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Tests and assessment in endurance running

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…few words about me

- O-runner since 1998, „former“ road and track runner and Ironman triathlete, floorball player, climber, hiker, MTB rider, …
- PhD student in Sports Science, MUNI SPORT (S&C)
- At MUNI:
  - Teaching classes S&C, T&F, SS
  - Quality coordinator for study programmes
  - Research: running economy, data analysis, …
- S&C coach in O, long-distance running, football, …
- Lecturing in coaches training (T&F, O, floorball, football, karate, XC skiing, …)
- Certified coach in O, T&F and DNS

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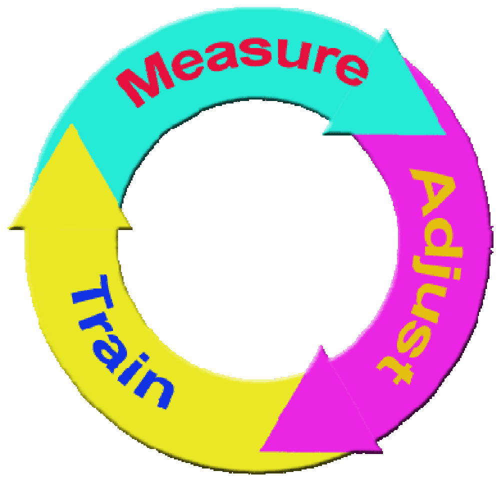
Focus of the lecture

- Endurance/distance running (ER)
  - Definition, factors
- A testing purpose in running
- 4 categories of tests/assessments in ER:
  - Performance tests
  - Movement screening
  - Strength diagnostics
  - Capacity tests



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Sports diagnostics

- „A **test** or **quiz** is used to examine someone's knowledge of something to determine what he or she knows or has learned. Testing measures the level of skill or knowledge that has been reached.
- **Evaluation** is the process of making judgments based on criteria and evidence.
- **Assessment** is the process of documenting knowledge, skills, attitudes and beliefs, usually in measurable terms. The goal of assessment is to make improvements, as opposed to simply being judged. In an educational context, assessment is the process of describing, collecting, recording, scoring, and interpreting information about learning.“

Cited: http://tutorials.istudy.psu.edu/testing/testing2.html

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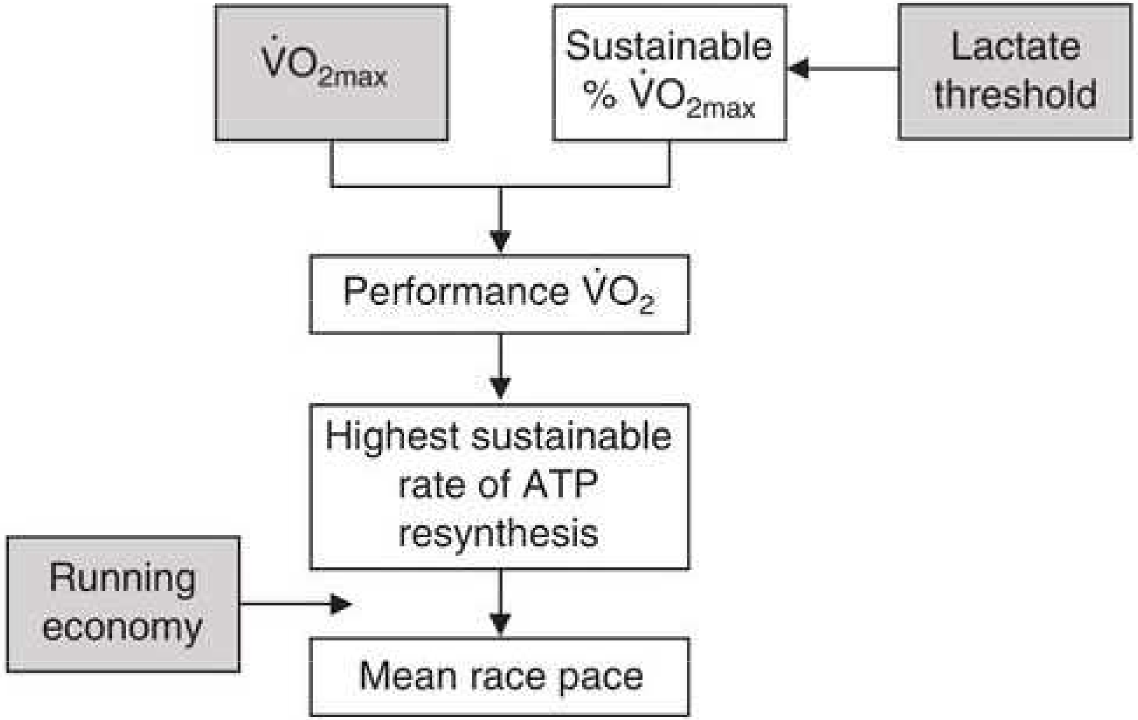
- Purpose?
- Reliability?
- Validity?
- Rules?
- Order?
- Comparison?

Factors affecting distance running performance



Midgley, A.W., McNaughton, L.R. & Jones, A.M. Sports Med (2007) 37: 857. https://doi.org/10.2165/00007256-200737100-00003

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WHAT?

WHO?

(micro-contest)

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- Lab testing (VO2max test)
- Kipchoge, Kenya (marathon WR: 2:01:39 = 2:53/km pace)

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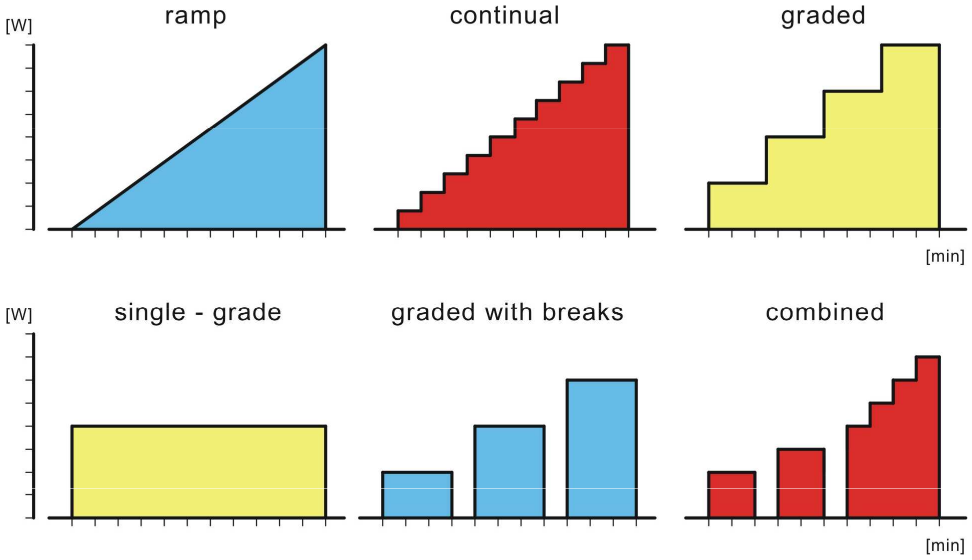
Performance testing



- lab X field
- <u>max (test/**race**) X submax</u>
- HR, SmO_2, VO_2, VCO_2, VE, GCT, VO, W, La, v, …

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VO_2max and running economy

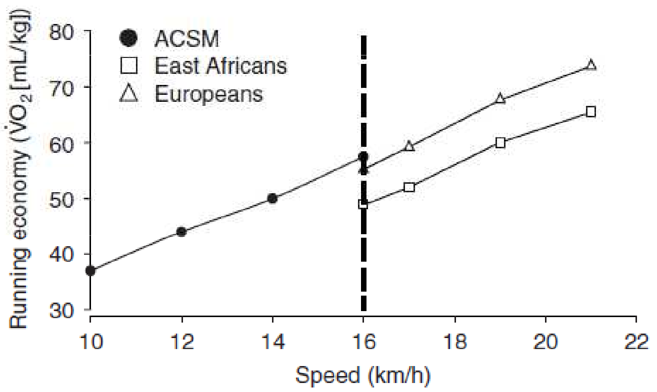

Fig. 1. Schematic values of the oxygen uptake cost of treadmill running (up a 1% gradient) in terms of normative data (from the American College of Sports Medicine [ACSM]), and based on pooled values for elite runners of European descent[1,3,6,7,9] and elite runners of East African descent.[5,7] The dashed vertical line represents a running velocity of 268 m/min, which is the most commonly used reference value. $\dot{V}O_2$ = oxygen uptake.

Table I. Reference values for the aerobic cost of running in different populations

Population	Maximal oxygen uptake	
	mL/min/kg	mL/min/kg$^{0.75}$
Reference value (ACSM) [80kg]	58	175
Elite Europeans/ North Americans (65kg)	55	156
Elite East Africans (60kg)	50	130

ACSM = American College of Sports Medicine.

Table II. Reference values for running economy in different populations

Population	Maximal oxygen uptake (mL/min/kg)
Reference value (ACSM)	218
Elite Europeans/North Americans	210
Elite East Africans	187

ACSM = American College of Sports Medicine.

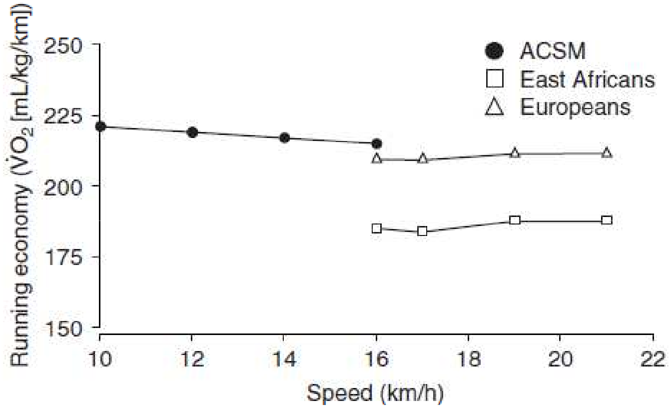

Fig. 2. Schematic values of the oxygen cost of treadmill running (up a 1% gradient) in terms of the oxygen uptake ($\dot{V}O_2$) required to run 1km, expressed in terms of normative data (from the American College of Sports Medicine [ACSM]), and pooled values for elite runners of European descent[1,3,6,7,9] and elite runners of East African descent.[5,7]

Foster, Carl & Lucia, Alejandro. (2007). Running economy: The forgotten factor in elite performance. Sports medicine (Auckland, N.Z.). 37. 316-9.

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Physiological factors for marathon performance time among top-class (TC) and high-level (HL) male runners.

Factors	TC	HL
Age (yr)	33.4 ± 2.0	30.3 ± 2.2
Weight (kg)	60.2 ± 2.9	59.3 ± 2.5
Height (cm)	172 ± 2	172 ± 2
MPT (min)	129 ± 2	133 ± 1
vMarathon ($km \cdot h^{-1}$)	19.5 ± 0.3	19.0 ± 0.1
vMarathon % v3000m	85.7 ± 0.9	86.4 ± 1.5
v1000m ($km \cdot h^{-1}$)	22.0 ± 0.8	21.8 ± 0.2
v3000m ($km \cdot h^{-1}$)	22.8 ± 0.6	22.0 ± 0.5
$\dot{V}O_{2peak}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	79.6 ± 6.2	67.1 ± 8.1
$FR\dot{V}O_{2max}$ (%)	89.8 ± 6.7	95.7 ± 8.7
Cr ($mL \cdot kg^{-1} \cdot km^{-1}$)	210 ± 12	195 ± 4

MPT, marathon performance time.

Physiological responses during the 10-km run at $v_{marathon}$ among TC and HL male runners.

Factors	TC	HL
$\dot{V}O_2$ @ 3 km ($mL \cdot min^{-1}$)	70.1 ± 7.9	64.6 ± 3.9
$\dot{V}O_2$ @ 10 km ($mL \cdot min^{-1}$)	71.4 ± 7.2	63.7 ± 5.7
HR @ 3 km ($beats \cdot min^{-1}$)	161 ± 3	170 ± 6
HR @ 10 km ($beats \cdot min^{-1}$)	167 ± 5	176 ± 7
Lactate @ start ($mmol \cdot L^{-1}$)	2.4 ± 1.0	1.9 ± 0.7
Lactate @ 3 km ($mmol \cdot L^{-1}$)	7.7 ± 6.7	4.6 ± 1.0
Lactate @ 10 km ($mmol \cdot L^{-1}$)	10.0 ± 3.0	7.2 ± 1.2
RER @ 3 km	0.92 ± 0.01	0.98 ± 0.08
RER @ 10 km	0.94 ± 0.01	1.00 ± 0.08
τ @ v1000 (s)	11 ± 7	14 ± 6
$\Delta\dot{V}O_2$6–3min @ vMarathon ($mL \cdot min^{-1}$)	125 ± 250	100 ± 173

$\dot{V}O_2$, HR, Lactate, RER @ 3 km are $\dot{V}O_2$, heart rate, blood lactate concentration, and rate of expiratory ratio at the third kilometer during the 10-km run at vMarathon; $\dot{V}O_2$, HR, Lactate, RER @ 10 km are $\dot{V}O_2$, heart rate, blood lactate concentration, and rate of expiratory ratio at the tenth kilometer during the 10-km run at vMarathon; $\Delta\dot{V}O_2$6–3 min @ vMarathon is the difference (in $mL \cdot min^{-1}$) of rate of oxygen uptake between the sixth and the third minutes during the 10-km run at vMarathon; τ @ v1000 is the time constant (in seconds) of oxygen kinetics during the all-out 1000-m run after the 10-km run at vMarathon.

BILLAT, V. L., A. DEMARLE, J. SLAWINSKI, M. PAIVA, and J.-P. KORALSZTEIN. Physical and training characteristics of top-class marathon runners. Med. Sci. Sports Exerc., Vol. 33, No. 12, 2001, pp. 2089–2097.

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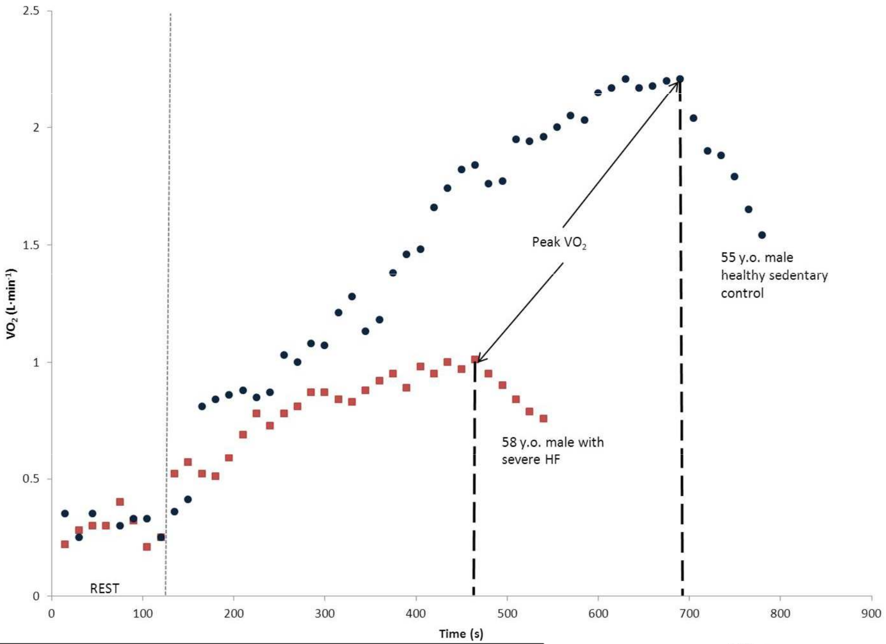

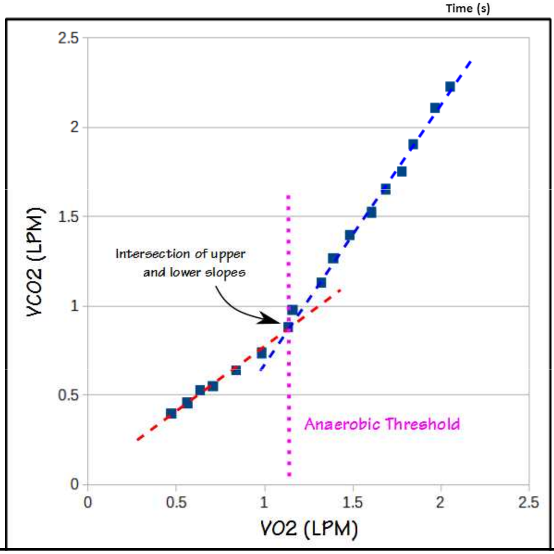

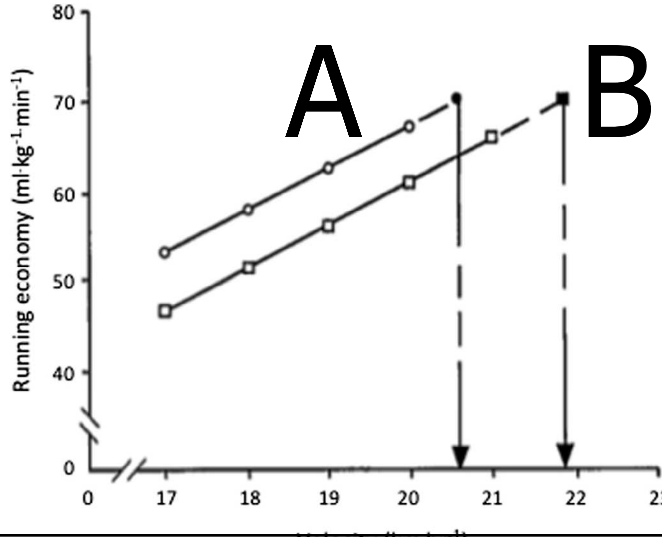

Who is (probably) better?

Barnes, Kyle & Kilding, Andrew. (2015). Running economy: Measurement, norms, and determining factors. Sports Medicine - Open. 1. 10.1186/s40798-015-0007-y.

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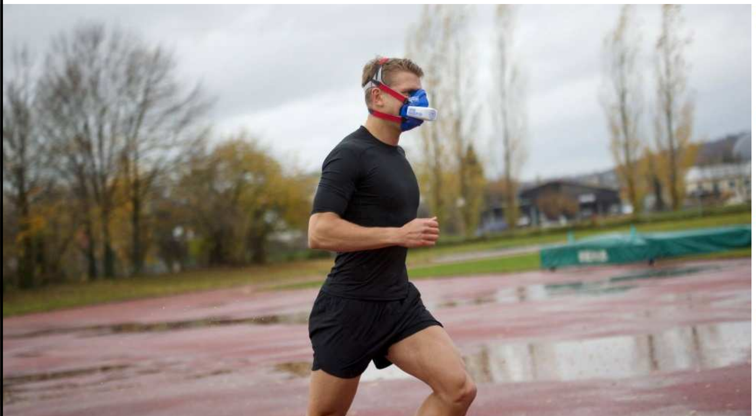
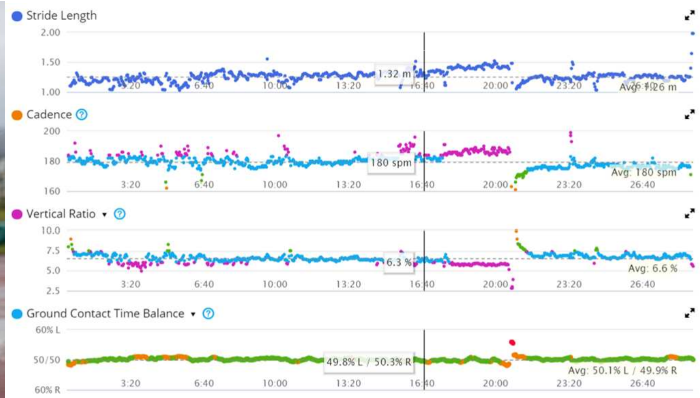
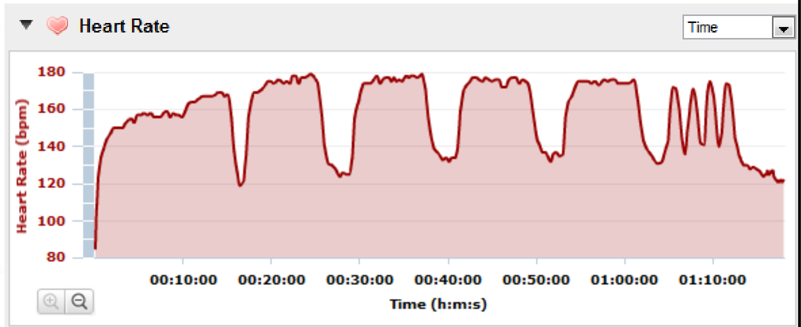
More and more field testing (wearables)

…and more and more data







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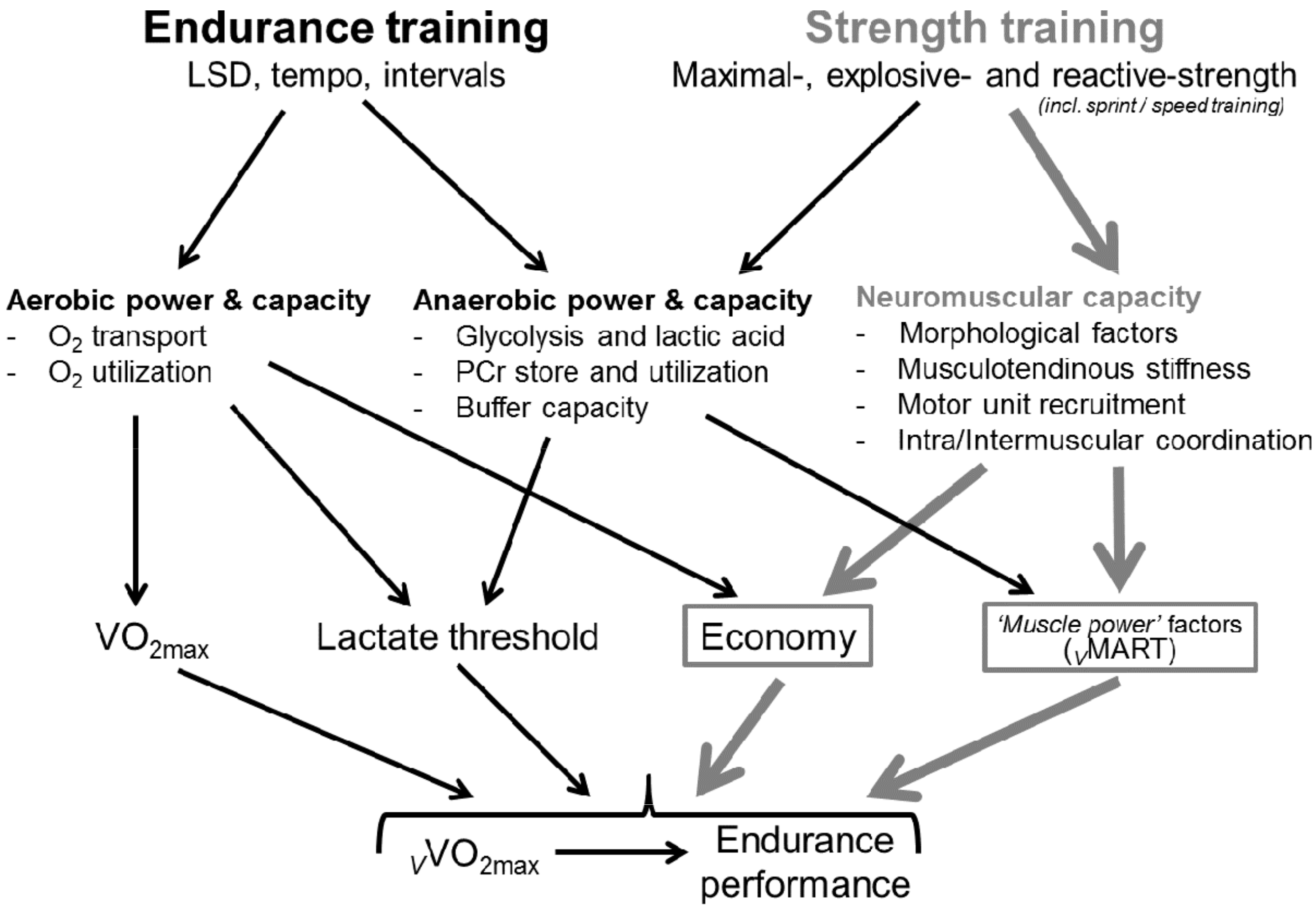

Paavolainen, L.M., Häkkinen, K.K., Hämäläinen, I., Nummela, A., & Rusko, H. (1999). Explosive-strength training improves 5-km running time by improving running economy and muscle power. *Journal of applied physiology, 86 5*, 1527-33 .

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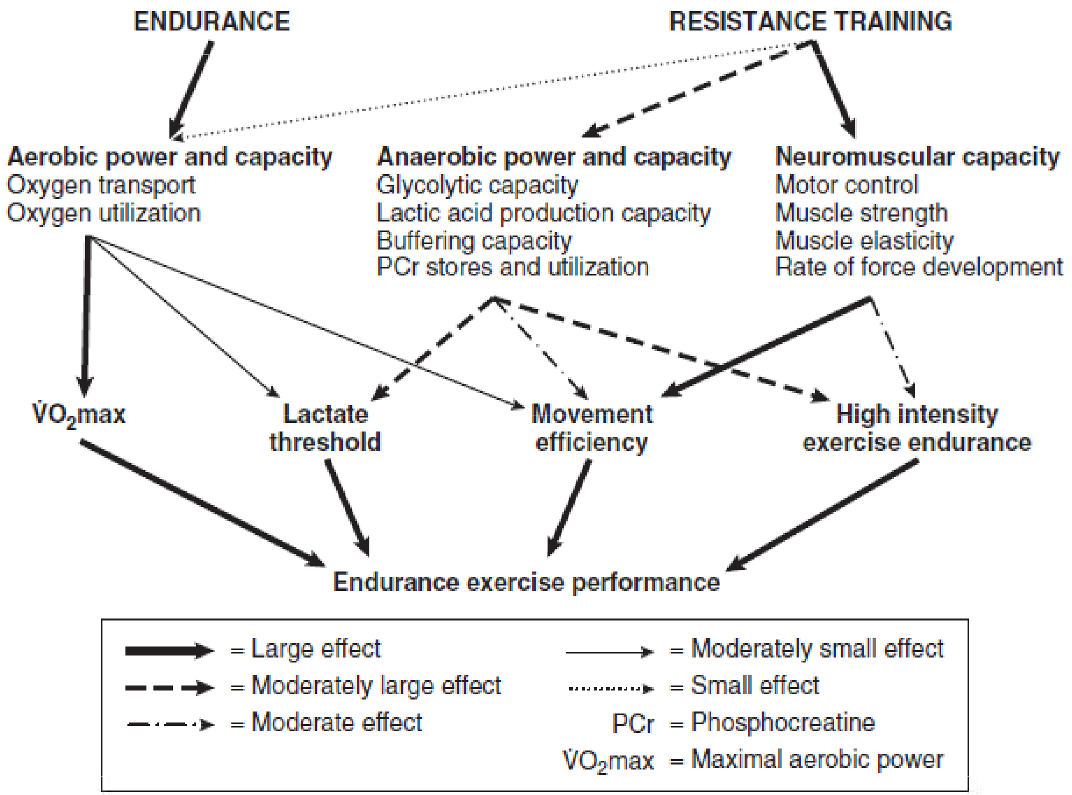

Figure 7.1 The influence of endurance and resistance training on endurance performance.

Adapted, by permission, from L. Paavolainen., K. Häkkinen, I. Hämäläinen, A. Nummela, and H. Rusko, 1999, "Explosive-strength training improves 5-km running time by improving running economy and muscle power," *Journal of Applied Physiology* 86(5): 1527-1533.

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Movement screening

– Contol and mobility during fundamental movement patterns

– Frequency: ongoing in every S&C session
– FMS
– Y balance test
– Arabesque
– Standing rotation

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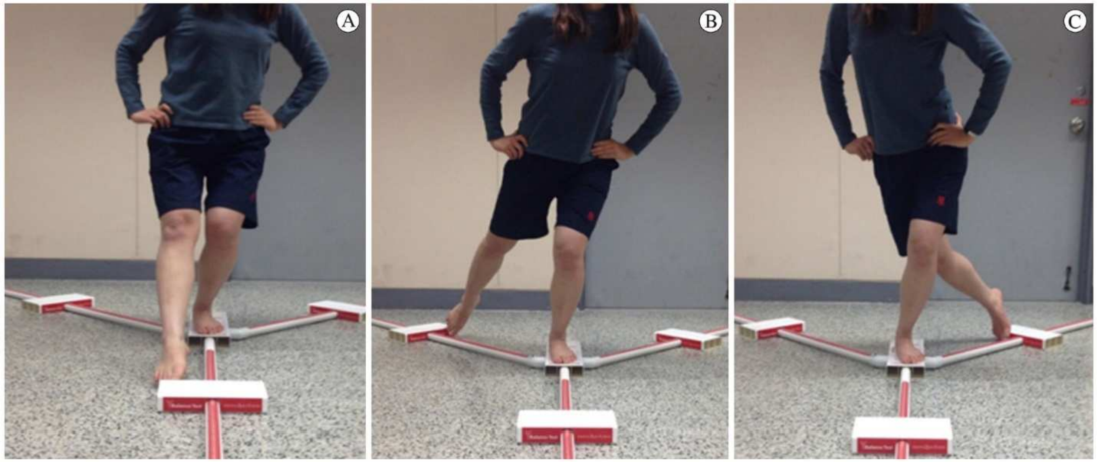
Y balance test (YBT)

Jackson S, Cheng MS, Kolber M, Smith AR. An investigation of relationships between physical characteristics of recreational runners and lower extremity injuries. J Orthop Sports Phys Ther 2016;46(1):A41.



- Score:
  - **Absolute reach distance (cm)** = (Reach 1 + Reach 2 + Reach 3) / 3
  - **Relative (normalised) reach distance (%)** = Absolute reach distance / limb length * 100
  - **Composite reach distance (%)** = Sum of the 3 reach directions / 3 times the limb length * 100
- RightAnterior, LeftA, RPosterioMedial, LPM, RPLateral, LPL

- Between-limb asymmetry, based on composite YBT scores, was significantly greater in injured runners than in their uninjured counterparts. An asymmetry of 3.6% or greater predicted 69.2% of the injuries.

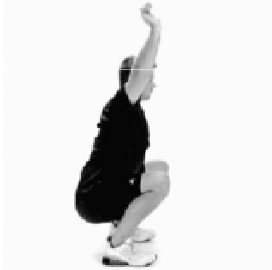
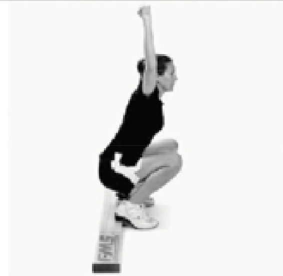
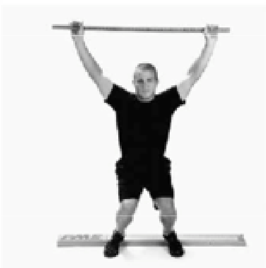
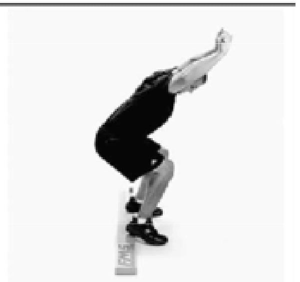
Plisky, P. J., Gorman, P. P., Butler, R. J., Kiesel, K. B., Underwood, F. B., & Elkins, B. (2009). The reliability of an instrumented device for measuring components of the star excursion balance test. *North American journal of sports physical therapy : NAJSPT*, *4*(2), 92–99.

Functional Movement Screen (FMS)

– FMS score = sum of individual tests (worse L/R score)
– Simple, easy, reliable, valid (?)

Smith, C. A. , Chimera, N. J. , Wright, N. J. & Warren, M. (2013). Interrater and Intrarater Reliability of the Functional Movement Screen. Journal of Strength and Conditioning Research, 27(4), 982–987. doi: 10.1519/JSC.0b013e3182606df2.

FMS – Overhead squat

Rating	Reference Photographs	
3		
2		
1		

FMS – Hurdle step


Hurdle Step 3 Front View


Hurdle Step 3 Side View


Hurdle Step 2 Front View


Hurdle Step 2 Side View


Hurdle Step 1 Front View


Hurdle Step 1 Side View

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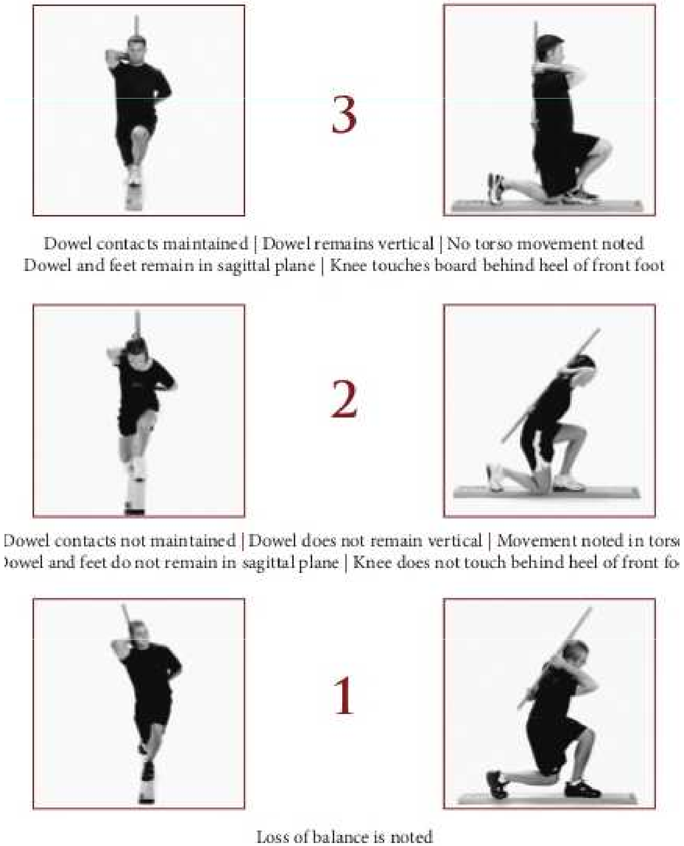
FMS – In-line lunge



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FMS – Shoulder mobility

3

Fists are within one hand length

2

Fists are within one-and-a-half hand lengths

1

Fists are not within one and half hand lengths

The athlete will receive a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

Clearing Test

Perform this clearing test bilaterally. If the individual does receive a positive score, document both scores for future reference. If there is pain associated with this movement, give a score of zero and perform a thorough evaluation of the shoulder or refer out.

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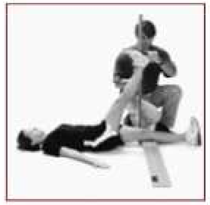
FMS – Active leg raise

3

Vertical line of the malleolus resides between mid-thigh and ASIS
The non-moving limb remains in neutral position

2



Vertical line of the malleolus resides between mid-thigh and joint line
The non-moving limb remains in neutral position

1

Vertical line of the malleolus resides below joint line
The non-moving limb remains in neutral position

The athlete will receive a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

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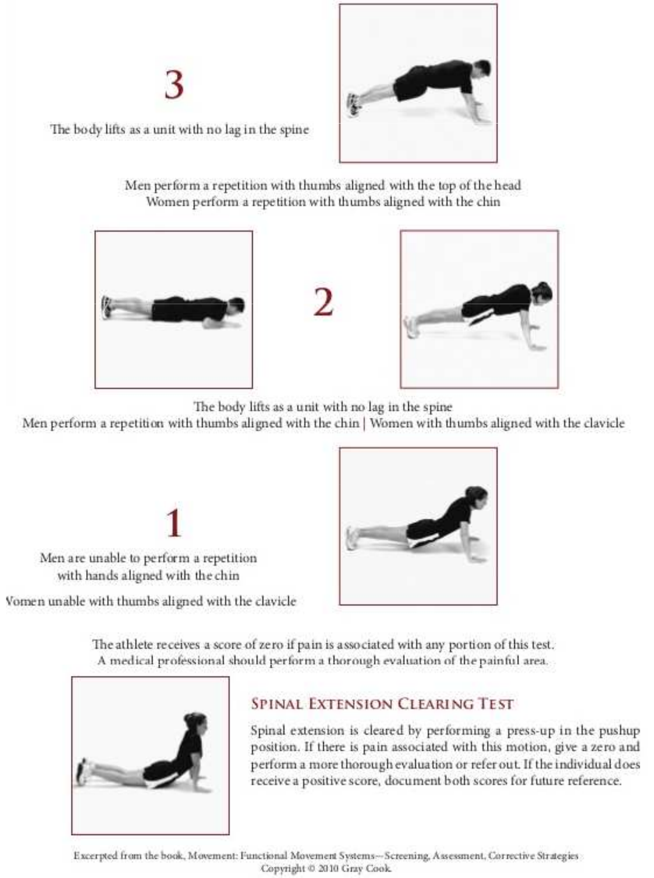
FMS – Trunk stability push-up



3

The body lifts as a unit with no lag in the spine

Men perform a repetition with thumbs aligned with the top of the head
Women perform a repetition with thumbs aligned with the chin

2

The body lifts as a unit with no lag in the spine
Men perform a repetition with thumbs aligned with the chin | Women with thumbs aligned with the clavicle

1

Men are unable to perform a repetition
with hands aligned with the chin

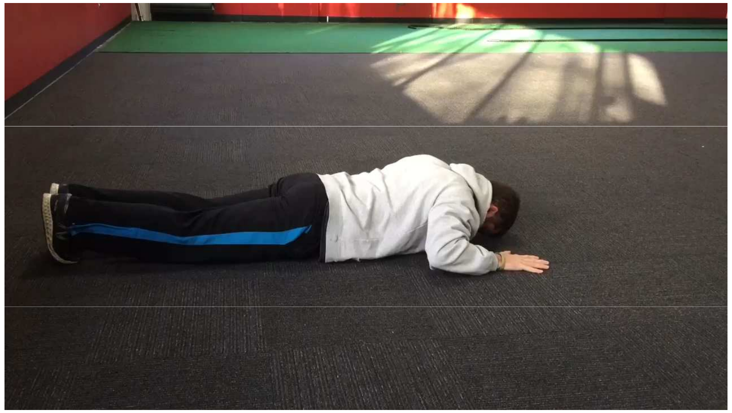
Women unable with thumbs aligned with the clavicle

The athlete receives a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

SPINAL EXTENSION CLEARING TEST

Spinal extension is cleared by performing a press-up in the pushup position. If there is pain associated with this motion, give a zero and perform a more thorough evaluation or refer out. If the individual does receive a positive score, document both scores for future reference.

Excerpted from the book, Movement: Functional Movement Systems—Screening, Assessment, Corrective Strategies
Copyright © 2010 Gray Cook.



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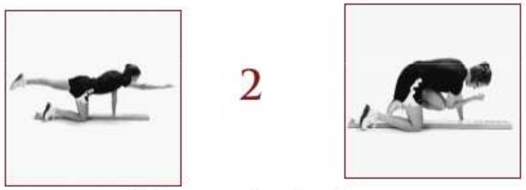
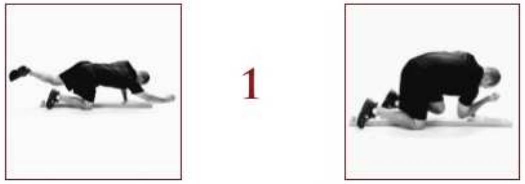
FMS – Rotary stability

Performs a correct unilateral repetition



Performs a correct diagonal repetition



Inability to perform a diagonal repetition

The athlete receives a score of zero if pain is associated with any portion of this test. A medical professional should perform a thorough evaluation of the painful area.

Spinal Flexion Clearing Test

Spinal flexion can be cleared by first assuming a quadruped position, then rocking back and touching the buttocks to the heels and the chest to the thighs. The hands should remain in front of the body, reaching out as far as possible. If there is pain associated with this motion, give a zero and perform a more thorough evaluation or refer out. If the individual receives a positive score, document both scores for future reference.

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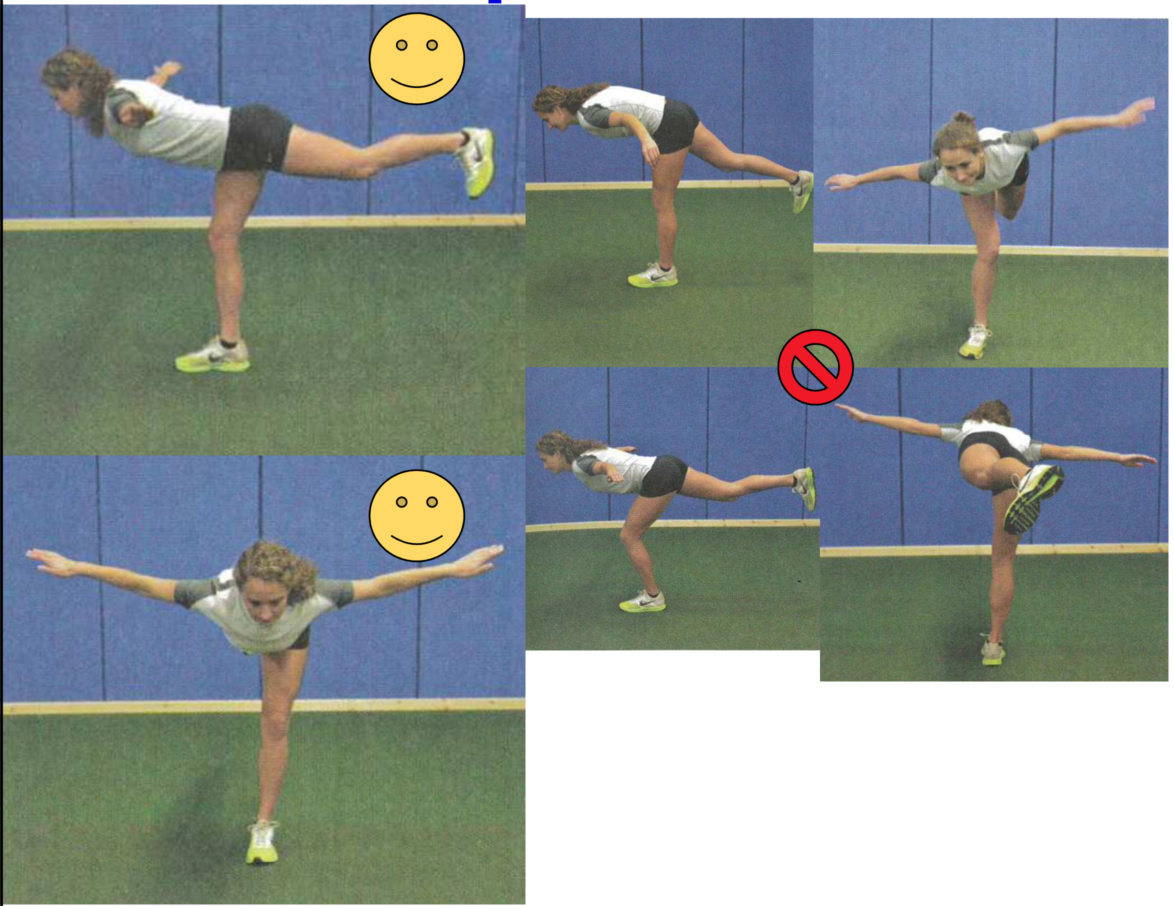
Arabesque



- Ability to hinge from the hips
- ROM
- Unilateral balance and control

- Errors:
  - Poor posture
  - Excessive knee bend on support leg
  - Lack of ROM
  - Shoulder-hip-ankle misalignment
  - Lack of balance and control

Standing rotation

– Ability to lock the pelvis to the ribcage during roation movement
– IR range of movement in the hip
– Ability to pronate and supinate at the foot

– Errors:
  – Lack ROM on one or bothe sides
  – Torso is twisted
  – Knee doesn‘t rotate with the pelvis
  – Opposite foot doesn‘t roll inwards
  – Nearsite foot doesnt‘t roll outwards

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Hop and stick

- Eccentric control at the knee and hip
- Ability to maintain posture during explosive movement
- Relative hip and knee dominance when generating and controlling force

- Errors:
  - Ankle-knee-hip misalignment
  - Excessive flexion on landing
  - Torso is too upright or thrown forward on takeoff and/landing
  - Poor posture
  - Lack of balance on landing

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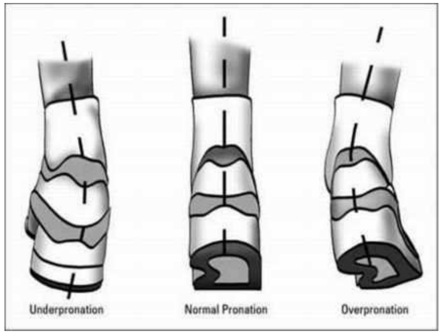
FMS, YBT – Houston, we have a problem…

- neither the FMS (CS, presence of pattern asymmetry, and low score on an individual test) nor YBT (asymmetry and CS) are associated with lower extremity injury risk in high school athletes (*football, lacrose, basketball*). These findings have practical application for athletic trainers and strength and conditioning professionals tasked with conducting preseason injury risk assessments in, and developing foundational training programs for, high school athletes. The authors support the use of FMS and YBT to identify deficiencies in functional movement patterns and dynamic balance from which targeted interventions can be implemented. An important goal of a strength and conditioning program is to improve the performance of key movement patterns (i.e., adding strength, power, speed, and agility). The development of better quality in these movement patterns is crucial to the efficacy of the overal program.

Lisman, P. , Hildebrand, E. , Nadelen, M. & Leppert, K. (9000). Association of Functional Movement Screen and Y-Balance Test Scores With Injury in High School Athletes. Journal of Strength and Conditioning Research, Publish Ahead of Print,doi: 10.1519/JSC.0000000000003082.

Running gait & posture

Phase	Early swing	Late swing	Stance
Technical markers	• Hip flexors contract to bring thigh through rapidly • Heel recovers tight to buttock • Torso upright, shoulders over hips • Minimal rotation through trunk • Extended chest position • Neutral lower back	• Hip of swing leg higher than stance side • Toe tight to shin as leg drops • Foot drops down and backwards directly underneath body • Relaxed arm swing from shoulders	• Foot lands on outside edge (supinated) • Foot strike under or slightly ahead of body • Slight flexion at knee and ankle (hips high) • Ankle–knee–hip alignment • Hip extends powerfully • Lower back held neutral in late stance



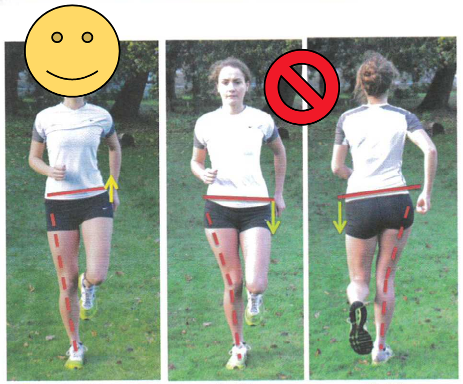


Fig. 3.9 Fig. 3.10 Fig. 3.11

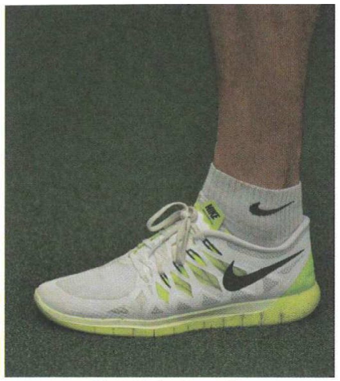


Fig. 3.13: Flat foot strike.

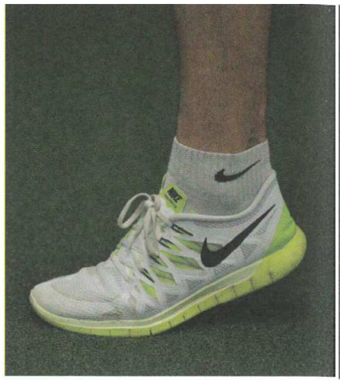


Fig. 3.14: Forefoot strike.


Fig. 3.12: Heel strike.

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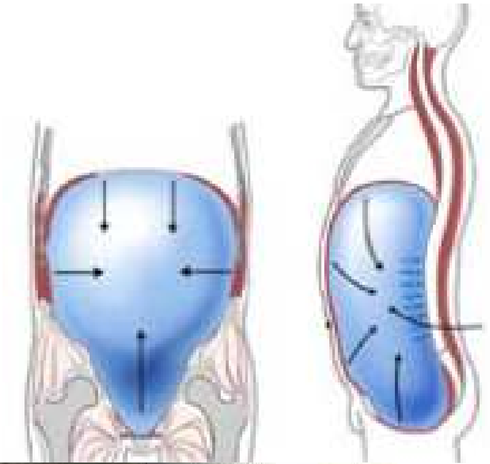
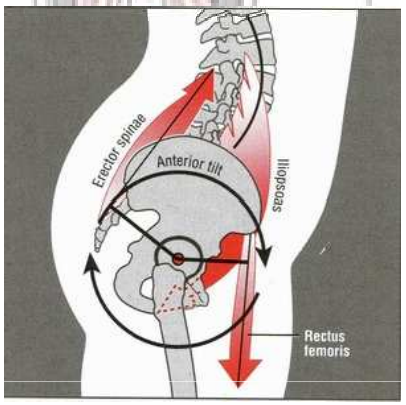
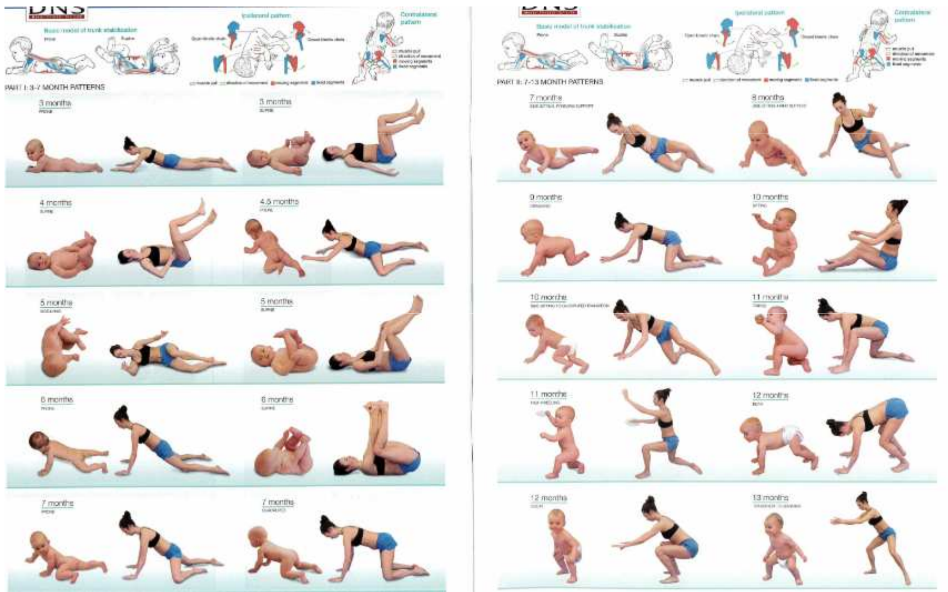
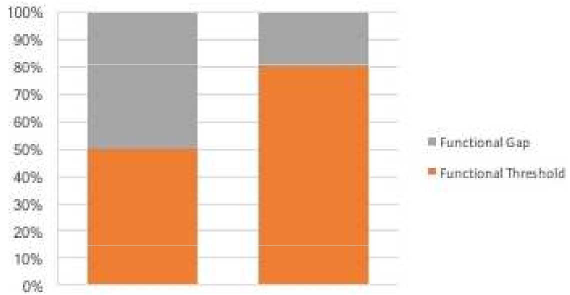
Dynamic neuromuscular stabilization









- Key principles:
  - Diaphragm = respiration + stabilization
  - Joint centration
  - Isolated leg/arm movement
  - Foot activation
  - Functional capacity
  - Excercises in developmental positions

Frank, Clare & Kobesova, Alena & Kolář, Pavel. (2013). Dynamic neuromuscular stabilization & sports rehabilitation. International journal of sports physical therapy. 8. 62-73.

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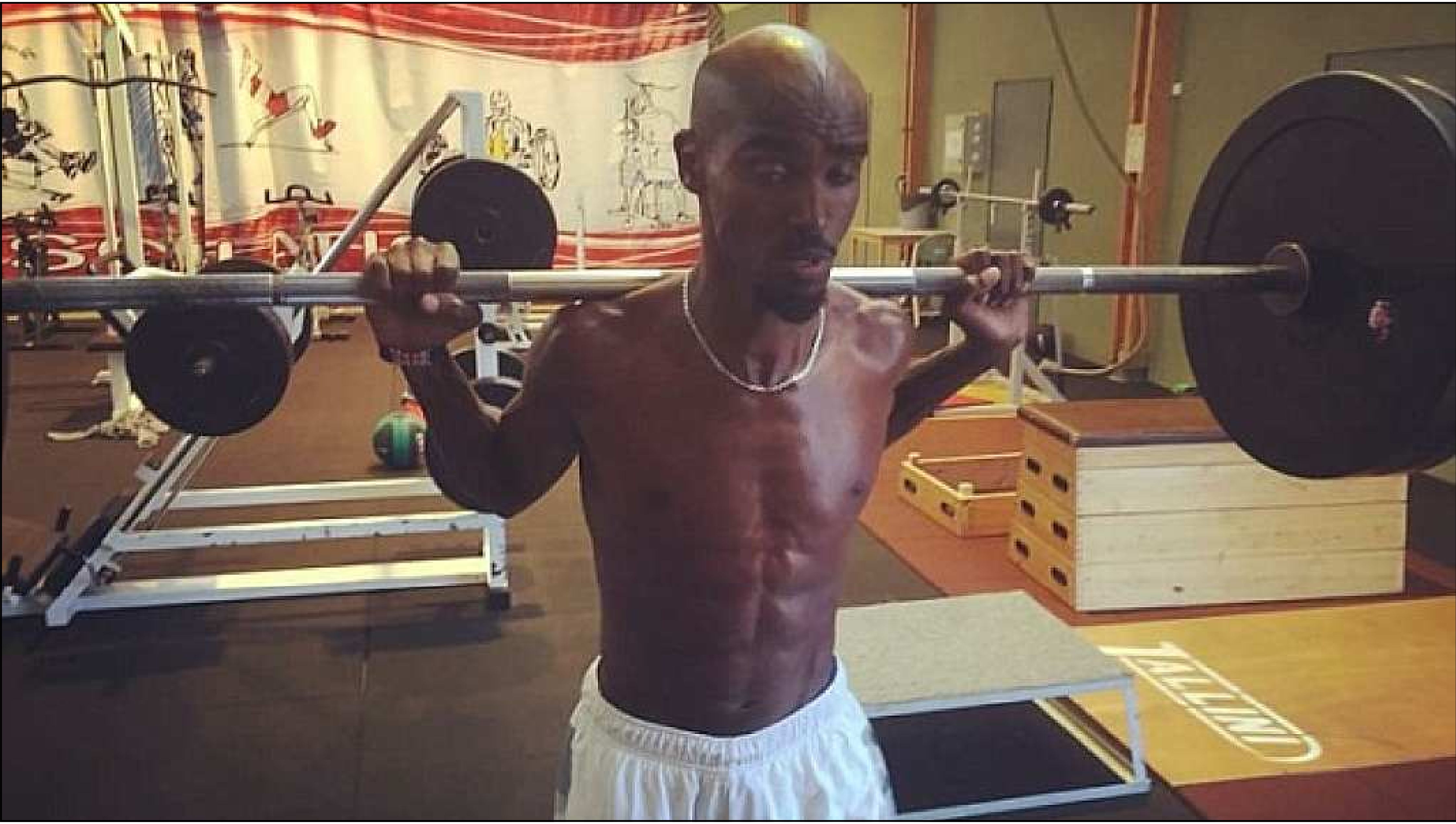

Strength diagnostics

- Maximum strength
- Explosive strength
- Plyometric qualities

- Frequency: weekly

https://www.runnersworld.com/news/a20794927/thats-not-fat-how-ryan-hall-gained-40-pounds-of-muscle/

Strength diagnostics

– Vertical jump
– Re-bound jump from 30 cm – RSI = fly time / con
  (sometimes cm / s)
– Hop and stick distance (unilateral!)
– 1RM
  – Directly X undirectly?
  – Squat? Leg press?
  – Deadlift? SL DL?

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40e édition

Capacity tests

- Capacity of specific muscles and tissues around joints susceptible to injury
- Frequency: indirectly and directly every 3-6 months
- Single calf raise (> 30 reps)
- SL hamstring bridge (> 30 reps)
- Press ups (> 40 reps)
- Prone extension (> 180 sec)
- Side plank (> 120 sec)
- Double leg hold (> 120 sec)

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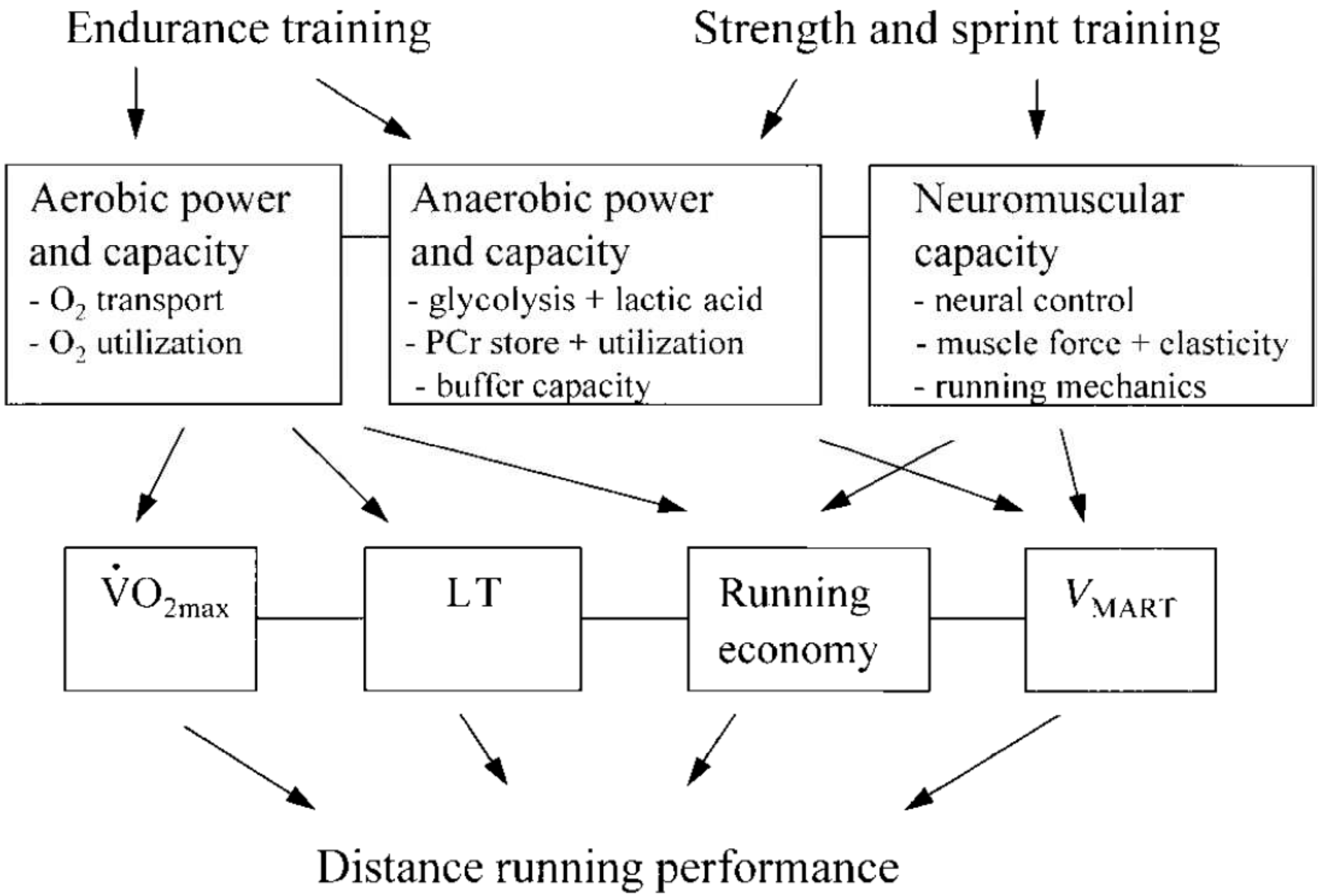
…almost at the finish!

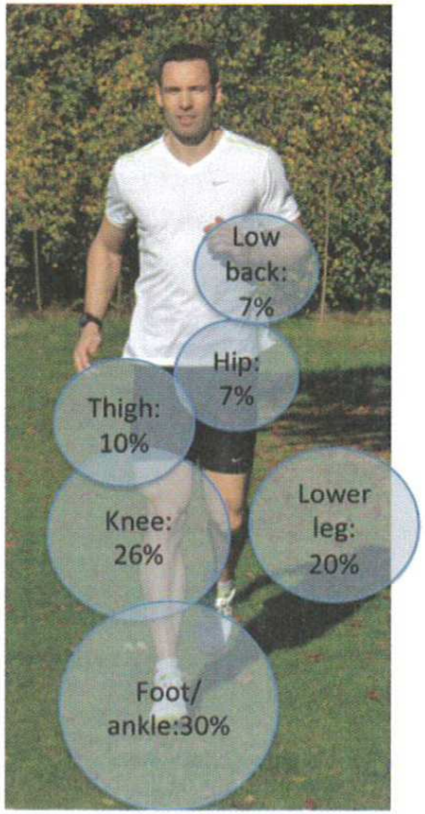
It makes perfect sense, right?



This is the (another) reason why we are doing it

Characteristic of RRI	n (%)	Duration of RRI in wks mean (SD)	Lost training sessions/wk mean (SD)	Pain intensity mean (SD)
Type				
Muscle strain/rupture/tear	25 (30)	3.6 (2.7)	4.3 (2.9)	5.8 (2.0)
Low back pain	12 (14)	2.4 (0.8)	1.6(1.0)	5.2 (2.5)
Tendinopathy	10(12)	4.0 (2.1)	2.8 (2.0)	6.0 (2.0)
Plantar fasciitis	7(8)	4.7 (3.5)	5.7 (5.5)	5.8 (2.5)
Meniscal or cartilage damage	6(7)	3.2 (1.8)	4.0 (5.0)	3.6 (2.4)
Contusion/haematoma/ecchymosis	4(5)	2.5 (1.0)	4.6 (2.3)	6.4(1.8)
Intense spasm or severe cramp	3(4)	2.0 (0.0)	3.8 (4.2)	4.8 (2.2)
Sprain (injury of the joint and/or ligaments)	2(2)	3.0(1.4)	3.3 (2.3)	3.7 (0.6)
Stress fracture (overload)	2(2)	4.0 (0.0)	3.8 (4.2)	7.8(1.5)
Arthritis/synovitis/bursitis	1(1)	2.0[a]	2.0[a]	9.0[a]
Dislocation, subluxation	1(1)	2.0[a]	3.0[a]	3.0[a]
Patellar chondromalacia	1 (1)	12.0[a]	3.7(1.4)	8.7 (0.8)
Not identified	10 (12)	3.3 (1.8)	4.4 (3.3)	3.9 (2.2)

Characteristic of RRI	n (%)	Duration of RRI in wks mean (SD)	Lost training sessions/wk mean (SD)	Pain intensity mean (SD)
Anatomical location				
Knee	16 (19)	4.3 (3.0)	4.2 (3.3)	4.9 (2.7)
Foot/toes	14(17)	3.7 (2.7)	4.5 (4.4)	5.6 (2.4)
Leg	12 (14)	4.0 (3.1)	3.9 (2.1)	5.5 (2.2)
Lumbar spine	12 (14)	2.5 (0.9)	1.8(1.0)	5.6 (2.4)
Thigh	12(14)	2.5 (1.2)	3.4 (3.1)	5.9 (1.9)
Ankle	6(7)	2.7 (1.0)	2.4(1.8)	5.3 (2.6)
Hip/groin	5(6)	4.0 (3.5)	6.8 (4.0)	7.3(1.4)
Achilles tendon (calcaneal)	3(4)	4.7 (1.2)	1.7(1.7)	6.1 (2.1)
Cervical spine	2(2)	3.0(1.4)	4.3 (4.2)	4.7 (3.1)
Pelvis/sacrum/buttocks	2(2)	7.0 (4.2)	4.6(1.1)	5.4(1.5)



Hespanhol Junior, Luiz & Costa, Leonardo & Lopes, Alexandre. (2013). Previous injuries and some training characteristics predict running-related injuries in recreational runners: A prospective cohort study. Journal of physiotherapy. 59. 263-269. 10.1016/S1836-9553(13)70203-0.

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…and of course

– Building stronger, faster and more resilient runners.
– Runners shouldn‘t be afraid about being bulky, they should be afraid about being weak!

Paavolainen, L.M., Häkkinen, K.K., Hämäläinen, I., Nummela, A., & Rusko, H. (1999). Explosive-strength training improves 5-km running time by improving running economy and muscle power. *Journal of applied physiology, 86 5*, 1527-33 .

Blagrove RC, Howe LP, Cushion EJ, Spence A, Howatson G, Pedlar CR, Hayes PR. Effects of Strength Training on Postpubertal Adolescent Distance Runners. Med Sci Sports Exerc. 2018 Jun;50(6) 1224-1232. doi:10.1249/mss.0000000000001543. PMID: 29315164.

… & hundreds more!

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Thank you for you attantion!

Q&A

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