Multi-limb coordination, Manual dexterity, Arm-hand steadiness,
Have We Sold Ourselves Short?

- Six Pack Abs
- Long-Lean Hollywood Muscles
- Thinner Thighs
- Mirror Muscles
- Chest and Bi’s

- Nice car, but how about the driver??????
# The Measureable Elements of Physical Fitness

<table>
<thead>
<tr>
<th>Skill-Related Fitness</th>
<th>Health-Related Fitness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Agility</td>
<td>1. Cardiorespiratory Endurance</td>
</tr>
<tr>
<td>2. Balance</td>
<td>2. Body Composition</td>
</tr>
<tr>
<td>3. Coordination</td>
<td>3. Musculoskeletal</td>
</tr>
<tr>
<td>4. Speed</td>
<td>a. Flexibility</td>
</tr>
<tr>
<td>5. Power</td>
<td>b. Muscular Strength</td>
</tr>
<tr>
<td>6. Reaction Time</td>
<td>c. Muscular Endurance</td>
</tr>
</tbody>
</table>
The Nervous System: The Unsung Hero in Exercise Science

Vincent Metzo, MA, LMT, CSCS
Obesity Is Not The Only Problem

- “Structured physical training in schools was sacrificed to sports and games around 1920. By the 1950s there were signs that America was growing clumsy and unbalanced. There was an initial phase of denial, and American physical educators have since been slow to face the crisis. Army recruits fresh from the civilian sector generally have poor posture and motor patterns that impede training and lead to injuries”.

  Steve Cellucci. USAPFS commandant.
Three Parts

• How does the nervous system help the body?

• How does the body help the nervous system?

• How can we help the nervous system help the body help itself?
How Does the Nervous System Help the Body?

Strength and Skill Related Adaptations
Figure 22.21. Relative roles of neural and muscular adaptations in strength improvement with resistance training. Note that neural adaptations predominate in the early phase of training (this phase also encompasses most training studies). Hypertrophy-induced adaptations place the upper limit on longer-term training improvements. This tempts many athletes to use anabolic steroids and/or human growth hormone (dashed line) to induce continual hypertrophy if training alone fails. (From Sale DG, Neural adaptation to resistance training. Med Sci Sports Exerc 1988;20:135.)
Figure 19.9. Motor unit and motor neuron pool. A. Motor unit represents an α-motoneuron and the fibers it innervates.

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Figure 19.9. Motor unit and motor neuron pool. B. Motor neuron pool represents all the α motor neurons that innervate one muscle.

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Adaptations That Can Boost Strength Without Increasing Muscle Hypertrophy

- Enhanced output from supraspinal centers as suggested by findings with imagined contractions
- Reduced coactivation of antagonist muscles
- Greater activation of agonist and synergist muscles
- Enhanced coupling of spinal interneurons that produces cross-education
- Changes in descending drive that reduce the bilateral deficit
- Shared input to motor neurons that increases motor unit synchronization
- Greater muscle activation (EMG)
- Heightened excitability and altered connections into motor neurons

*Neuromechanics of Human Movement*, Roger Enoka (Enoka, 2008)
Speed Dexterity and Complexity

• Coordination between the muscles is the single greatest contributor to non-hypertrophy related strength gains.
Figure 5. Pyramid of Learning. (Williams & Shellenberger, 1-4)
Higher Level Brain Centers

“Intent to Lift”

Motor Cortex

Spinal Cord

“Feed Forward” from cerebellum – anticipatory movement accuracy

Information “Feed Back” from MSOs, GTOs, Joint receptors, Tactile receptors.

Specific Motor Unit Activation
EMG Output
Acute force Production by muscle

Training Adaptations:
- Muscle fiber changes
- Selective hypertrophy
- Muscular endurance, strength, power based on program variables
Skill

• Skill: the acquired ability to consistently and accurately achieve goal acquisition through a variety of conditions (Higgins, S., Motor Skill Acquisition, Journal of Physical Therapy).
SKILL Related Changes

• **Intermuscular coordination**: the synchronization, sequencing, excitation, and inhibition of MU actions from different muscle groups to produce the desired movement.
  – Sequential Segmental Summation
  – Agonist-Antagonist Cooperation
**SKILL** Related Changes

- **Intramuscular coordination:** the control of the number, rate, and pattern of MU recruitment to control the tension by exciting/inhibiting the appropriate number and type of MU’s.
  - Rate of Force Development (RFD)
SKILL Related Changes

• **Efficient movement**: the acquired SKILL to move in a smooth, fluid, and differentially relaxed manner. Balance, timing, coordination, dynamic postural control, anticipation, kinesthetic awareness, and more.
Changes in Muscles Used to Perform the Skill

• EMG patterns produced while people practiced skills have shown that early in practice a person uses his or her muscles inappropriately.
• More muscles than are needed commonly are involved.
• Timing of the activation of the involved muscle groups is incorrect.
• With Practice:
  – the number of muscles involved decreases until a minimal number of muscles are activated,
  – the timing of when the involved muscles are activated becomes appropriate.
Changes in Muscles Used to Perform the Skill

• By structuring muscle activation appropriately, the motor control system can take advantage of physical properties of the environment, such as gravity, momentum, or other basic physical laws.

• By doing this, the motor control system reduces the amount of work it has to do and establishes a base for successful skill performance.
Momentum is Part of Life:
Defined: Momentum (G) the quantity of motion possessed by a body and is the product of mass (m) and velocity (v).

- Momentum training teaches us complex and sophisticated NM strategies that can be used in real life with real life objects.
Changes in Energy Cost

• We can reasonably expect that the learner would become a more economical (i.e., efficient) user of energy.

• Economy of movement refers to minimizing the energy cost of performing a skill.

• Beginners expend a large amount of energy (i.e., have a high energy cost), whereas skilled performers perform more efficiently, with minimum expenditure of energy.
Expert Bag Punching

©July 28, 1903
American Mutoscope & Biograph Company
SKILL and Injury Prevention

• Injuries usually occur during deceleration (landing or stopping racquet or bat after swing/stopping arm after throw or punch)

• SKILL RELATED TRAINING for:
  – Agonist-Antagonist Cooperation
  – Higher Rates of Force Development
  – Smooth deceleration & force absorption throughout entire NMS
How Does the Body Help the Brain?

Plasticity, Memory, and Cognition
Who You Calling a Dumbbell???

- Grey Tsunami
- Learning and academic achievement in children
Resistance training and functional plasticity of the aging brain

• Aging, Mobility and Cognitive Neuroscience Laboratory at the University of British Columbia
• After 12 months of lifting weights twice a week, the women performed significantly better on tests of mental processing ability than a control group of women who completed a balance and toning program
• Complements the effects on selective attention that have previously been ascribed to aerobic exercise in seniors.
• Only observed among those who trained twice weekly; participants of the once-weekly resistance training did not demonstrate comparable responses
Resistance training and functional plasticity of the aging brain

• Teresa Liu-Ambrose, a principal investigator suggested “resistance training at first requires an upsurge in brain usage. You have to think about “proper form and learning the technique, while there generally is less learning involved in aerobic training,” like running.

• Resistance training may both demand and create additional brain circuitry.
Training-Induced Brain Structure Changes in the Elderly

- Elderly persons were able to learn three-ball cascade juggling.
- Gray-matter changes in the older brain related to skill acquisition were observed in area hMT/V5 (middle temporal area of the visual cortex).
- Volunteers who learned to juggle showed transient increases in gray matter in the hippocampus on the left side and in the nucleus accumbens bilaterally.
- Nucleus accumbens is involved in reward systems. It is a neural interface between limbic (emotional) and motor systems, turning reward information into motivated action.
- A brain-plasticity-based training program would potentially promise an improvement of the operational capabilities of aging.
- As people age, they should not do less, but do more to keep and maintain their abilities.

http://www.jneurosci.org/content/28/28/7031.full
SAT and Fitnessgram

State Study Proves Physically Fit Kids Perform Better Academically

2001 Grade 7 SAT 9 Physical Fitness
California Dept of Education Study

SAT 9 Percentile

Number of Fitness Standards Achieved

322,000 Seventh Graders
State Study Proves Physically Fit Kids Perform Better Academically

Grade 9 SAT and Physical Fitness Scores
California Dept of Education Study

Number of Fitness Standards Achieved
279,000 Ninth Graders
How Can We Help the Nervous System Help the Body Help Itself?

Motor Development, Brain Plasticity, Crossing the Midline, Rhythm and Relative Time Invariance
Motor Development

• “Not matching a child’s activities with his or her developmental level is in fact, a serious problem today. Many parents and teachers believe that children can be introduced to sports or other activities without regard to their developmental age—just because they are at a certain chronological age or they are in a certain grade”.

Billye Ann Cheatam, PhD. Western Michigan University
Integrating Reflexes and Foundations of Movement Skills

- Body Image
- Body Concept
- Body Schema
- Laterality
- Directionality
- Fundamental Movement Skills
- Specialized Movement Skills
- Functional Movement Skills
- Biomotor Abilities
Figure 5. Pyramid of Learning. (Williams & Shellenberger, 1-4)
Early Movement Milestones

• Locomotor and object-control skills that emerge before a child attains upright or bipedal locomotion.

• Rolling over, crawling, creeping sitting standing, walking, and object manipulation.

• Walking which usually occurs at around 12-13 months of age is typically considered to be the last early motor milestone.
Developmental Reflexes

- Asymmetrical Tonic Neck Reflex
- Symmetrical Tonic Neck Reflex
Asymmetric tonic neck reflex

• In an infant
• Head turned to side causes extension of one or both extremities on that side. Flexion of extremities on other side.
• Disappears by 6–7 months. Abnormal after.
Symmetric tonic neck reflex

- In an infant
- Flexion of the neck causes Flexion of the arms extension of legs.
- Extension of the neck causes Extension of the arms Flexion of legs.
- Makes the top half of the body work opposite from the bottom half.
- The STNR helps a baby pull into a crawling position by straightening the baby's neck and arms while simultaneously bending the baby's legs.
- In control of a baby's body at the age of six months.
Symmetric tonic neck reflex

• Should not be in control of the child's body after the age of two years.
• If a baby does not crawl properly and for at least six months, the STNR will remain somewhat in control (immature) and can cause problems later on.
• When a child goes to school, an immature STNR can significantly interfere with the child's ability to sit still, pay attention, and write easily.
• As well as cause clumsiness and inhibit motor skill acquisition.
Immature STNR

• Squirming
• Getting up frequently
• Losing attention quickly
• Daydreaming frequently
• Writing poorly
• Writing laboriously
• Reversing letters or numbers
• Moving awkwardly or clumsily
• Avoiding athletics
• Developing athletic skills slowly
Movements to Enhance Motor Learning (and integrate STNR)

• Walk on toes, heels, toes pointed in or out
• Combat crawl over pillows, around obstacles, under and through boxes, etc.
• Animal walks – inch worm, crab walk, bear walk, bunny hop, frog leap, elephant walk
• Hang a ball with a string – hit it with one hand, then both together; elbows; or empty wrapping paper roll, etc.
• Kickball, tetherball, balloon volleyball, basketball, Koosh ball, Zoom Ball
• Targeting with bean bags, tennis balls, Koosh balls, etc.
• Playground – swings, slides, monkey bars, tire swing

"Today's Child" article on gross motor skills dated 3/3/2000
Fundamental Movement Skills

• Locomotor and object-control skills performed in an upright or bipedal position that are used by people in all cultures of the world.

• Walking, running, jumping, sliding, hopping, and leaping, as well as object control skills such as throwing, catching, striking, bouncing, kicking, pulling and pushing.
Fundamental Movement Skills
Specialized Movement Skills

• Combine one or more of the early movement milestones and/or the fundamental movement skills.
• Mature patterns of movement that have been refined and combined into sports or other complex and specific movement skills.
• Hammering a nail, shooting an arrow, sewing a button, performing a forward roll or triple jump, shooting a free throw in basketball, spiking a volleyball, and pitching a baseball are all examples.
• These skills may emerge before the fundamental movement skills, they are then referred to as splinter skills.
Functional Movement Skills

• These are early movement milestones, fundamental and/or specialized movement skills that are performed in their meaningful and natural contexts (such as while at play, during work, during a game, etc.).
Laterality

- Awareness that one’s body has two sides and they are different.
- Laterality can only occur once a person/child has developed body awareness and schema.
- Catching a ball thrown to the right side of their body with their right hand, to the left side with their left hand, and in the middle with both hands.
- Allows the person/child to do different things with each limb simultaneously; standing on one leg while kicking a ball with the other; supporting their weight on one arm while moving the other; holding a paper with one hand while writing with the other; reading from left to right.
- Right and left sides of the body can typically be identified accurately by the age of seven, later development (age of ten) may put one at a disadvantage academically and in physical education.
Lateral Preference

- An extension of laterality
- We progress to favor one eye, hand, leg over the other for tasks.
- This preferred side is more coordinated than the other and is the side that the person will automatically use when trying to precisely accomplish a task or learn a new skill.
- We can’t determine that something is on our left if the left and the right sides of our body “feel” the same to us.
- This preference is also necessary for the two limbs to work together to accomplish a task, the preferred limb taking the primary role and the non-preferred limb helping it.
- Learning new skills where the limbs need to move in opposition such as throwing a ball, following directions, and coordinating movements becomes much more difficult without lateral preference.
The Midline

- In anatomy this is the mid-sagittal plane dividing the body into equal right and left hands.
- A “midline problem” manifests as the person not crossing the midline of their body when they follow through with a throw or a kick, have problems performing dance steps where one foot crosses the other, or reaching across the body to catch a ball (such as with a baseball mitt).
- In these instances, the midline is acting as a barrier that prevents the person from crossing it.
- Midline problems relate to laterality and lateral preference concepts mentioned above.
- Midline problems often cause delays in developing laterality, lateral preference, and learning motor skills that require cross-lateral motor patterns.
Directionality

• Awareness of movements or areas outside the body such as before-behind, above-below, and left-right.
• First we learn these references in our own bodies and then project them outside of our bodies.
• Directional discrimination is based on a firm foundation of body concept, body schema, laterality and lateral preference.
• Following instructions such as “move to the right”, “pass the ball behind you” are very difficult for children to follow who do not have a solid sense of directionality.
<table>
<thead>
<tr>
<th>Foundation</th>
<th>Problems</th>
<th>KB Exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laterality and Bilaterality</td>
<td>Difficulty coordinating movements of the limbs together. Limbs move together but not on purpose</td>
<td>Use exercises where limbs must work in opposition to each other.</td>
</tr>
<tr>
<td>Lateral Preference</td>
<td>Person lacks a favored limb and therefore has trouble differentiating between which side objects are on or movements should occur on.</td>
<td>Focus exercises on one side of the body for a few sessions. Light weight, high reps.</td>
</tr>
<tr>
<td>Midline</td>
<td>Person has trouble coordinating two limbs to work together especially in opposition or when they must move opposite to each other.</td>
<td>Movements where the limbs must cross the midline of the body.</td>
</tr>
<tr>
<td>Directionality</td>
<td>Has difficulty differentiating between up-down, over-under, right-left, in front-in back.</td>
<td>Movements in different directions.</td>
</tr>
</tbody>
</table>
Got Rhythm?

Coordinative structures and Relative Time Invariance
Coordinative Structures

• Functionally specific collections of muscles and joints that are constrained by the nervous system to act cooperatively to produce an action; sometimes referred to as muscle, or motor, synergies.
Intrinsic coordinative structures

• Involved in actions such as walking, running, and bimanual coordination.

• Muscles and joints of the limbs involved have a natural tendency to demonstrate inter-limb coordination patterns that have characterized our performance of them since early in life.

• When performing a skill involving bimanual coordination, which requires the simultaneous use of both arms and hands, both infants and adults typically demonstrate a similar natural tendency to move the arms and hands simultaneously both spatially and temporally.
Rhythmic Structure of Gait Patterns

• Distinct rhythmic relationships exist between the movement of the arms and that of the legs.

• 2:1 ratio (i.e., two arm swings to each leg stride) for very slow walking.

• 1:1 ratio for walking at speeds greater than 0.75 m/s (1.7 mi/hr, or 2.72 km/hr).

• The pelvis and thorax also demonstrate a rhythmic relationship during walking.
Coordinative Structures Developed Through Practice

• New combinations of muscles and joints that act together to produce a coordination pattern that will allow the achievement of an action goal.
Relative Time

• The proportion, or percentage, of the total amount of time required by each component of a skill during the performance of that skill.
FIGURE 5.4 An illustration of invariant relative time for a hypothetical four-component motor skill when it is performed normally at a 10 sec duration (a), speeded up to a 5 sec duration (b), and slowed down to a 15 sec duration (c).
Teaching Rhythm: A Key to Learning Proper Technique in the Power Clean

• VOLUME 34 | NUMBER 2 | APRIL 2012 of Strength and conditioning journal
Teaching Rhythm:

• Rhythm represents the fixed cadence of a motor skill that separates one category of motor skill from another.

• This fixed rhythmic structure is hypothesized to be embedded in all motor skills, regardless of motor skill speed.

• Proposal that mastering the rhythmic component of a skill is a key step toward skill acquisition.

• RHYTHM OR RELATIVE TIMING IS AN IMPORTANT PEDAGOGICAL COMPONENT THAT CONTRIBUTES TO TECHNICAL MASTERY AND CAN BE APPLIED TO THE POWER CLEAN.
Run Away and Join the Circus

Physical Culture
culture

– The totality of socially transmitted behavior patterns, arts, beliefs, institutions, and all other products of human work and thought.

– These patterns, traits, and products considered as the expression of a particular period, class, community, or population.

– The predominating attitudes and behavior that characterize the functioning of a group or organization.
physical culture

• philosophy, regimen, or lifestyle seeking maximum physical development through such means as weight (resistance) training, diet, aerobic activity, athletic competition, and mental discipline.

• Specific benefits include improvements in health, appearance, strength, endurance, flexibility, speed, and general fitness as well as greater proficiency in sport-related activities.
Ancient Greeks

• Milo of Croton, who popularized progressive resistance training by purportedly carrying a calf daily from its birth until it became full-size.
Arete, or “virtue”

• Ideal of a sound mind and sound body was cultivated in the gymnasia, where young men exercised, bathed, socialized, and discussed philosophy.

• Greeks employed physical culture as a form of preventive medicine and as a means of recuperating from illnesses and weaknesses.
Mens sana in corpore sano

• The phrase is derived from Satire X of the Roman poet Juvenal (10.356).
• The phrase is part of the author's answer to the question of what people should desire in life.

"A sound mind in a sound body."
Thank You!

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