

Chronobiological Effects on Exercise

It has long been known that most physiological variables demonstrate predictable, rhythmic variability within the 24-hour day. For example, body temperature is lower during the early morning hours and progressively increases during the waking hours. The fluctuation of any variable within the 24-hour day is described as a “circadian” rhythm. If not measured at equal increments throughout the 24-hour day, changes in a variable are best described as “time of day” or “chronobiological” variation. Because we do not exercise during normal sleeping hours, we will focus on chronobiological variation in exercise performance during the segment of the day in which activity typically occurs, 8:00 AM - 8:00 PM.

Chronobiological variation in exercise performance

The intensity and duration of exercise performance varies. So do chronobiological influences on exercise performance. During laboratory testing protocols of 10-12 minutes used to determine maximal aerobic exercise capacity, no fluctuation in performance is evident during normal waking hours. That is, during a cycling or treadmill test of gradually increasing intensity, neither time until exhaustion nor maximal oxygen uptake varies according to time of day. Nor does heart rate – which is a good indicator of exercise intensity – differ during tests performed at different times during normal waking hours. Likewise, during a more prolonged test of steady, submaximal intensity, exercise duration is similar in the morning and the afternoon, as is heart rate response to that aerobic effort.

In physical performance that relies mainly on the anaerobic system to provide energy (high intensity and short duration), time of day effects may or may not be observed. In all-out exercise tests lasting two to three minutes, research indicates that performance may be impaired in the morning compared to the afternoon. In contrast, it has been found that when testing involves maximal effort during cycling for less than one minute, performance does not differ during normal waking hours.

Most of the literature indicates that muscular strength demonstrates significant time-of-day effects. As with longer anaerobic testing, strength performance is less impressive before noon than it is in mid-afternoon and early evening. Moreover, when strength is measured with a device that controls for speed of limb movement (isokinetic), this chronobiological fluctuation is most pronounced at faster speeds. It has been suggested that muscle strength is greater later in the day because body temperature is also higher at this time. The gradual increase in body temperature throughout the afternoon and early evening also contributes to the improved flexibility observed then. Accordingly, both muscle contractility and extensibility are influenced by the body’s natural variation in temperature. This suggests that not only is greater strength performance more likely in the afternoon, but resistance to muscle injury may also be greater at that time.

Interestingly, there is some evidence that male hormonal responses to resistance training (weight lifting) are strongest in the morning. Resting circulating levels of testosterone, the primary musclebuilding hormone in adult males, are highest in the morning. In addition, following a bout of resistance training, testosterone elevations are more marked in the morning compared to the afternoon or early evening. This suggests that in contrast to strength performance, the muscle building potential of weight lifting may be at its peak before noon.

Training effects in chronobiological variation

In some studies, well-trained endurance athletes have displayed chronobiological variation in performance. Not surprisingly, these athletes performed best at the time of day at which they normally trained. What was surprising, however, was that chronobiological variation in performance was less apparent in middle-aged compared to younger athletes. Other studies have shown that even in a non-athletic population, a greater degree of adaptability was evident in older individuals in physical, psychological and mental capacities. Researchers have also found that in all age groups, adherence to regular exercise and fitness programs is highest among those who work out in the morning.

Although most physiological variables demonstrate circadian variation, many do not significantly fluctuate during the segment of the day when athletic endeavors typically occur. Therefore, many types of performance remain constant during normal daylight hours. An exception to this may be exercise of very high intensity and short duration. Muscle performance improves during the course of our normal waking hours. The fluctuation in those variables mirrors that of body temperature, which also progressively increases during those hours.

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