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The Flywheel Leg-Curl Machine: Offering Eccentric Overload for Hamstring Development

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For the sole purpose of developing knee-flexor strength, power, and size, almost any weight room or training facility is equipped with a prone, face-down leg-curl weight-stack machine. Such commercially available machines all aim at targeting and isolating the knee-flexor muscle group. Depending on mechanical design, they differ somewhat with regard to external torque offered and hence muscle use in the desired range of motion. Given the high rate of injury reported for the flexor-muscle group in athletes relying on high horizontal speed and power[1] and the fact that leg-curl machines are frequently used both in prevention and rehabilitation of hamstring injuries, the scant information describing the basic kinematics of this exercise is rather surprising.[2,3] A novel leg-curl device (YoYo™ Technology AB, Stockholm, Sweden) uses the inertia offered by rotating flywheels to provide resistance. Contrary to traditional weight-stack machines, this loading feature allows for exercise with eccentric overload, as shown elsewhere for configurations aimed at other muscle groups.[4-6] With use of the flywheel leg curl, an 8-week training program improved maximal running speed and, perhaps even more important, reduced the incidence of hamstring strains in elite soccer players.[7] Unfortunately, force–velocity profiles and electromyographic (EMG) activity during concentric–eccentric actions on this device were never examined. Here, we report kinematic data in athletes performing all-out knee flexions at different inertial settings using this particular flywheel configuration.

Methods

Twenty male soccer or rugby players volunteered for this study. Ten of these men (age 24.9 ± 2.6 years, body mass 81.3 ± 20.2 kg, and height 181.3 ± 7.8 cm) had previous experience (>5 sessions consisting of 4 sets of 7 maximal repetitions)

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with use of this particular exercise device, and 10 with similar physical characteristics and training history (26.3 ± 3.6 years, 85.6 ± 10.3 kg, 179.0 ± 7.3 cm) had only experienced 1 or 2 familiarization sessions. After adjusting leg-pad position and presetting range of motion using the rail-bar pin, subjects performed bilateral knee-flexor actions in the prone, face-down, position (hip angle 140° and feet in a neutral position; Figure 1) while holding on to the handlebars of the machine. Flywheel rotation was accelerated by pushing against the padded lever arm with maximal effort and through the entire range of motion (from close to 180º knee angle). After completion of this concentric action, on rewinding of the flywheel strap in the subsequent eccentric, descending action, and while slightly resisting, maximal effort was applied on passing 90° to make the flywheels come to a stop before the next cycle was initiated. One such bout consisted of 6 coupled concentric–eccentric actions. In a random fashion this protocol was executed at 2 different inertial settings using either 1 or 2 polymer wheels: weight 4.2 kg, density 1.4 kg × cm^{-3}, diameter 380 mm, thickness 20 mm, resulting in moment inertia of 0.11 and 0.22, for 1 and 2 wheels, respectively. Force, position, velocity, and root-mean-square electromyography (EMGrms) were recorded in a synchronized manner using the MuscleLab 4000e system (Ergotest AS, Langesund, Norway). Force was measured with a strain gauge (MuscleLab Force Sensor) fixed between the nylon strap that is anchored to the moving lever and winds around the flywheel shaft and a pin at the rear pulley. Position and velocity were measured with a linear encoder placed below the pulley (Figure 1). EMGrms activity was recorded from the biceps femoris (BF) and semitendinosus (ST) of the dominant limb, using dis-

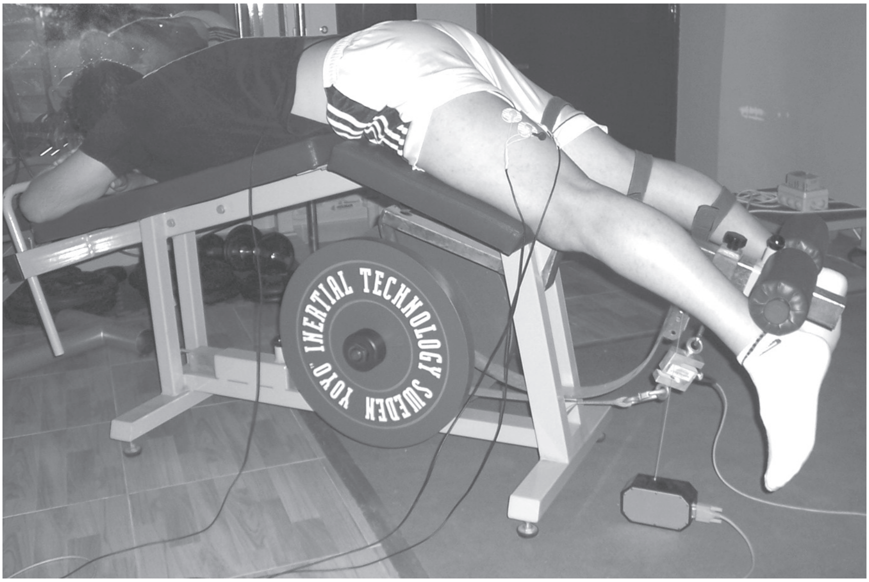

Figure 1 — Leg-curl flywheel machine.