

Since the introduction of the elliptical machine into the exercise market, the goal has been to simulate the movement of running and walking but without joint deteriorating impact. Ellipticals allow exercisers to enjoy ease of use through dependently linked pedals and arm handles, cardiovascular benefits of weight bearing and total body motion, and even muscle toning benefits from the variety of resistance options. The marketplace is full of elliptical offerings with similar end goals, but the subtleties of the motion kinematics can make a product stand out for its superior overall feel and quality of exercise.

### TOTAL BODY MOTION

University research shows that total body motion is beneficial for elliptical machines because of the enlistment of all major muscle groups. A biomechanics study performed by Concordia University in River Forest, Illinois showed that the combination of upper and lower body motion is key to the proper positioning and stabilization of a person's center of gravity. Machines that exercise the lower body only, and perhaps even offer adjustment in the lower body motion, can often compromise overall body position because the stationary handle locations cannot adapt to balance the upper body to the lower body motion. Proper balance is critical for an efficient, effective, and enjoyable workout.

### LOWER BODY – ELLIPTICAL PATH

The elliptical path should provide a smooth, continuous foot motion as a foundation for the total body motion. The pedals should be sized and spaced such that people of various body types have ample space for foot placement and choice of stance width. The Concordia University study showed that if the lateral pedal spacing is too wide, the exerciser may be forced to shift the hips laterally as force alternates between the left and right foot. This can lead to aggravation of the lower back and joints.

Additional biomechanics research shows that to simulate walking and running, the foot path should follow a relatively level path (when pictured from a sagittal or side view). The biomechanics of walking and running are well documented in the literature, showing support and return phases and the orientation of the motion path with respect to the ground. Many machines in the marketplace incorporate some degree of elevation or incline to the elliptical path; this incline has the benefit of enlisting different muscle groups. However, studies show it also has some detriments such as:

- Excessive hip flexion and little hip extension
- Misaligned force vectors at the knee due to the knee lift required at the front of the motion
- Verticality of motion, causing bounciness and potentially increased impact forces (can also lead to knee hyperextension)

A foot path with a more level orientation not only simulates a walking and running foot path, but it addresses the above concerns as follows:

- ✓ Rather than a hip motion which keeps the knees largely out in front of the exerciser, the thigh motion can be envisioned more like a "pendulum" which swings both forward and also slightly rearward of the exerciser. Since today's society often engages in prolonged periods of sitting, it is desirable to lengthen rather than tighten the hip flexors through exercise which incorporates hip extension. Extra hip extension also has the added benefit of increased gluteal contraction.
- ✓ When the knee doesn't have to lift as high in front of the user (to "step up" to the incline), the force vectors pushing downward and backward are more in line with the knee joint. Concordia University showed that ideally an exerciser's exertion should be directed through their center of gravity, which should also be in line with their major lower extremity joints such as the hip, knee, and ankle.
- ✓ A level ellipse decreases the overall vertical height that the exerciser's foot travels through, particularly during the phase when force is exerted. With less downward and more rearward directed force, the knee is discouraged from hyperextension and subjected to less strain. Less vertical drop can also decrease the impact force from body weight and exertion, and can be perceived as reduced bounciness. Exercisers may notice that this translates to a more stable eye position, which is helpful if they choose to read or watch TV during their workout.



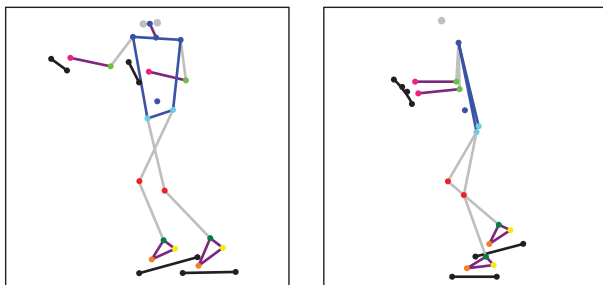
Research also shows that the stride length should not only accommodate the variety of body types, but it should also provide enough range of motion for an effective workout. A common complaint of ellipticals today from exercisers who are taller or more flexible is that the path feels too short and constrained. An added benefit of the level elliptical path is that it can be lengthened for greater range of motion without compromising comfort for shorter users or those with limited range of motion. When the ellipse is inclined, a longer stride length requires greater hip flexibility and forward trunk inclination (imagine climbing a staircase with taller and taller steps) because force is exerted with the knee farther and farther in front of the exerciser. The level ellipse path keeps force vectors aligned with the knee joint at the front of the motion path, and the extra stride length is generally accommodated toward the rear of the ellipse path and perceived as additional hip extension, which further promotes gluteal contraction and hip flexor stretching.

### UPPER BODY – ARM HANDLES

As mentioned, it is important to balance the elliptical path with a complementary arm motion. The elliptical parameters set the tone for the exerciser's body position through the feet and hips, and the arm motion closes the loop by connecting the trunk and arms to the rest of the machine. Improper balance between foot range of motion and hand range of motion can lead to excessive trunk rotation or "twisting". Improper positioning in space of the arm motion relative to the leg motion can lead to excessive trunk inclination, which may pull or push the exerciser's center of gravity forward or rearward of their overall body alignment.

Extensive research shows that upper body biomechanics are very sensitive to parameters such as pivot location, grip position, and grip angle.

The machine pivot location influences both the ellipse and the arm handle motion. The optimal balance in pivot lengths considers the typical ratio between an exerciser's arm length versus leg length, and how much arm travel would effectively balance the corresponding leg travel. On many ellipticals, the pivot point location ends up encroaching on available knee space for the exerciser's knee range of motion; ideally, the pivot point is positioned so as to provide ample knee clearance.



Digitized images of users on the cross-trainer during Kinematic studies.

The grip position with respect to the pedals (both vertical and fore-aft location) affects overall body positioning. The key is to establish an average relative location that is comfortably within reach for the full range of expected user heights. Positioning too far forward leads to excessive forward reach, which can strain the shoulder or cause the exerciser to lean forward and possibly strain the back. Positioning too far rearward can push the exerciser back and affect their stability, and it may also cause arm handle interference if the exerciser chooses to let go of the moving handles. Positioning too high or too low causes reach problems for shorter or taller exercisers, respectively.

The grip angle affects several variables in an exerciser's arm motion. First, depending on the exerciser's shoulder breadth, it controls the degree of shoulder abduction (elbow position away from the body). Grips tilted inward from vertical may nudge the exerciser's elbows outward; in the case of a person with narrow shoulders, this is beneficial to get the elbow in line with the wrist for better arm leverage. Second, the grip angle controls the amount of wrist rotation (radial and ulnar flexion) at the forward and rearward extremes of the arm motion. A completely vertical grip tends to cause excessive rotation, particularly for mid-height to taller exercisers. Finally, a more neutral wrist angle leads to better hand contact with the popular feature of heart rate hand sensors.

### FIT STRIDE™ 95Xi, 93X, 90X

The new Life Fitness Fit Stride™ Series cross trainers contain the following traits for enhanced biomechanics:

- Level elliptical path to simulate walking and running, and to reduce bounciness and knee strain
- Longer stride length for greater hip extension and glute enlistment
- Raised pivot point for upper/lower body balance
- Angled grips for wrist comfort and leverage

R E F E R E N C E S

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