FUNCTIONAL TRAINING

Steven Plisk, MS, CSCS*D

In the last decade, *functional training* has evolved from novel buzzword to household term. It's a paradigm based on the common ground between sports rehabilitation and preparation.

Following are some popular definitions of functional training:

- An exercise continuum involving balance and proprioception, performed with the feet on the ground and without machine-assistance, such that strength is displayed in unstable conditions and body weight is managed in all movement planes.[5]
- Multi-joint, multi-planar, proprioceptively-enriched activity that involves deceleration (force reduction), acceleration (force production) and stabilization; controlled amounts of instability; and management of gravity, ground reaction forces and momentum.[7-9]
- A spectrum of activities that condition the body consistent with its integrated movement and/or use.[20]

Taken at face value, these descriptions seem pretty sound. Unfortunately, the more popular a fitness issue becomes, the more often it tends to be misinterpreted or misapplied.

I propose an alternate definition: *Functional training involves movements that are specific — in terms of mechanics, coordination and/or energetics — to one's activities of daily living (ADLs).* When considered in these terms, the range of "functional" activities may be broader than commonly thought. This brings us to a key issue.

"ATHLETES" VS. "NON-ATHLETES"

There seems to be a common belief that sports activities differ enough from ADLs that athletes should train one way, whereas non-athletes should train another. While this is typically true in terms of power output, both types of activities tend to share some basic features:

- They involve skillful application of ground reaction forces.
- Forces are transmitted through the body's segments.
- Tasks are performed in multiple planes of motion, often with no machine to guide one's movement (in biomechanics parlance, this is referred to as unlimited degrees of freedom). Consequently, we must control, direct and stabilize the mass of our own bodies as well as other objects.
- Tasks, while often repetitive, are usually brief in nature. In fact, rapid "spikes" in force

output are the rule rather than the exception.

- In order to achieve the balance and leverage needed to perform these tasks, we regularly get into certain positions. And the more habitually we do so, the more this reinforces corresponding motor programs and functional adaptations.

For these reasons, it's helpful to rethink the traditional distinction between athletic and non-athletic activities. Indeed, many sport movements (e.g. running, jumping) are simply high-powered ADLs where the issue is one of degree more so than fundamental difference. Furthermore, considering how recreationally active many "non-athletes" are, the role of functional training becomes even more apparent for overall quality of life and injury prevention.

BACK-ENGINEERING THE MACHINE

Architects have an axiom: *Form follows function*[A] — i.e. the design of a structure should be determined by its purpose. When viewing the human body as a designed system that adapts to the demands imposed on it, we can learn a lot about how it works (and how to train it) by examining its anatomy.

Two features are particularly notable. First, most of our major muscles are "multiarticular", crossing more than one joint (Figure 1). They are designed to transmit and summate forces through the body.[22]

Second, muscles in adjacent segments have complementary characteristics. In the lower limb, the proximal extensors (e.g. quadriceps femoris) have pennate fibers, long fascicles, large cross-sectional areas and a short tendon. This arrangement is ideal for force production and reduction more so than velocity. The distal extensors (e.g. gastrocnemius, soleus), on the other hand, have shorter fascicles and a tendon that's almost as long as the muscle belly. This minimizes the mass of the lower leg, reducing energy requirements during locomotion. When stretch-loaded, the Achilles tendon can lengthen up to 5% before shortening. This enhances elastic energy utilization and mechanical efficiency — and the resulting ability to accelerate, decelerate and achieve high velocities.[30]

To operate as an effective "kinetic chain", our joints must be stabilized as forces are transmitted through them. Functional training tasks should, therefore, emphasize multi-joint movements where muscles work in coordinated task groups. They should also be dynamic enough to activate the reflexes that enhance the system's stability and efficiency. And they should require skillful solutions, similar to the motor problems posed by many ADLs.

FUNCTIONALITY & SPECIFICITY

Functional training methods are based on the principle of specificity. Unfortunately, this is another concept that tends to get hackneyed or misconstrued.

Specificity actually exists on three fronts: *mechanical*, *coordinative* and *energetic*. When choosing training tasks, the key is to not be fooled by outward appearances. An exercise may look like an ADL without being specific to it (e.g. if force or coordination demands are sacrificed in an attempt to simulate a motion). The opposite is true as well. In order to be functional, certain criteria must be met on each front.

Mechanics. Traditionally, the principle of mechanical specificity involves selecting exercises with regard to a target activity's joint involvement and movement direction.[2] These factors are very important, but there are additional considerations. Perhaps most relevant are the basic laws of motion taught in high school science curricula:

- *Impulse = force · time.*[B] Execution of skillful tasks usually requires peak force application for a very short time. For example, the ground support phase when walking is about 0.3 – 0.4 second in duration, and as brief as 0.1 – 0.2 second when running; whereas absolute maximum force development requires 0.6 – 0.8 second (Figure 2). So in terms of performance and injury prevention, brief, explosive force production may be as important as brute strength.
- *Power = force · velocity.* A critical power output is required to perform many tasks. Depending on the movement, power production usually peaks at 30-50% of maximum force and/or velocity (Figure 3). This doesn't mean that heavy resistance training should be abandoned; rather, the range of productive workloads extends beyond the "slow squeeze" zone.
- *Force = mass · acceleration.* This is the most deceptively simple of these laws, but its implication is profound: Once the mass (resistance) is determined, maximal force — relative to one's strength — and neuromuscular activity are only achieved if it's maximally accelerated.

In terms of mechanics, then, functional strength can be expressed in terms of execution time, movement speed and acceleration. Despite the importance of explosive forces, however, it should not be inferred from these laws that weights are to be yanked on and hurled around recklessly. On the contrary, the application of sound technique during impulsive, powerful movements is a key determinant of performance in many tasks. It should also be a basic objective of training.

Many ADLs involve a combination of lengthening (eccentric), shortening (concentric) and/or stabilizing (isometric) muscle actions. Indeed, ballistic activities like running involve springlike actions where the prime movers are forcibly stretch-loaded, and rapidly recoiled in a reactive manner. This phenomenon is referred to as the "stretch-shortening cycle".[2,23,31] By virtue of reflex activation and elastic energy recovery, the stretch-shortening cycle enhances power and impulse production as well as mechanical efficiency and stability. It is another important determinant of performance that should also be addressed in training.

Training tasks should be chosen according to their mechanical specificity to the demands of an ADL. In other words, their basic mechanics, but not necessarily appearance, should correspond to one or more target activities.[2,23,31] Because walking, running and jumping are universal ADLs involving brief ground reaction forces, the laws of motion described above are especially important criteria. Other considerations include amplitude and direction of movement, accentuated region of force application, and regime of muscular work (i.e. concentric, isometric, eccentric).

Coordination. As mentioned earlier, ADLs often involve movement in multiple planes with no external guidance. This presents a motor coordination challenge that has important implications for skill acquisition and transfer.

In some ways, functional training is analogous to upgrading a computer system. Having the right hardware is important, but we also need the right software (read: motor programs) to run it. The unique thing about our on-board computers is that movement is one of their essential tasks. Consider the problems this presents: Our operating system must manage the momentum of a complex machine as it moves over various terrain, navigates through traffic, and manipulates all sorts of objects. It supports itself on a single limb (when walking), and repeatedly launches itself as a projectile (when running). Its center of mass is regularly outside its base of support when changing velocities. External forces — especially gravity — constantly disturb its balance.

Robust hardware is an obvious advantage when solving these problems. But it's equally important to have powerful software to drive the machine, as well as sensitive feedback mechanisms (i.e. reflexes) that enable rapid adjustments.[10,14,19]

This has two important implications with regard to training:

- *Neither our hardware nor software come "factory installed".* Both are a work in progress, remodeling themselves according to the ongoing demands imposed on them. This is why developmental considerations are so important in training (these are addressed in the next section).

- *Our hardware is upgraded by the software (or downgraded, in the case of detraining or debilitation).* When working with underpowered or undersized athletes, it's tempting to use "bodybuilding" methods. These should be used with discretion, however, because their trade-offs may negate some of the benefits.

When we hear axioms like "train movements, not muscles", here's the take-home message: Challenge athletes with motor problems involving skillful solutions — specifically requiring them to control, direct and stabilize their bodies, as well as any objects being manipulated. When their software is tasked in this manner, hardware upgrades will usually take care of themselves.

Energetics. Many ADLs are discrete in nature. Even some that appear to be prolonged or endurance-oriented, upon closer inspection, actually involve a series of brief spikes in power output. With few exceptions, life tends to be a stop-and-go sport.

The traditional "repetition maximum" approach to strength training, where each set is completed in continuous fashion until failure, can be problematic. Both amplitude and rate of force development — as well as overall muscle activation — are depressed in such circumstances, with obvious ramifications for task performance.[2,13,23,31] Although fatigue is a natural consequence of training stress, it is not the stimulus for strength gains or skill acquisition. In fact, it tends to interfere with them.[1,2,15,21-24,28,29,31]

There's a better way, involving fatigue management tactics and a general emphasis on work quality (task execution). A simple means of achieving this is to structure training sessions around brief work bouts or clusters separated by frequent "rest pauses", in much the same way athletes and coaches conduct speed/technique training sessions in order to achieve learning and performance goals.[1,2,15,21-24,28,29,31]

Summary. A movement can be considered functional if its mechanics, coordination demands and energetics are specific to a target activity. In practical terms, it's better to prioritize tasks in terms of transfer of training/learning effects than to simulate the outward appearance of an ADL.

The three faces of specificity are not mutually exclusive. For this reason, it's helpful to consider each of them when choosing training tasks. This leads to an inclusive strategy where training goals can be achieved through a blend of traditional and non-traditional exercises. Some practical considerations for designing one's training menu are discussed below in the <u>Selecting & Prioritizing Tasks</u> section.

Simulation poses two problems: (1) movement mechanics are often compromised; and (2) it's tempting to use guided-resistance apparatus that imitates a target activity, but may actually reduce the coordinative demands placed on the athlete. This is not an indictment of exercise machines in general. Some (e.g. cable-pulley systems that redirect the load without restricting movement) are very functional when used with discretion. But despite any similarities in appearance, guided-resistance apparatus tends to transfer poorly to ADLs. Unguided, free-weight equipment — starting with one's own body mass — is usually a superior choice.[2,17,18,23,25,31]

DEVELOPMENTAL ISSUES

Critical/Sensitive Periods. The relative emphasis on different training means and methods should be influenced by the athlete's developmental status, especially with regard to critical or sensitive periods. Preadolescence is the optimal window for enhancing basic movement competencies and coordination skills.[1,3,4,6,13,16,26] These are still trainable to an extent during and after adolescence, although emphasis should progressively shift toward developing strength and power, as well as sport-specific skills.

A remarkable pruning process occurs in the brain before and during adolescence, during which: (1) unused connections between neurons are eliminated; and (2) connections that are used regularly are reinforced, making them faster and more efficient.[27] This may be the ultimate example of the use-it-or-lose-it principle. It's also why aspiring young athletes must be taught a systematic movement curriculum.

Motor skills are the language of movement. This isn't just a cute metaphor: Both speech and athleticism are skills, each involving pre-movement planning in certain brain centers. We all realize how difficult it is to master a new language if we don't start learning it early enough — before the adolescent pruning process begins. The same holds true for coordination skills. This doesn't mean we should abandon proprioceptively challenging tasks in adolescence or adulthood. Instead, it means it's time to introduce skill-based strength/power techniques.

Training should, therefore, be viewed as a long-term curriculum where acquisition of movement competencies precedes performance.[1,3,4,6,13,16,26] Movement mechanics and techniques, as well as basic fitness qualities (i.e. "general preparation" tasks) are priorities early on. The intent is to progressively automate these so athletes can focus their attention capacity on tactics and strategies (i.e. "special preparation") as they advance through the syllabus.

Aging. Once we reach our 50s, a steep decline in functional strength is underway.[11,12] In many ways, this process resembles advanced detraining. Movement speed, rate of force development, and especially power diminish even faster than maximum strength. Fast-twitch muscle fibers disappear more rapidly than slow-twitch, decreasing in size as well as number, and being replaced by fatty/fibrous tissue. This is due, in part, to inactivity as well as general deterioration of the nervous system.

Functional strength training is advantageous because it helps preserve fast-twitch fibers, lean body mass, and overall capacity to activate one's muscles. It should include modified explosive training, which can enhance power, rate of force development and reactive ability in the elderly.[11,12] This has clear implications for quality of life (e.g. climbing stairs, preventing falls).

SELECTING & PRIORITIZING TASKS

Universal Athletic Position. For many ADLs, the "universal athletic position" (UAP; Figure 4) is an appropriate starting point when selecting and prioritizing training tasks. The important features of this position are:

- *The athlete squats into a balanced position.* The hips are behind the center of gravity, shoulders are in front, and torso is flat or "double-arched" (inclined at an angle of about 45º).
- *The athlete's body weight is distributed on a full foot.* This can be achieved in either a double-support stance (with the feet approximately hip- or shoulder-width apart, when performing bilateral movements) or single-support stance (during unilateral movements).
- *Neither this position, nor the activities performed from it, involve guided-resistance apparatus.* On the contrary, this position should be used to perform skillful tasks that satisfy each of the specificity criteria described above.

The UAP is almost ubiquitous in ADLs requiring athletes to get leverage and/or generate power. In some cases, it is used as a static "ready position"; whereas in others, the athlete moves through it dynamically (e.g. during a countermovement or wind-up) to exploit the stretch-shortening cycle. It's no coincidence that the traditional exercises used in many training programs (e.g. Olympic lifts, squats, jumps) share these features. Just as importantly, the UAP can be used when performing non-traditional tasks involving diagonal/rotational, horizontal and/or vertical movement.

It's not the outward appearance of the UAP that makes it functional. The ability to accommodate the specificity requirements of many ADLs from this position are its real virtues.

Balance & Stabilization. Various balance and stability techniques have been developed to enhance the proprioceptive demands of training. These typically involve certain types of equipment (e.g. body weight only, dumbbells, medicine balls, unstable surfaces) and creative exercises (e.g. core stability movements, diagonal/rotational movements, offset loading, unilateral loading).

In the sense that they can augment the coordinative challenges of training — and expand one's exercise repertoire — these techniques serve a very useful role. It's important not to deviate too far toward one specificity criterion, however, at the expense of another. Moreover, it would be an inefficient strategy to address the aspects of specificity independently, rather than select tasks that integrate them.

If used appropriately, both traditional and non-traditional tactics can be functional. But it's important to keep in mind that no training exercises or devices are inherently specific to an ADL. The key is in their execution.

CLOSING COMMENTS

Functional training is an intriguing paradigm that has challenged some conventional beliefs. It offers a novel way to address the classic problem of how to achieve optimal training specificity. As is the case with any school of thought, however, a principle-based approach is the key to avoiding dogmatic or exclusive thinking.

Effective training begins with a working understanding of all three aspects of specificity, and an objective needs analysis of the target activity. Many ADLs share certain features: They involve brief, skillful application of ground reaction forces, and transmission of those forces through the body's segments; and they are multi-planar and unguided in nature, requiring the athlete to control, direct and stabilize his/her own body (and possibly equipment). We frequently get into the UAP in order to acquire the leverage and balance needed to perform such movements. Collectively, these issues dictate the types of training tasks that tend to be most functional.

Sound training strategies involve a rational combination of means and methods.[2,13,23,31] Functional training should not be viewed as a panacea, or a separate method to be partitioned from the rest of one's program. A more pragmatic approach is to choose a basic menu of movements that meet the criteria described above, and seek opportunities to integrate each aspect of specificity into every task.

ACKNOWLEDGMENTS

Thanks to Mike Barnes, Juan Carlos Santana, Loren Seagrave and Mike Stone.

NOTES

A. The origin of this phrase can be traced to American sculptor Horatio Greenough, but architect Louis Sullivan adopted it and made it famous in his article "The Tall Office Building Artistically Considered" (*Lippincott's Magazine*, March 1896).

B. *Impulse* is also defined as the change in *momentum* resulting from a force. Impulse is measured as the product of force and time; whereas momentum is measured as the product of mass and velocity. These qualities are directly related to one another, and have similar implications for training.

REFERENCES

1. Aján T. & Baroga L. (1988) **Weightlifting.** Budapest: International Weightlifting Federation/Medicina Publishing House.
2. Baechle T.R. & Earle R.W. (Editors; 2000)/National Strength & Conditioning Association. **Essentials of Strength Training & Conditioning** (2nd Edition). Champaign IL: Human Kinetics.
3. Balyi I. (2004) Long-term athlete development: trainability in childhood and adolescence. *Olympic Coach* 16(1): 4-9.
4. Bar-Or O. (Editor; 1995) **The Child & Adolescent Athlete.** Oxford: Blackwell Science.
5. Boyle M. (2003) **Functional Training for Sports.** Champaign IL: Human Kinetics.
6. Drabik J. (1996) **Children & Sports Training.** Island Pond VT: Stadion Publishing.
7. Gambetta V., Gray G. (1995) Following a functional path. *Training & Conditioning* 5(2): 25-30.
8. Gambetta V., Clark M. (1998) A formula for function. *Training & Conditioning* 8(4): 24-29.
9. Gambetta V. (1999) Force and function. *Training & Conditioning* 9(5): 36-40.
10. Gollhofer A. (2003) Proprioceptive training: considerations for strength and power production. In: Komi P.V. (Editor), **Strength & Power in Sport** (2nd Edition). Oxford: Blackwell Science; pp. 331-342.

11. Häkkinen K. (1994) Neuromuscular adaptation during strength training, aging, detraining and immobilization. *Critical Reviews in Physical & Rehabilitation Medicine* 6(3): 161-198.

12. Häkkinen K. (2003) Ageing and neuromuscular adaptation to strength training. In: Komi P.V. (Editor), **Strength & Power in Sport** (2nd Edition). Oxford: Blackwell Science; pp. 409-425.

13. Harre D. (1982) **Principles of Sports Training.** Berlin: Sportverlag.

14. Houk J.C., Rymer W.Z. (1981) Neural control of muscle length and tension. In: Brookhart J.M., Mountcastle V.B., Brooks V.B. & Geiger S.R. (Editors), **Handbook of Physiology 1: The Nervous System.** Bethesda MD: American Physiological Society; pp. 257-323.

15. Magill R.A. (2004) **Motor Learning & Control** (7th Edition). New York NY: McGraw-Hill Higher Education.

16. Malina R.M., Bouchard C. & Bar-Or O. (2004) **Growth, Maturation & Physical Activity** (2nd Edition). Champaign IL: Human Kinetics.

17. Morrissey M.C., Harman E.A., Johnson M.J. (1995) Resistance training modes: specificity and effectiveness. *Medicine & Science in Sports & Exercise* 27(5): 648-660.

18. Nosse L.J., Hunter G.R. (1985) Free weights: a review supporting their use in rehabilitation. *Athletic Training* 20(4): 206-209.

19. Prochazka A. (1996) Proprioceptive feedback and movement regulation. In: Rowell L.B. & Shepherd J.T. (Editors), **Handbook of Physiology 12: Exercise: Regulation & Integration of Multiple Systems.** New York NY/Oxford: American Physiological Society/Oxford University Press; pp. 89-127.

20. Santana J.C. (2000) **Functional Training.** Boca Raton FL: Optimum Performance Systems.

21. Schmidt R.A. & Lee T.D. (1999) **Motor Control & Learning** (3rd Edition). Champaign IL: Human Kinetics.

22. Schmidt R.A. & Wrisberg C.A. (1999) **Motor Learning & Performance** (2nd Edition). Champaign IL: Human Kinetics.

23. Siff M.C. (2003) **Supertraining** (6th Edition). Denver CO: Supertraining Institute.

24. Singer R.N., Hausenblas H.A. & Janelle C.M. (Editors; 2001) **Handbook of Sport Psychology**

(2nd Edition). New York NY: John Wiley & Sons.

25. Stone M., Plisk S., Collins D. (2002) Training principles: evaluation of modes and methods of resistance training — a coaching perspective. *Sports Biomechanics* 1(1): 79-103.

26. Tittel K. (1991) Coordination and balance. In: Dirix A., Knuttgen H.G. & Tittel K. (Editors), **The Olympic Book of Sports Medicine.** Oxford: Blackwell Scientific Publications; pp. 194-211.

27. Wallis C., *et al.* (2004) What makes teens tick? *TIME* 163(19): 56-65.

28. Weinberg R.S. & Gould D. (2003) **Foundations of Sport & Exercise Psychology** (3rd Edition). Champaign IL: Human Kinetics.

29. Williams J.M. (Editor; 2001) **Applied Sport Psychology** (4th Edition). Mountain View CA: Mayfield Publishing.

30. Winters J.M. & Woo S.L.Y. (1990) **Multiple Muscle Systems**. New York NY: Springer-Verlag.

31. Zatsiorsky V.M. (1995) **Science & Practice of Strength Training.** Champaign IL: Human Kinetics.

Figure 1: Human musculature.

Source: National Strength and Conditioning Association, 2000*, Essentials of Strength Training and Conditioning,* ed. T.R. Baechle and R.W. Earle, 2nd ed., page 29, figure 3.4. © 2000 by the National Strength and Conditioning Association. Reprinted with permission from Human Kinetics (Champaign IL).

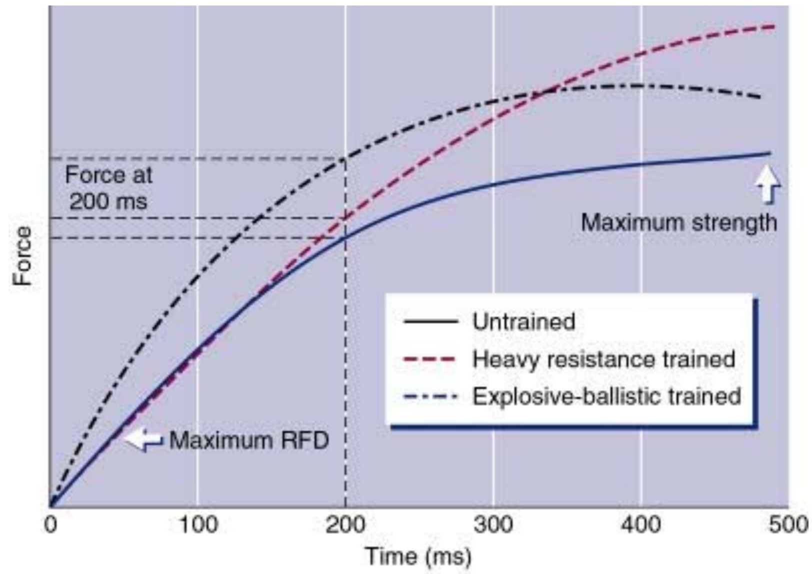

Figure 2: Impulse = force · time. Force as a function of time, indicating maximum strength, rate of force development [RFD], and force at 0.2 sec for untrained [solid line], heavy-resistance trained [dashed line], and explosive-ballistic trained [dotted line] subjects. Impulse is the change in momentum resulting from a force, measured as the product of force and time (represented by the area under each curve), and is increased by improving RFD. When performing functional movements, force is typically applied very briefly (often 0.1 – 0.2 second, whereas absolute maximum force development requires 0.6 – 0.8 second).

Source: National Strength and Conditioning Association, 2000*, Essentials of Strength Training and Conditioning,* ed. T.R. Baechle and R.W. Earle, 2nd ed., page 473, figure 20.1. © 2000 by the National Strength and Conditioning Association. Reprinted with permission from Human Kinetics (Champaign IL). Originally adapted from K. Hakkinen and P.V. Komi, 1985, *Scandinanvian Journal of Sports Science* 7(2): 55-76. © 1985 Munksgaard International Publishers, Ltd. Copenhagen, Denmark.

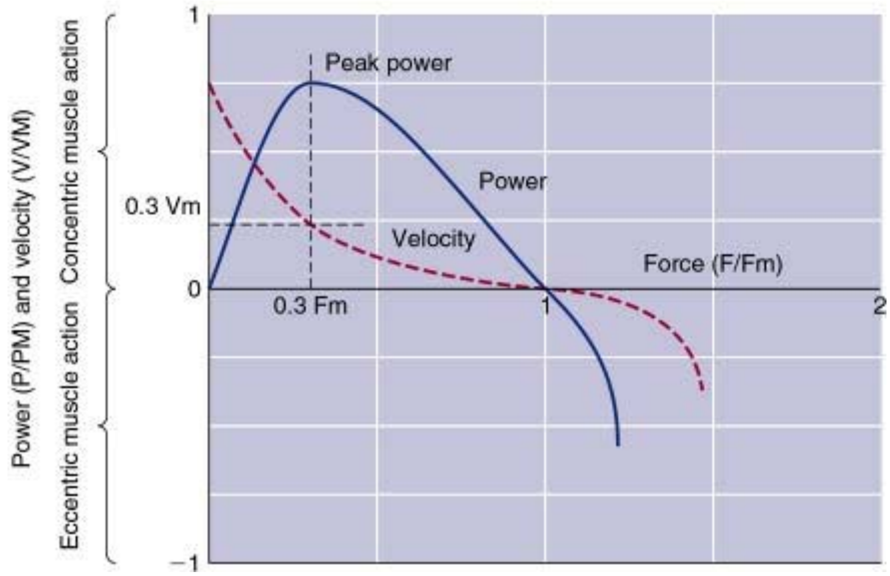

Figure 3: Power = force · velocity. Velocity as a function of force [dashed line], and resulting power production/absorption [solid line], in concentric and eccentric muscle actions. The greatest forces occur during explosive eccentric (lengthening) actions. Depending on the movement, peak power [Pm] is usually produced at 30-50% of maximum force [Fm] and velocity [Vm]. A critical power output is required to execute any skill, which is why the range of productive training workloads extends beyond the "slow squeeze" zone.

Source: National Strength and Conditioning Association, 2000*, Essentials of Strength Training and Conditioning,* ed. T.R. Baechle and R.W. Earle, 2nd ed., page 474, figure 20.2. © 2000 by the National Strength and Conditioning Association. Reprinted with permission from Human Kinetics (Champaign IL). Originally adapted from J.A. Faulkner, D.R. Claflin and K.K. McCully, 1986, Power output of fast and slow fibers from human skeletal muscles. In *Human Muscle Power* edited by N.L. Jones, N. McCarney and A.J. McComas (Champaign IL: Human Kinetics), 88.

Figure 4: The universal athletic position (UAP). The athlete squats into a balanced position; body weight is distributed on a full foot; and neither this position nor the activities performed from it involve guided-resistance apparatus. The UAP can be used to perform a variety of traditional and non-traditional (diagonal/rotational, horizontal, vertical) movements that satisfy the specificity requirements of many ADLs.

Sources:

Top left and bottom left: C.W. Pack Sports (a sports photography company based in

Hawaii & Connecticut)

Top right: © Randall J. Strossen PhD. Reprinted with permission from *MILO: A Journal For Serious Strength Athletes*, published by IronMind Enterprises Inc., Nevada City CA.

Bottom right: internet