Olympic Committee, he recently helped the women's volleyball team at Squaw Valley, who weren't jumping high enough. Using computer analysis of their movements, he and colleagues found that the volleyball players didn't have sufficient height and strength in their arms, as compared with their legs, for the work of leaping. "They worked on it for six weeks," recalls the biomechanist, "increased their arm strength, and increased their jumping capacity quite a bit."

Dr. Ariel gets to the heart of challenges like these by using the data-gobbling, data-juggling talents of the computer, which if properly programmed, can analyze and manipulate data concerning the complex motions and interactions of human-body segments and athletic gear. Originally he labored to reduce limb and trunk movements to stick-figure representations from motion-picture photographs superimposed on each other. Finding the conventional ways tedious and time-consuming, he experimented with shortcuts. Now he feeds coordinates of points on a body into computers by several methods.

In one of them, a scanning device glances over a photographic image projected on a screen, responding to its light and dark areas. A computer connected to the scanner then plots the positions of joints to produce stick-figure tracings. Two other gadgets depend on sound rather than light to position body segments on a cathode-ray tube or paper printout. In one technique, Dr. Ariel touches a "sonic pen" to a photographic image displayed over a kind of grid with tiny microphones around its edges. The microphones pick up sound impulses and measure how far away the source is; the computer converts the coordinates to visual images. From this, says Dr. Ariel, he can calculate the forces, velocities, and accelerations, if given the segment weights and distribution of body mass.

Restless and curious, Dr. Ariel has explored a broad spectrum of athletic activities—running, field events, diving, golf, basketball, football, ice skating, and tennis—at Computerized Biomechanical Analysis, Inc. (CBA), his private company.

Although still an adjunct professor of computer science at the University of Massachusetts, he presently has little to do with pure research, having made a conscious decision in 1971 to steer a commercial course. CBA has taken on a number of projects for manufacturers so Dr. Ariel can recover his investment in facilities. "The money has to come from somewhere," he laments.

Although he's been consulted by professional teams in the past, he's not currently active in such work. He is, however, busy dealing with tennis rackets, golf clubs, and football helmets and jackets newly conceived to prevent injuries. Furthermore, he's absorbed in developing new, large exercise devices—he has contributed to the Universal, Nautilus, and Paramount equipment—perhaps even for home use. Someday, he speculates, the exercise machine's computer will describe how to work out to be a better tennis player, bowler, or orienteerer, and in addition, tell the athlete what to eat and how much.

David Whieldon
Book 6

Biomechanics
of Sports
and
Kinanthropometry

Volume 6

Biomécanique
du sport
et
kinanthropométrie

Compiled and edited by

FERNAND LANDRY, Ph. D.
WILLIAM A.R. ORBAN, Ph. D.

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SCIENCES DE L'ACTIVITÉ PHYSIQUE
Computerized Dynamic Resistive Exercise

Gideon Ariel

Introduction

The relationship between resistance exercises and muscle strength has been known for a long time. Muscular strength may be defined as the force a muscle group can exert against a resistance in a maximal effort, and any motion by the human requires muscular involvement. Forty to sixty percent of the human body is composed of contractile tissue forming 437 different voluntary muscles, and the most fundamental function of these muscles is the ability to produce motion by their own contraction. The action of these muscles on the bones, which provides the leverage system, permits man to stand erect, carry out activities of daily living and participate in athletic performances requiring optimal efficiency in muscular contraction and coordination. This motion of the musculoskeletal system is governed by the strength of the muscles and skeletal structure.

In 1948 Delorme [3] adopted the name “progressive resistance exercise” for his method of developing muscular strength through the utilization of counterbalancing the weight of the extremity with a cable and pulley arrangement and, thus, gave load-assisting exercise to muscle groups which would not perform antigravity motions. McQueen [4] distinguished between exercise regimens for producing muscle hypertrophy and for producing muscle power. He concluded that the number of repetitions for each set of exercises determines the different characteristics of the exercise. Based on evidence presented in these early studies, hundreds of investigations have been published relative to muscular development through resistance exercise with various methods being introduced. Techniques for muscular development include isotonic, isometric, isokinetic, eccentric, concentric and many other exercise techniques. Each system has been supported and refuted by numerous investigations.
With the purchase of the Ariel Computerized Exercise System you join a select group of people:
The National Aeronautic and Space Agency selected the Ariel CES for research in adaptation of exercise to zero gravity. According to the experts at NASA, the Ariel CES is the only programmable modality which can provide the necessary exercise for humans in space to counteract the effects of zero gravity.

In a laboratory at Harvard Medical School, studies are being conducted with the Ariel CES to determine human adaptation to physical stress, lack of sleep, and exercise on various biochemical processes.

The United States Olympic Committee purchased the Ariel CES to assist in research for appropriate alternates to anabolic steroids or other ergogenic aids for athletes.

Hospitals and rehabilitation centers have purchased the Ariel CES to enhance the traditional methods of diagnoses, research, and rehabilitation protocols.

Health and fitness clubs have selected the Ariel CES because it allows both instructors and members to assess performance levels, follow changes, as well as tailoring special exercise regimens.
The ARIEL Edge

computerized exercise system drives physical conditioning, sports training, rehabilitation and research to a whole new playing field.

KEY ADVANTAGES

- Provides training modes including fatigue, work, pyramiding, and isometric sticking-point challenges. Combines cardiovascular conditioning and resistance training.

- The ARIEL Edge adjusts to you. Analyzes the velocity, acceleration, position, applied force and resistance 16,000 times per second throughout the entire range of motion and adjusts to match the resistance.

- Intelligent Programming simulates training at the same speed athletes compete. Eliminates the inertia experienced with traditional weight training. Allows for high-speed training of the type II fast twitch muscle fibers.

- Enhances muscular development. The faster the muscles contract, the faster the limbs move. The faster the limbs move, the faster the body can run, jump, hit, throw and all-around functionally perform better.

- No pain, all gain. When using the ARIEL Edge there is no eccentric (negative) resistance applied to the muscle, therefore no muscle tear down, which causes DOMS (Delayed Onset Muscle Soreness).
ACCOMMODATING RESISTANCE CURVE OF A BENCH PRESS PUSHING/PULLING MOVEMENT WITH COMPARISON OF DIFFERENT TRAINING SESSIONS
Force, Position, and EMG of the flexors and extensors of the elbow
How To Stay Fit

the President's personal exercise program
THANK YOU