

Exercise Response to

Elliptical

Trainers

Exercise science research is just beginning to catch up with the use of the popular elliptical-motion cardiovascular training machines.

By John Porcari, Ph.D., Carl Foster, Ph.D.,
and Pat Schneider

EACH YEAR, NEW, innovative exercise machines are developed to try to capture the popularity in this multi-million-dollar fitness industry. One of the latest products on the market is the class of machines called elliptical trainers. With elliptical trainers, the lower body motion is a cross between an upright stationary cycle and a stepper, except that the feet move in an egg-shaped, or elliptical pattern, as opposed to a circular path. Since the feet never leave the footpads, ground reaction or impact forces in the feet are purported to be lower, resulting in fewer orthopedic injuries to the lower extremities. This is good news for the large number of people who are looking for a high-intensity, low-impact substitute to jogging. While the popularity of elliptical trainers has virtually exploded, research on their benefits is relatively scarce.

The elliptical study

Since research on elliptical trainers is so limited, a two-part study was conducted at the University of Wisconsin-La Crosse to shed some light on the effectiveness of these new machines.⁴ The first portion of the study compared the intensity of a workout on an elliptical trainer to several other common exercise modalities. Specifically, the study compared exercising on the Nordic-Track Ellipse to running or walking on a Trimline 1000 motorized treadmill, stepping on a Precor 921e hydraulic stepper and riding a Tunturi cycle ergometer. The second portion of the study involved documenting the verti-

John P. Porcari, Ph.D., is the executive director of the La Crosse exercise and health program at the University of Wisconsin-La Crosse and is on the faculty in the department of exercise and sports science. Carl Foster, Ph.D., is an associate professor in the department of exercise and sports science. And Pat Schneider is a research assistant with the La Crosse Exercise and Health Program.

cal ground reaction forces in the feet while exercising on these modalities. One of the major problems with jogging and other high-impact aerobic activities is, because the body becomes airborne and has to land, forces equal to 24 times a person's body weight must be absorbed on landing. These forces are initially absorbed by the foot and then are transmitted to the ankle, knee, hip or back, often resulting in injury.

Sixteen volunteers between the ages of 27 and 54 practiced on each machine until they were comfortable setting workloads and consistently exercising on them. The participants then completed a 20-minute exercise bout on each modality on a separate day. Each bout was conducted at a self-selected intensity. This model is more realistic for the public, as most people who buy or use exercise equipment tend to exercise at their own pace. During each exercise bout, oxygen consumption, heart rate, ratings of perceived exertion and caloric expenditure were recorded.

On a separate day, the subjects completed a 5-minute bout of exercise on each modality and had vertical ground

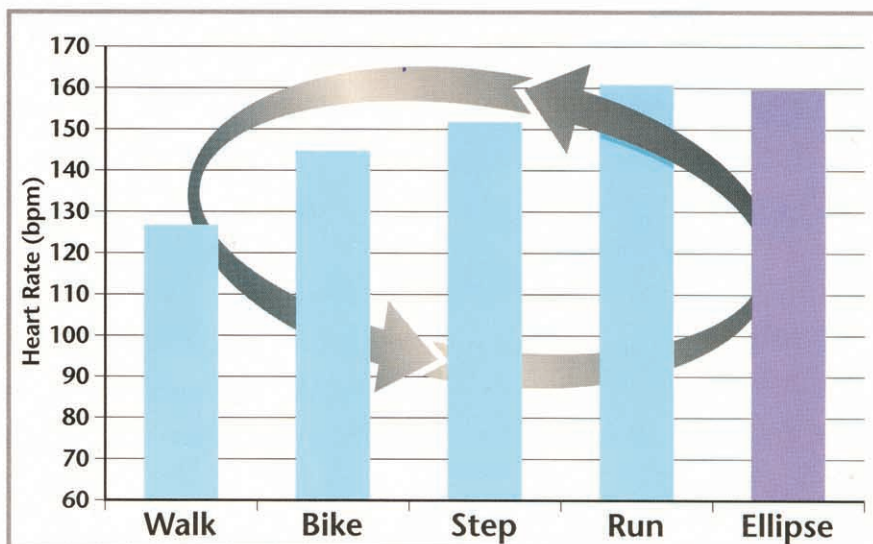


Figure 1. Average heart rate responses to 20 minutes of treadmill walking and running, stepping, stationary cycling and exercising on an elliptical trainer.



reaction (impact) forces measured in their feet. This was accomplished by placing a wafer-thin insert into both shoes. These inserts were interfaced with a computerized program that measured force production throughout the entire gait cycle. Peak forces were then determined, which were subsequently represented as a percentage of each subject's body weight.

Study findings

The study found that the heart rate and oxygen consumption values for exercising on the elliptical trainer were virtually identical to running on the treadmill, yet the impact forces in the feet were more comparable to walking (Figures 1-3). The ground reaction forces during running were almost 2.5 times body weight (Figure 3). Also, the heart rate and oxygen consumption values for running and exercising on the elliptical trainer were significantly higher than all of the other modalities, despite similar rates of perceived exertion (RPE) values. The RPE values for the elliptical trainer, treadmill running, stepping and stationary cycling were identical, av-

eraging 12.8 on the Borg 6-20 scale, which corresponds to "somewhat hard."

Related studies

The findings in this study relating to heart rate and energy cost are virtually identical to those in a well-publicized study reported several years ago.⁵ That study found that running on a treadmill was superior to exercising on stationary cycle ergometers, rowers, steppers and simulated cross-country ski machines, despite similar RPE values. Walking on the treadmill elicited the lowest heart rate (HR) and oxygen consumption values in the elliptical study and, in several other studies conducted at the University of Wisconsin-La Crosse, similar results were found. Individuals tend to exercise at a lower perceived exertion level (11.5 to 12.0 on the Borg scale) when walking on a treadmill and have lower HR, oxygen consumption and caloric expenditure responses.

In another related study, Len Kravitz and colleagues at the University of Mississippi compared four home brands of elliptical trainers.³ The results regarding the intensity of the workout were very

similar to the University of Wisconsin-La Crosse findings. In the home elliptical study, subjects exercised at RPE values between 12.5 and 13.0 on the Borg scale, and exercised at an average of 72 percent of maximal heart rate values. While the intensity of the workout was similar on all machines, the quality and "feel" of the workout varied tremendously between brands. As a warning to members who purchase home equipment, make sure that they try the machines out to test their "feel" before making a purchase.

While the issue of quality is not as much of a problem with commercial units, the "feel" of different machines can

Heart rate and oxygen consumption for exercise on an elliptical trainer were virtually identical to running on a treadmill, but impact force was less.

vary substantially. This is because the shape of the ellipse varies on different machines. Some machines incorporate a more circular pathway, while others have a flatter (more egg-shaped) elliptical pattern. Don't be turned off on ellipticals

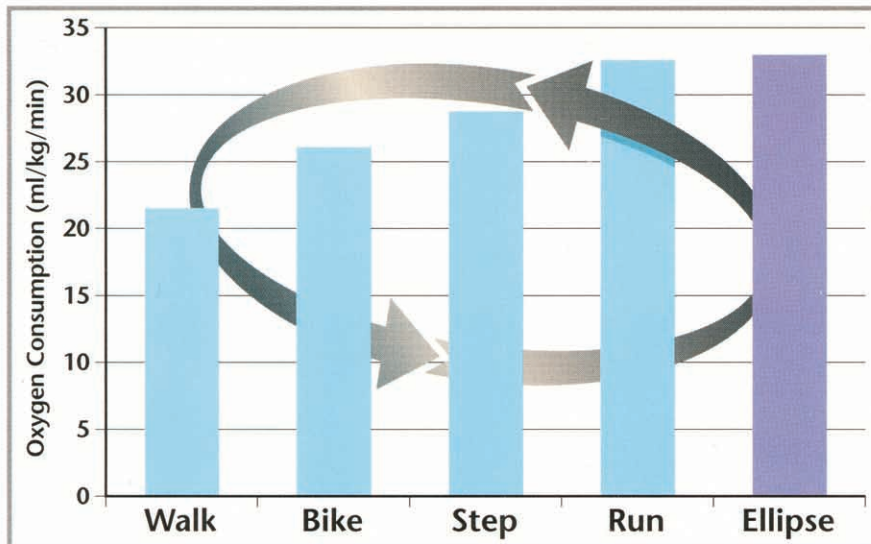


Figure 2. Average oxygen consumption values during 20 minutes of treadmill walking and running, stepping, stationary cycling and exercising on an elliptical trainer.

Elliptical trainers

provide a wide range of exercise intensity while limiting the risk of lower extremity injuries.

of their workout. The same holds true for elliptical trainers, as most commercial models allow the user to go forward or backward. But is there any benefit to the backward motion? A study found that when users went backward, they actually burned 7 percent more calories than when going forward.³ However, a study at the University of Wisconsin-La Crosse laboratory failed to substantiate this claim, and found that at identical speeds and resistance levels, exercising forward and backward on the Precor

because one machine doesn't feel right; try different brands.

What about going backward?

In a gym, you'll see people pedaling backward on a stationary cycle or walking backward on a stepper in attempts to target different muscle groups or to increase the intensity

Transport resulted in the same intensity workout.² Thus, it appears that the jury is still out on the backward issue from an energy-cost point of view, but going backward can provide variety to a workout, and future studies using electromyographs (EMG) may shed light on the muscle usage question.

The bottom line

Since a larger number of people are reaching an older age, more and more exercisers are seeking low-impact exercise alternatives. It has long been recognized that one of the major benefits of walking is that it is a low-impact activity, which results in relatively few orthopedic injuries to the lower extremities. A major drawback for more fit individuals, however, is that there is an upper limit to the workout intensity of walking. Elliptical trainers may be able to fill this void, as they can provide exercise over a wide range of exercise intensities, while minimizing the potential for lower extremity injuries. **RM**

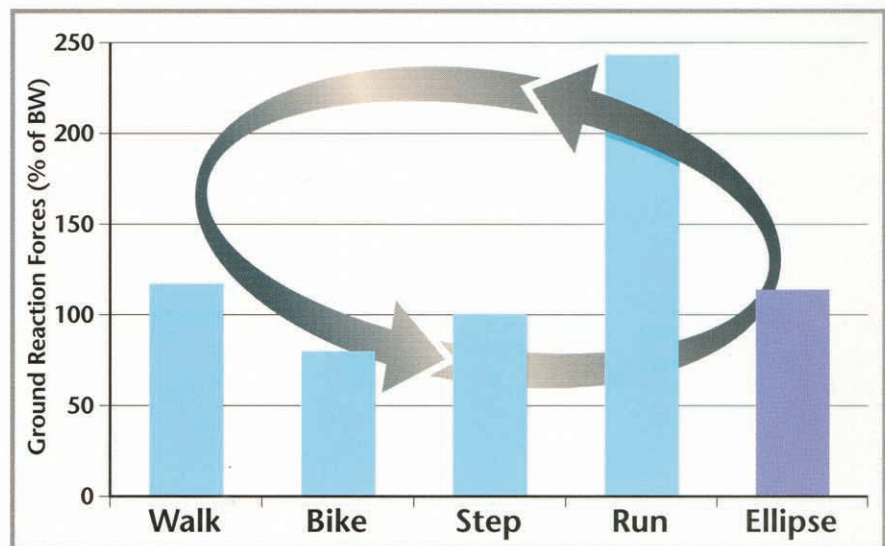


Figure 3. Peak ground reaction forces measured during each condition. Values are scaled relative to a subject's body weight (e.g., 100 percent means that the peak forces were equal in magnitude to the subject's own body weight).

REFERENCES

1. American Council on Exercise. Elliptical trainers go head-to-head. *ACE Fitness Matters* May/June: 11-15, 1998.
2. Bakken, A. A comparison of energy cost during forward and backward stepping exercise on the Precor C544 Transport. Unpublished master's thesis, University of Wisconsin-La Crosse, 1997.
3. Kravitz, L., B. Wax, J.J. Mayo, R. Daniels and K. Charette. Metabolic response of elliptical exercise training. *Medicine and Science in Sports and Exercise* 30: S169, 1998.
4. Porcari, J.P., J.M. Zedaka, L. Naser and M. Miller. Evaluation of

5. Zeni, A.I., M.D. Hoffman and P.S. Clifford. Energy expenditure with indoor exercise machines. *Journal of the American Medical Association* 275(18): 1424-1427, 1996.