Instability Resistance Training

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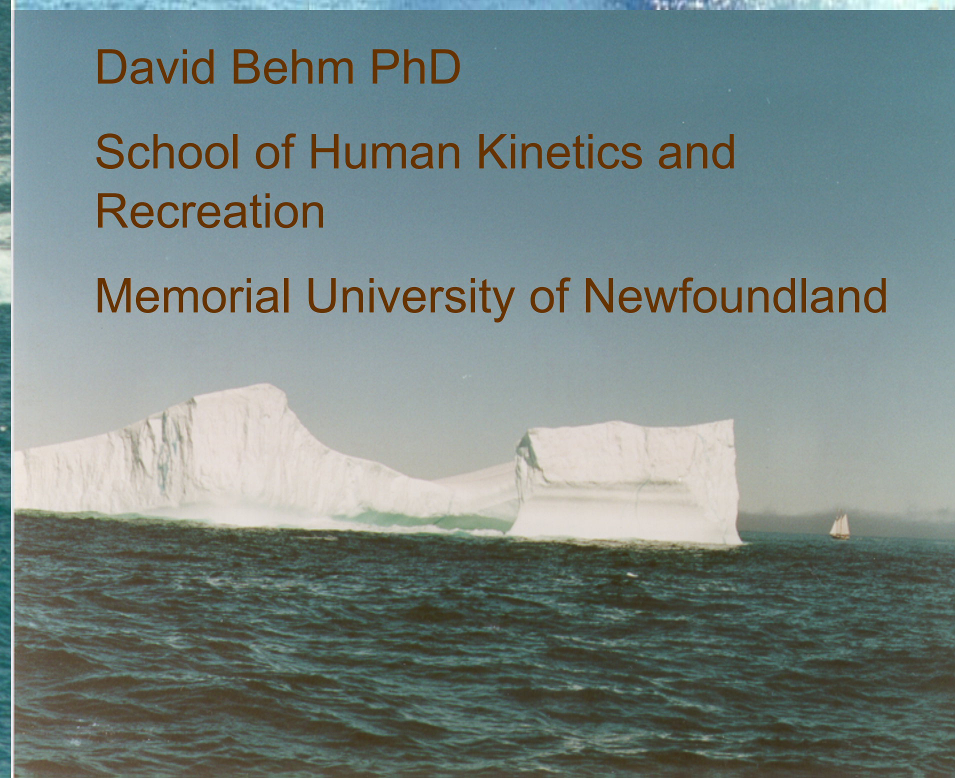


Platform or Base Instability

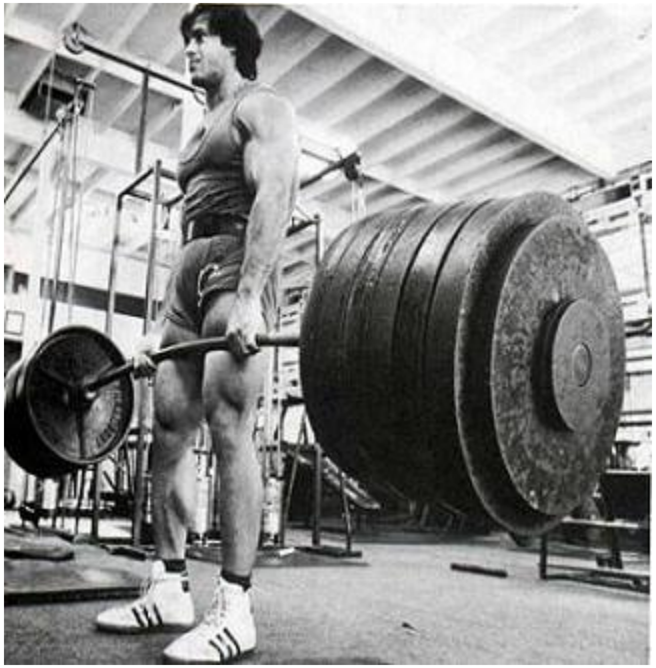
Device or Implement Instability

Postural Instability

Bulgarian Squat

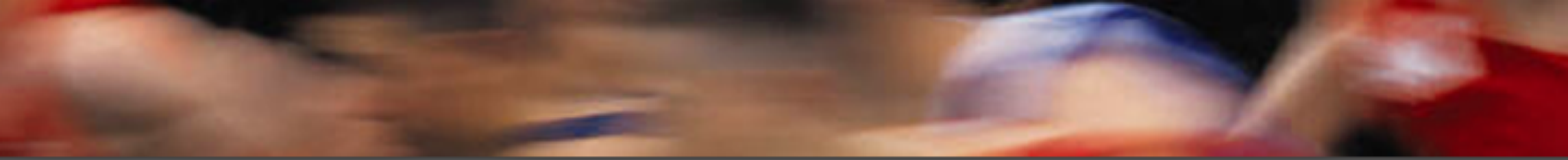
Proponents: Training Specificity

Opponents: Core stability is inherent with heavy traditional closed chain training.



Willardson 2004 (SCJ)

"the optimal method to promote increases in balance for any given sport is to practice the skill itself on the same surface on which the skill is performed in competition"



Canadian Society for Exercise Physiology (CSEP)
Children Resistance Training (RT)
Position Stand (Behm et al. 2008)

- Exercises that require **balance** should also be incorporated into **youth RT programs** since balance is essential for **optimal performance** and the **prevention of athletic injuries**.

- Given that **balance and coordination are not fully developed in children** (Payne and Isaacs 2005), balance training may be particularly **beneficial for reducing the risk of injury while performing RT**, particularly to the lower back.

Balance Training Effects on Balance

Table 2: Sample of Studies Examining the Effect of Balance Training on Balance and Stability

Authors(s)/Year	n	Intervention	% change	Effect Size
Tsang et al. 2003	42	Comparison of static standing and limits of stability tests for maximum excursion between elderly control and Tai Chi subjects	13%	1.09
Stanton et al. 2004	18	Swill ball training (6 weeks) on Sarhmann test of core stability	450%	2.88
Bruhn et al. 2004	33	Sensorimotor training on postural stabilisation	6.8%	0.1
Li et al. 2004	188	Functional balance measures on the Berg balance scale with 12 month study period	7.90%	-
Gioftsidou et al. 2006	13	Balance training (12 weeks) on Instability index	51%	1.11
Kean et al. 2006	24	Static balance time with fixed foot balance training	9.50%	0.57
Yaggie et al. 2006	36	Balance training effects on balance	68.5%	1.43
Nagy et al. 2007	19	8 week balance training on anteroposterior path of elderly	1.30%	0.18
		8 week training on mediolateral sway path of elderly	30.00%	4.17
Spennewyn 2008	30	Balance outcomes in fixed resistance equipment	49%	-
		Balance outcomes in free form resistance equipment	245%	-
Panics et al. 2008	20	Pproprioception training on knee joint position	170.90%	-
Sato et al. 2009	20	Core Strength training on Star Excursion balance	11	0.82
Schilling et al. 2009	19	Comparisons of activity-specific balance confidence pre and post intervention	4.10%	0.96
Kibele & Behm 2009	40	7 weeks of instability training and traditional resistance training on balance using a wobble board: pr	4.40%	1.5
Kibele & Behm 2009	40	7 weeks of instability training and traditional resistance training on balance using a balance beam	14.70%	0.67
Granacher et al. 2011	30	Balance training on postural sway in 6-7 year olds	7.80%	0.21
		Balance training on CMJ with 6-7 year olds	5.90%	0.32

Balance Training Effects on Balance

Table 2: Sample of Studies Examining the Effect of Balance Training on Balance and Stability

Authors(s)/Year	n	Intervention	% change	Effect Size
Granacher et al. 2011	32	Combined balance & strength training on center of pressure displacement in middle-aged adults	11.70%	0.42
Ogaya et al. 2011	23	Wobble board training (9 weeks) in the elderly: standing on the wobble board	113%	1.17
Muelbauer et al. 2011	20	Center of pressure: Firm ground, eyes open vs foam ground, eyes open for two-legged stance	65.20%	2.71
		Center of pressure: Firm ground, eyes open vs foam, eyes open for step stance condition	32.10%	1.71
		Center of pressure: Firm ground, eyes open vs foam, eyes open for tandem stance condition	26.30%	1.2
		Center of pressure: Firm ground, eyes open vs foam, eyes open for one-legged stance condition	28.60%	1.64
Total	**647**	**Means**	**105%**	**1.243**

Can’t Shoot A Cannon from a Canoe

Behm et al. 2004 (JSCR)

significant positive correlation (0.65) between maximum hockey skating speed and static balance test in hockey players under 17 years

Kean, Behm and Young 2006 (JSSM)

- 5 weeks of static balance training in recreationally active subjects resulted in 33% ↑ in static balance and 9% ↑ in vertical jump height

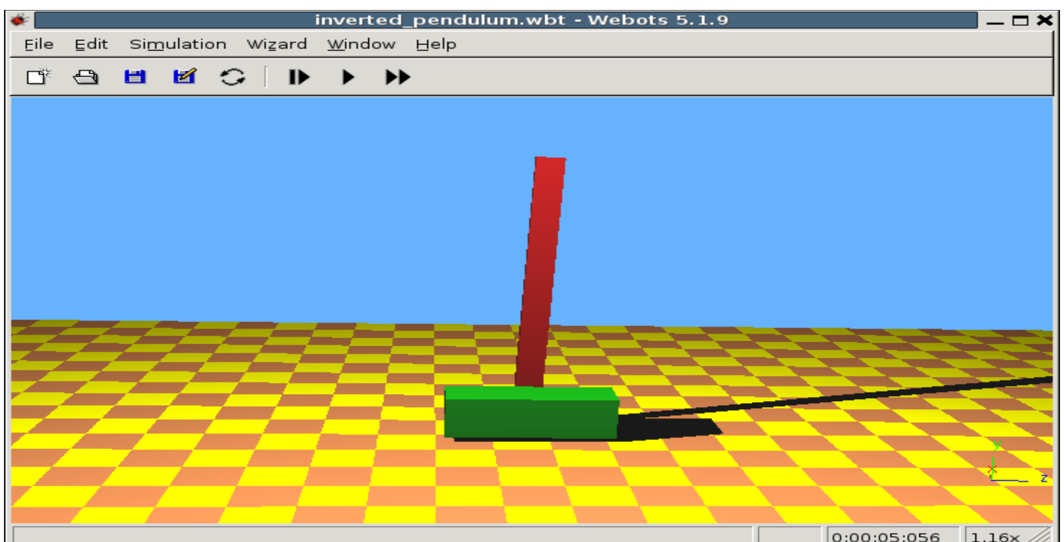
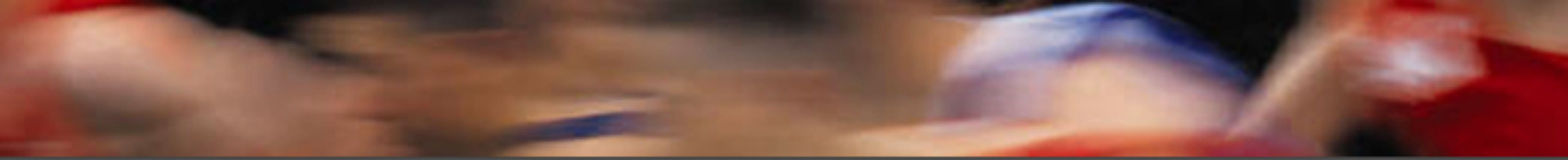


Table 3: Sample of Studies Examining the Effect of Balance Training on Functional Measures

Authors(s)/Year	n	Intervention	% change	Effect Size
Myer et al. 2006	11	Dynamic stabilization and balance training on vertical jump	9.30%	0.75
		Dynamic stabilization and balance training on hamstrings torque	17.40%	0.89
Kean et al. 2006	7	Fixed foot balance training on CMJ height	9.50%	0.57
Yaggie et al. 2006	36	Balance training effects on vertical jump	-0.05%	0.02
		Balance training effects on shuttle run time	3%	0.27
Taube et al. 2007	23	Vertical ground reaction force following sensorimotor training	14.9%	1.01
Oliver et al. 2009	8	Functional balance training in collegiate women volleyball athletes on single leg squats (right)	80.9%	-
		Functional balance training in collegiate women volleyball athletes on single leg squats (left)	141.7%	-
		Functional balance training in collegiate women soccer athletes on single leg squats (right)	32.8%	-
		Functional balance training in collegiate women soccer athletes on single leg squats (left	4.7%	-
Total	**85**	**Means**	**31.43%**	**0.585**



Instability vs. stability training

(Sparkes and Behm 2010 JSCR) (Kibele and Behm 2009 JSCR)

- Untrained individuals were involved in 8 weeks (Sparkes and Behm 2010) or 7 weeks (Kibele and Behm 2009) of either traditional stable or instability resistance training.

- Kibele and Behm used only upper body exercises,
- Sparkes and Behm used full body

- All measures improved over time for both groups

- Sparkes: Even static balance ↑ similarly between groups. Trend (p=0.08) for the unstable group to increase unstable forces to a greater extent

  Kibele: No differences in strength, balance, long jump, shuttle run or sprint between groups

Effect of Instability Resistance Training on Performance

Table 4: Sample of Studies Examining the Effect of Instability Training on Performance Measures

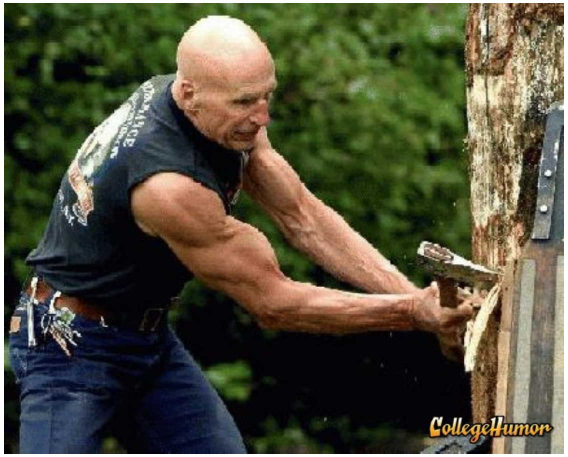
Authors(s)/Year	n	Intervention	% change	Effect Size
Stanforth et al. 1998	20	10 week resistaball training study on double leg lowering	49.60%	1.17
		10 week resistaball training study on cybex back extension	156.20%	1.98
		10 week resistaball training study on cybex abdominal	94.80%	1.09
Bruhn et al. 2004	33	Sensorimotor training on MVC	6.7%	0.21
		Sensorimotor training on squat jump height	4.6%	0.21
Tsimaras et al. 2004	15	Muscle strength and dynamic balance ability training at 300 deg/s	20%	0.68
		Muscle strength and dynamic balance ability training at 60 deg/s	13.60%	0.41
Bruhn et al. 2005	18	Strength training & sensorimotor training on muscle strength on development of bilateral 1 RM	37.00%	1.11
Carter et al. 2006	20	Stability ball training on static back endurance	30.30%	0.7
		Stability ball training on side bridge test	5.70%	0.52
Gruber et al. 2007	33	Sensorimotor training on MVC	0.53%	0.05
Cowley et al. 2007	14	Instability training using stability ball platform on 1RM strength during barbell chest press exercise	15.50%	3.1
		Instability training using flat bench platform on 1RM strength during barbell chest press exercise	17.40%	3.8
Thompson et al. 2007	18	Club Head speed results in older golfers after functional training	4.90%	0.53
Cressey et al. 2007	19	10 weeks lower body unstable surface training on Bounce drop jump power	0.8%	0.11
		10 weeks of lower body unstable surface training on CMJ power	0.0%	0
		10 weeks of lower body unstable surface training on 40 yard sprint time	1.8%	0.82
		10 weeks of lower body unstable surface training on T-test times	2.9%	1.33

Table 4: Sample of Studies Examining the Effect of Instability Training on Performance Measures

Authors(s)/Year	n	Intervention	% change	Effect Size
Cowley et al. 2007	14	Instability resistance training on 1 RM strength during barbell chest-press on a stability ball	15%	3.06
		Instability resistance training work capacity during barbell chest-press on a stability ball	27%	3.02
Kibele et al. 2009	40	7 weeks of instability training and traditional resistance training on strength during leg extension	9.50%	0.32
		7 weeks of instability training and traditional resistance training on shuttle run time	20%	0.2
Sekendiz et al. 2010	21	Swiss ball core strength training on trunk flexor strength	28.50%	1.19
		Swiss ball core strength training on trunk extensor strength	23.60%	0.92
		Swiss ball core strength training on lower limb extensor strength	8.50%	0.44
		Swiss ball core strength training on lower limb flexor strength	36.50%	1.66
Sparkes & Behm 2010	18	Instability resistance training (8 weeks) on MVIC unstable / stable force ratio	21%	1
		Instability resistance training (8 weeks) on CMJ	5.7%	1
		Instability resistance training program (8 weeks) on MVIC forces	23.6%	0.44
Saeterbakken et al. 2011	24	Core stability training on throwing velocity in female handball players	4.90%	0.2
Granacher et al. 2011	32	Combined balance & strength training on CMJ in middle-aged adults	4.10%	0.22
		Combined balance & strength training on plantar flexors MVC in middle-aged adults	19.30%	0.59
		Combined balance & strength training on plantar flexors isokinetic force in middle-aged adults	16.50%	0.49
Total	**339**	**Means**	**22.0%**	**0.98**

"Old Man Strength"

- When competing; who gets the ball or puck between a typical
- 27 year old, 80 kg athlete vs.
- 17 year old, 80 kg athlete
- (with similar lean body mass)?



- Why?
- Better balance, stability and coordination

Improve balance : improve strength at any age!

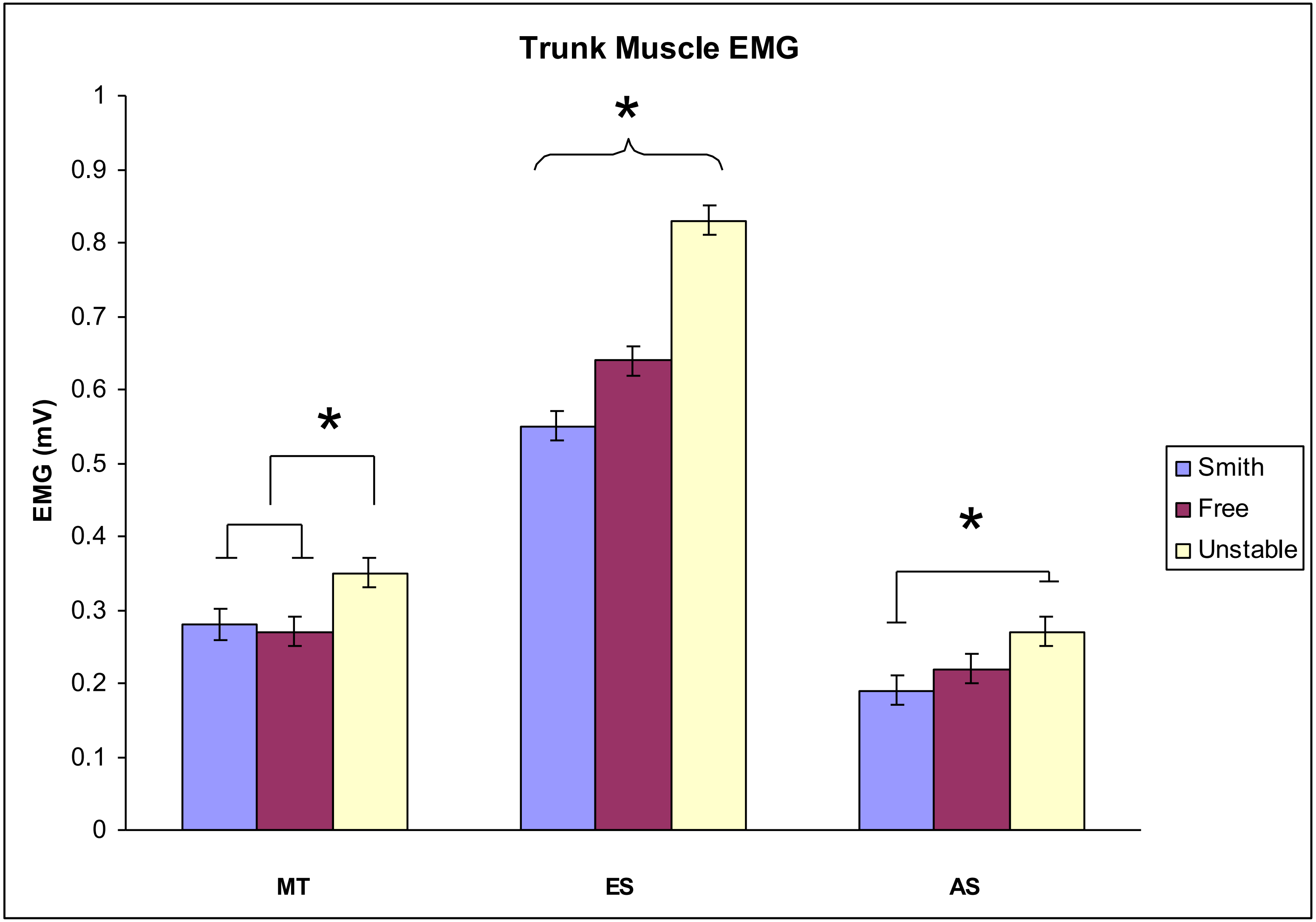
Unstable Squats: Trunk/ Core Activation

Anderson and Behm 2004b (CJAP)

- Study examined unstable vs. stable squats

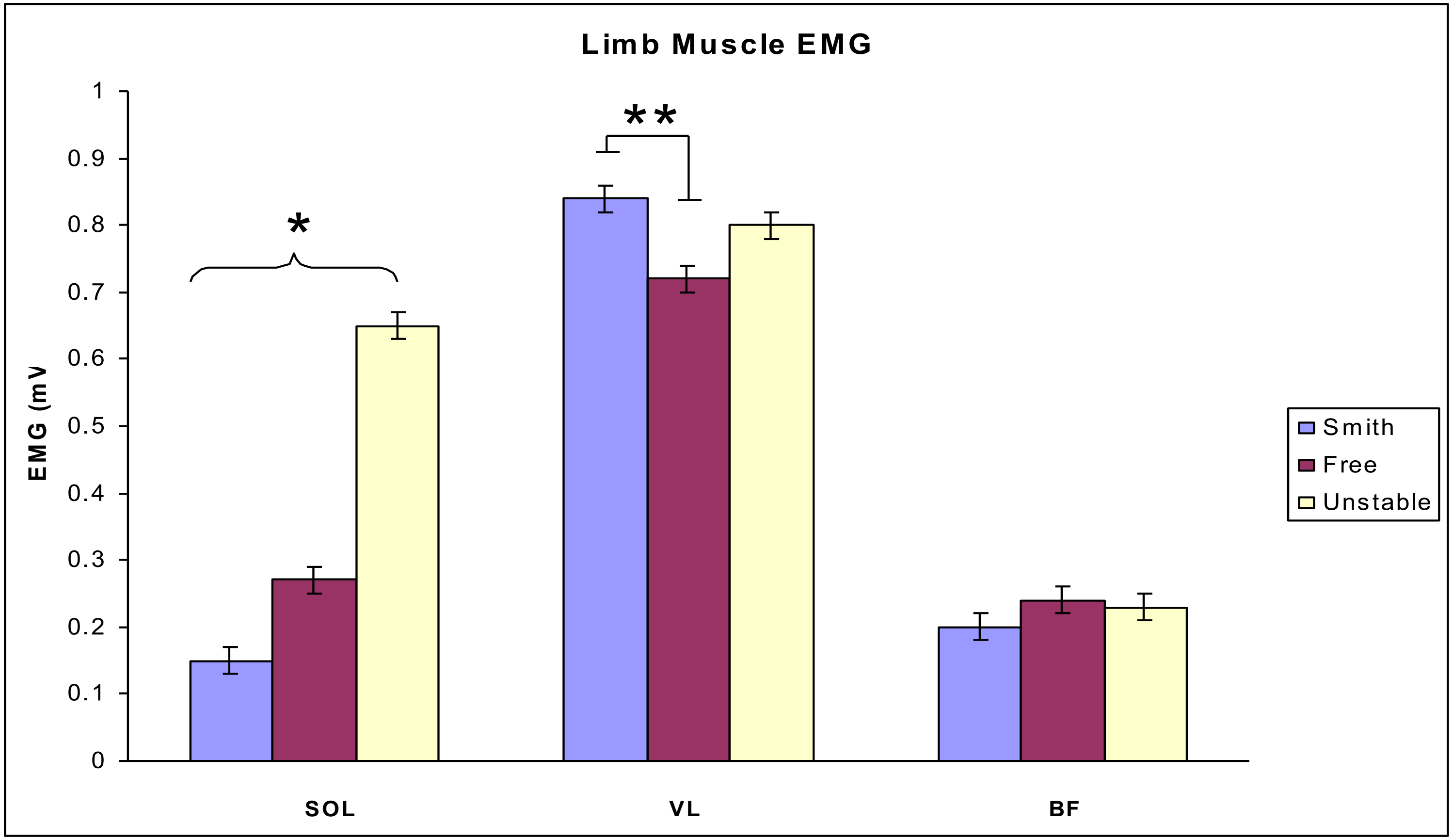
(using body mass, 65 lbs, 60% of body mass)

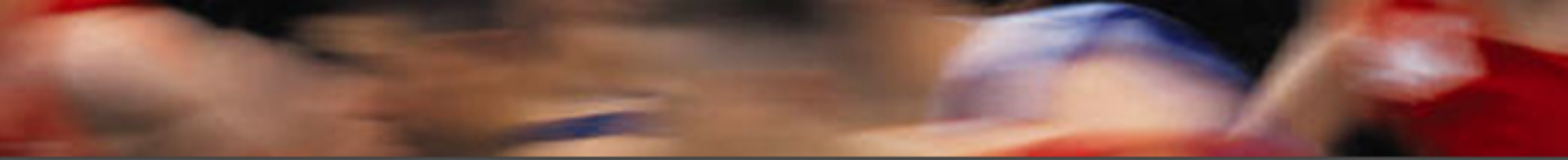
Increased instability leads to increased activation of trunk stabilizers



No major changes in thigh muscle EMG with instability

Soleus (postural muscle) showed greater activation with instability





Unstable Callisthenic Exercises

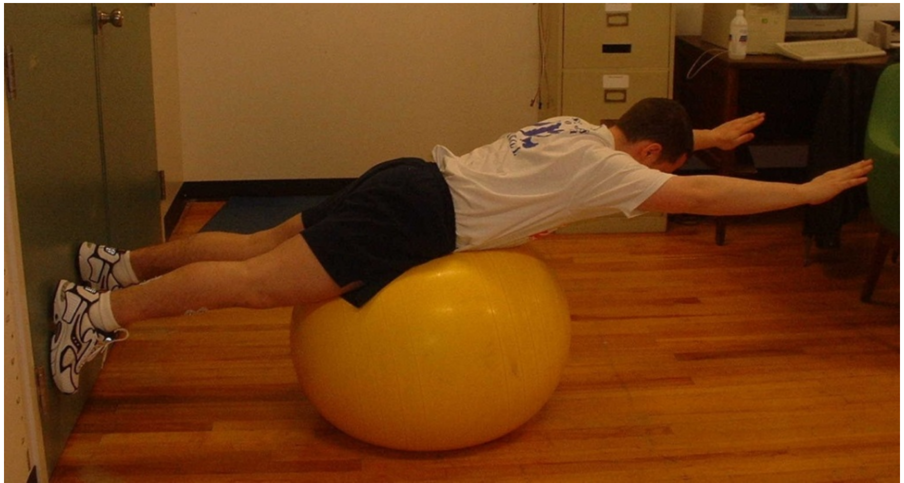
(Behm et al. 2004 JSCR)

Study examined a number of common rehab exercises for the back under stable and unstable conditions

Instability provided greater trunk muscle activation overall (27-54%)



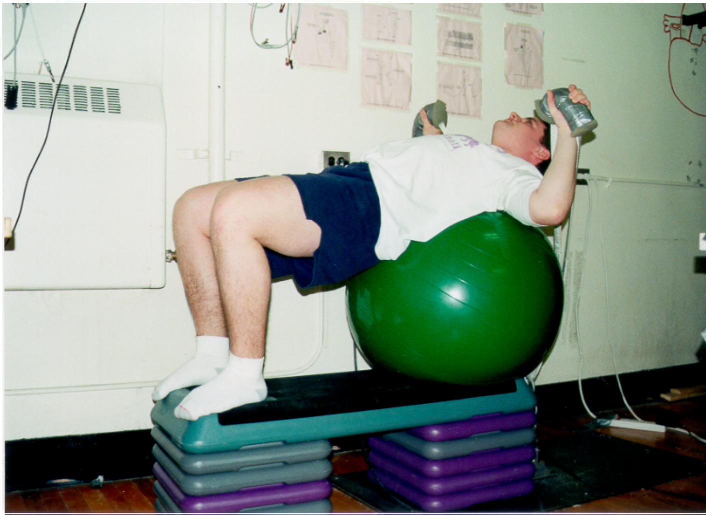




Unstable chest press

Anderson and Behm 2004

- Chest press study showed a 60% ↓ in force with unstable platform,
- EMG activity was similar with stable conditions
- Indicates that muscles perform more of a stabilizing role when unstable



Trunk Muscle Activation with Stable versus Unstable Exercises

Table 5: Sample of Studies Examining EMG Data Under Stable versus Unstable Conditions - Trunk Stabilizer Muscle Activity

Authors(s)/Year	n	Intervention	% change	Effect Size
Vera-Garcia et al. 2000	8	External oblique muscle performing a curl up on a stable bench vs. moderate instability	101.80%	-
		External oblique muscle performing a curl up on a stable bench vs. extreme instability	-15.50%	-
Behm et al. 2005	11	EMG for lumbosacral erector spinae during stable exercises vs. unstable exercises	4.70%	0.59
		EMG for lower abdominal stabilizers during stable exercises vs. unstable exercises	27.90%	0.82
Anderson & Behm 2005	14	EMG activity of the abdominal stabilizer muscles during the smith machine squat vs. unstable squat	29.60%	2.8
		EMG activity of the abdominal stabilizer muscles during the free squat vs. unstable squat	18.60%	2.7
		EMG of the lumbo-sacral erector spinae during the free squat vs. unstable squat	22.90%	4.7
		EMG of the lumbo-sacral erector spinae during the smith machine squat vs. unstable squat	20.00%	6.7
		EMG of the upper lumbar erector spinae during the smith machine squat vs. unstable squat	33.80%	-
		EMG of the upper lumbar erector spinae during the free squat vs. unstable squat	22.90%	-
		EMG of the soleus during the smith machine squat vs. unstable squat	73.10%	16.3
		EMG of the soleus during the free squat vs. unstable squat	58.50%	10.7
Marshall et al. 2006	12	Transversus abdominus during squats performed with a stable surface vs. swiss ball	-56.70%	0.35
Marshall et al. 2006	14	Transversus abdominus with a swiss ball vs. stable surfaces	-57.10%	0.48

Trunk Muscle Activation with Stable versus Unstable Exercises

Table 5: Sample of Studies Examining EMG Data Under Stable versus Unstable Conditions - Trunk Stabilizer Muscle Activity

Authors(s)/Year	n	Intervention	% change	Effect Size
Freeman et al. 2006	10	Right erector spinae during push-up: no legs vs. standard	4.50%	0.04
		Left erector spinae during push-up: no legs vs. standard	-85.20%	2.3
Norwood et al. 2007	15	Latissimus dorsi under stable and dual instability conditions	180.50%	0.98
		Erector spinae under stable and dual instability conditions	875.90%	1.9
Sternlicht et al. 2007	41	Stability ball crunch with a traditional crunch on upper rectus muscle	-30.70%	0.44
Bressel et al. 2008	12	50% of 1RM vs. BOSU trainer with free weight squat exercise on transversus/internal oblique	-12.70%	0.28
		50% of 1RM vs BOSU trainer with the free weight squat exercise on erector spinae	10.70%	0.21
Willardson et al. 2009	12	Transverse abdominus/internal oblique activity for Back Squat stable 50% of 1RM vs. BOSU 50% of 1RM	-26.90%	0.64
		Erector spinae activity for Back Squat stable 50% of 1RM vs. BOSU 50% of 1RM	14.50%	0.34
Schwanbeck et al. 2009	6	Erector spinae with a free weight squat to smith machine squat	-45.50%	0.59
Kohler et al. 2010	30	Lower erector spinae with a shoulder press under unstable load/unstable surface vs. stable load/stable surface conditions	24%	0.24
		Upper erector spinae with a shoulder press under unstable load/unstable surface vs. stable load/stable surface conditions	37%	0.49
Total	**185**	**Means**	**47.33%**	**2.48**

Rehabilitation

– Could be advantageous for rehabilitation by $\downarrow$ load while maintaining high muscle activation

Core Training

Maximum stiffness of a vertebral joint can be achieved with contractions as low as 25% of MVC (Cresswell et al. 1994)

Efficiency of multifidus can be improved with training loads of 30-40% of MVC (Cholewicki and McGill 1996)

Positive Summary

- Instability resistance training can improve
  - balance,
  - trunk and postural limb muscle activation
  - Trunk ROM
  - sport environment specificity,
  - reduce joint injuries and rehabilitation
  - increase performance in children and youth

Factors Affecting Strength Adaptations

- Need high intensity load to promote strength adaptations (Kraemer and Fleck 1988)
- 40-120% of 1 RM recommended to promote strength gains (Kraemer and Fleck 1988)

Effect of Instability Exercises on Force Output

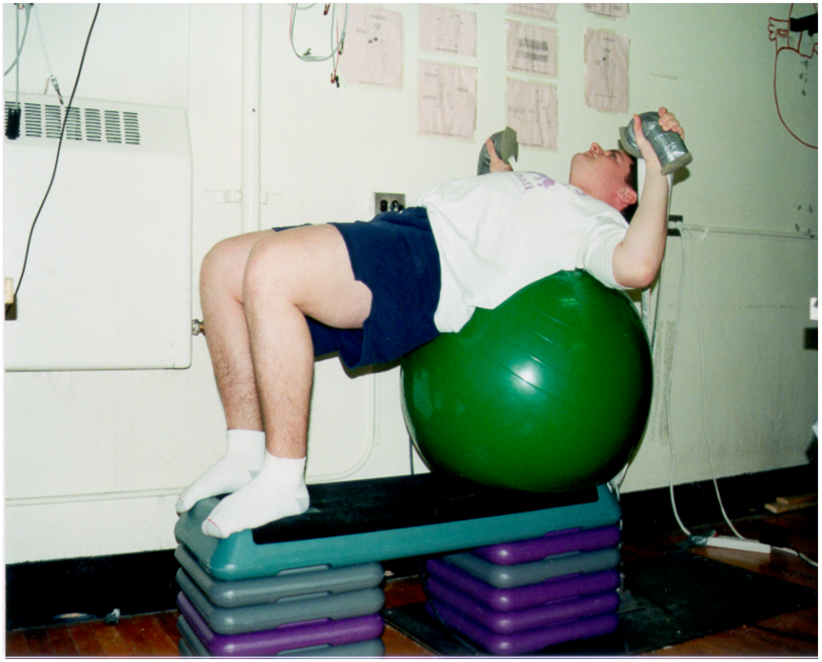
Behm, Anderson and Curnew 2002

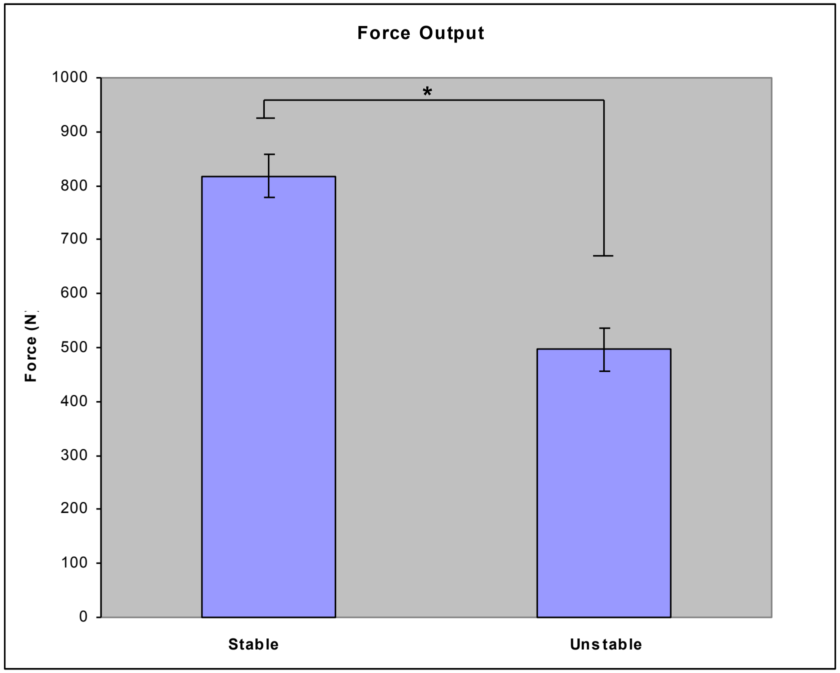
- Stable and unstable leg extension (LE) and PF
- LE force decreased 70%, EMG decreased 44%
- PF force decreased 20%, EMG decreased 3%
- LE very unstable,
- PF only moderately unstable

Unstable chest press

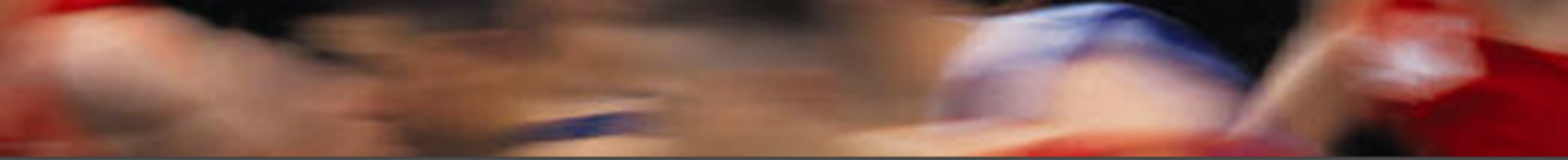
Anderson and Behm 2004

Chest press study showed a 60% ↓ in force with unstable platform,





Instability reduces power output (Drinkwater, Pritchett and Behm 2007 IJSPP)



Instability reduces power output (Drinkwater, Pritchett and Behm 2007 IJSPP)

- ↓Concentric power (Effect Size = 1.3 – 2.06)
- ↓ Eccentric power (Effect Size = 1.4 -1.8)
- ↓ Concentric force (Effect Size = 0.8 – 3.8)
- ↓ Concentric velocity (Effect Size = 0.8 – 1.3)
- ↓ Squat depth (Effect Size = 0.5 – 1.7)

Instability-Induced Force Deficits

Table 1: Sample of Force and Performance Data Comparing Stable to Unstable Conditions

Authors(s)/Year	n	Intervention	% change	Effect Size
Kornecki and Zschorlich 1994	12	Pushing action with varying degrees of freedom (force)	-20%	1.93
		Pushing action with varying degrees of freedom (power)	-40%	2.22
Behm et al. 2002	8	Leg extension MVC force under stable versus unstable conditions	-70.50%	5.6
		Plantar flexion MVC force under stable versus unstable conditions	-20.20%	1.6
Anderson and Behm 2004	10	Bench press under stable versus unstable conditions	-59.60%	5.2
McBride et al. 2006	9	Isometric squat peak force output in stable vs. unstable conditions	-83.80%	2.48
		MVC squat force output in stable vs. unstable	-82.90%	3.9
Behm and Sparkes 2006	18	Bench press under stable versus unstable conditions	-42%	1.7
Drinkwater et al. 2007	14	Squat power under stable and unstable conditions	-24%	3.8
		Squat concentric force under stable and unstable conditions	-18%	3.8
Cowley et al. 2007	14	Work capacity of barbell chest press on stable versus unstable ball pre-training	-12%	0.5
		Work capacity of barbell chest press on stable versus unstable ball post-training	-3.70%	0.01
		Strength of barbell chest press on stable versus unstable ball pre-training	2%	0.5
		Strength of barbell chest press on stable versus unstable ball post-training	0.70%	0.16
Koshida et al. 2008	20	Peak power during dynamic bench press under stable vs. unstable conditions	-12.50%	0.61
		Force during dynamic bench press under stable vs. unstable conditions	-6.20%	0.23
		Velocity during dynamic bench press under stable vs. unstable conditions	-11%	0.62
Goodman et al. 2008	13	Bench press 1 RM strength under stable versus unstable conditions	-0.50%	0.06
Kohler et al. 2010	30	10 RM shoulder press strength under stable load/stable surface vs. unstable load/unstable surface	-30%	0.72
Chulvi-Medrano et al. 2010	31	Deadlift force differences under stable vs. unstable conditions	-52.60%	7.46
Total	**179**	**Mean**	**-29.3%**	**2.155**

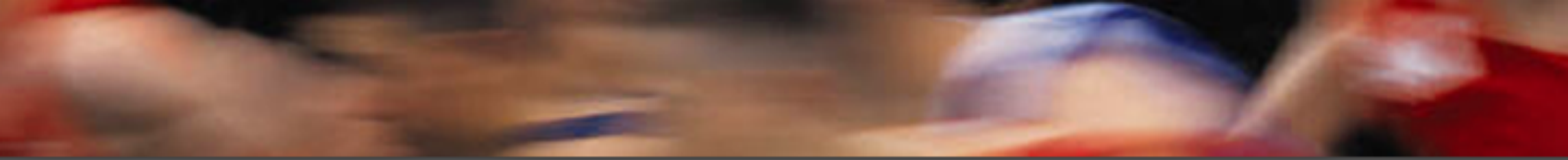
Co-ordination

- Stiffening strategy adopted with instability (Carpenter et al. 2001)
- Postural threats reduce the rate and magnitude of movements (Adkin et al. 2002)
- Unstable conditions resulted in 30-40% greater co-contractions (Behm et al. 2002)
- Would an instability training program reduce these effects ?

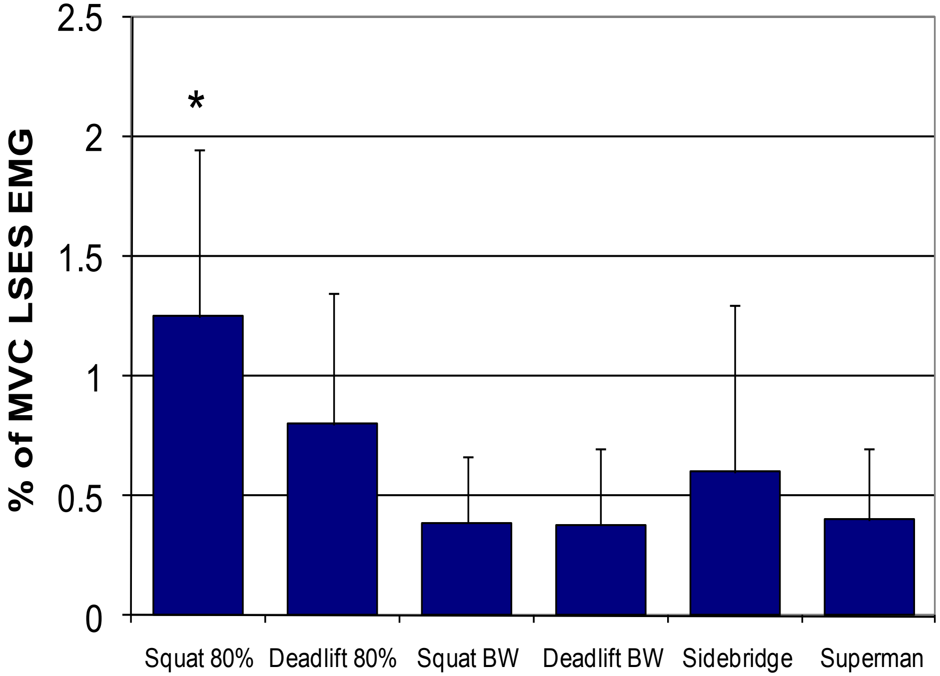
  (positive trend in Sparkes and Behm study)

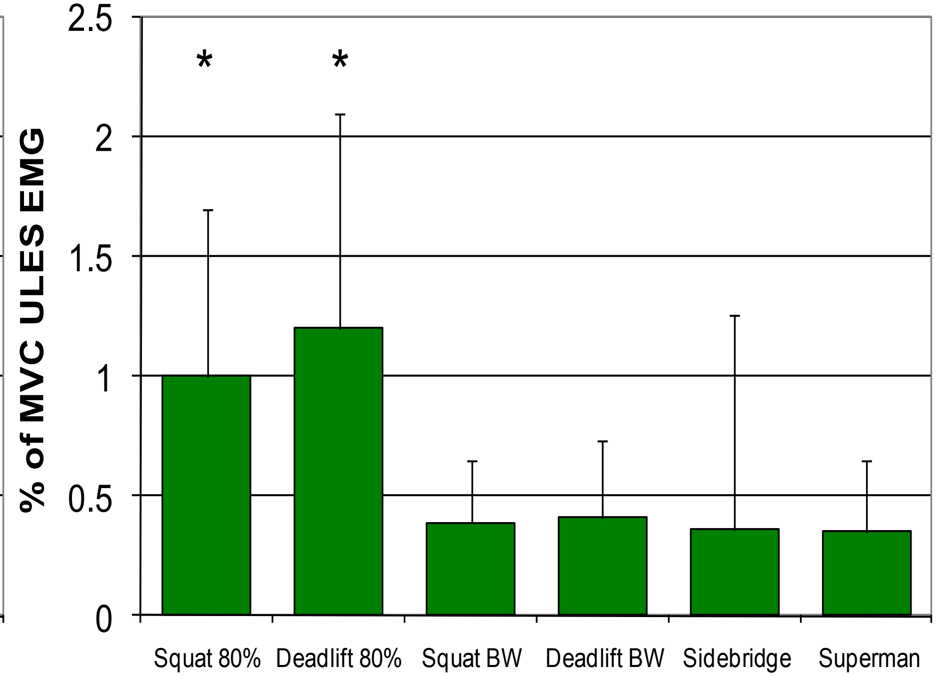
Do traditional resistance exercises enhance core stability? (Hamlyn and Behm 2007 JSCR)

- Subjects performed 3 reps of squats and dead lifts at 85% of 1 RM
- Also performed unstable sidebridge and superman exercises
- Squat and dead lift had 50-70% $\uparrow$ trunk activation



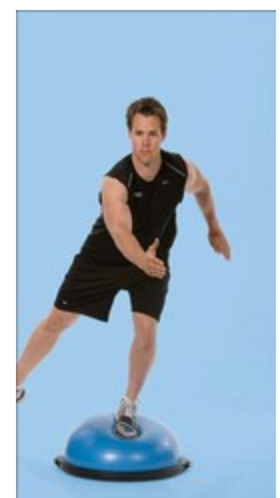
Erector Spinae Activation

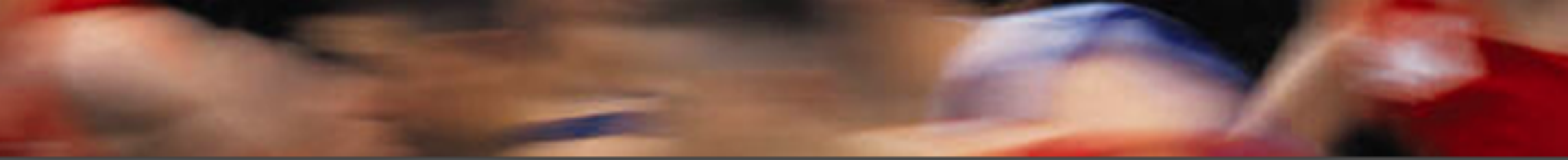




Do highly trained individuals need static instability training? (Wahl and Behm 2008 JSCR)

- Subjects with a mean of 8 yrs of free weight training experience performed exercises on
- 1. Inflatable discs,
- 2. BOSU balls,
- 3. Swiss balls
- 4. Wobble boards
- 5. stable floor

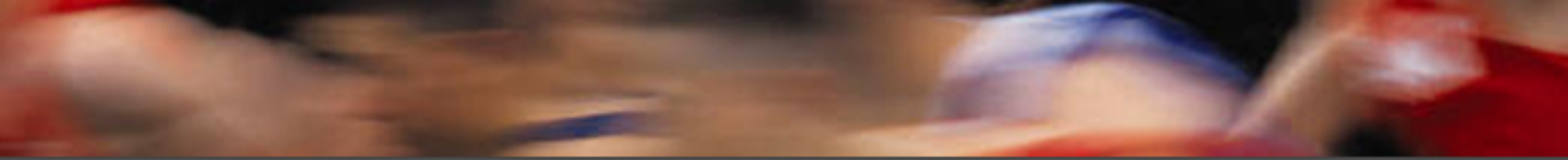




Wahl and Behm JSCR 2008

No difference in trunk EMG between stable and unstable surfaces when using inflatable discs and BOSU balls

The more highly unstable Swiss balls and wobble boards did provide higher muscle activation.



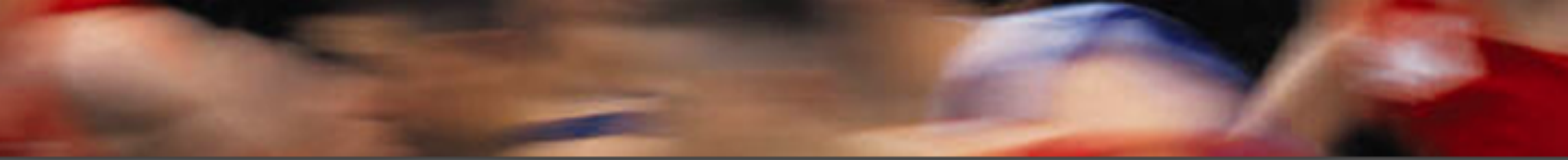
Negative Summary

- Decreased force, power and velocity with instability
- Increased stiffness strategy (i.e. ↑ co-contractions)
- With high instability; decreased muscle activation
- With untrained, instability may not provide additional strength benefit
- With highly trained, moderate instability may not be of benefit

CSEP Position Stand (Behm et al. 2010)

Ground based free weight lifts are highly recommended for **athletic conditioning** of the core musculature as they can provide the moderately unstable environments to augment core and limb muscle activation while still **providing maximal or near maximal force and power outputs**.

Individuals who are involved with **rehabilitation**, **health-related fitness pursuits** or cannot access or are **less interested** in the training stresses associated with ground based free weight lifts, can also receive **beneficial resistance training adaptations with instability devices and exercises to achieve functional health benefits.**



Recommendations

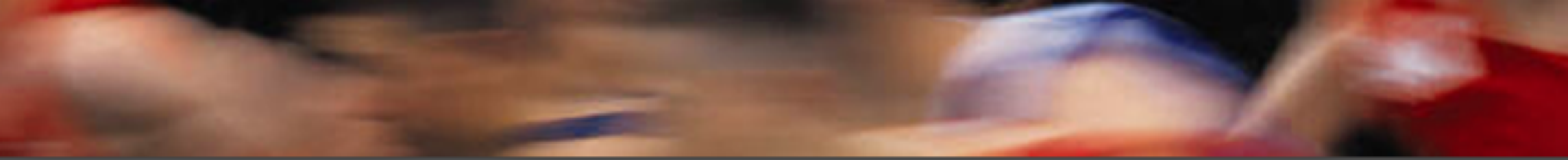
- Children and youth tend to have ↓ balance compared to adults and can benefit more from instability resistance exercises than highly trained adult athletes

  (accelerate balance improvements)

Sport Applications

- Highly trained youth (children) should also emphasize ground based free weights (e.g. squats, Olympic lifts) but should include instability exercises in periodized programs and warm-ups

Squat warm-up

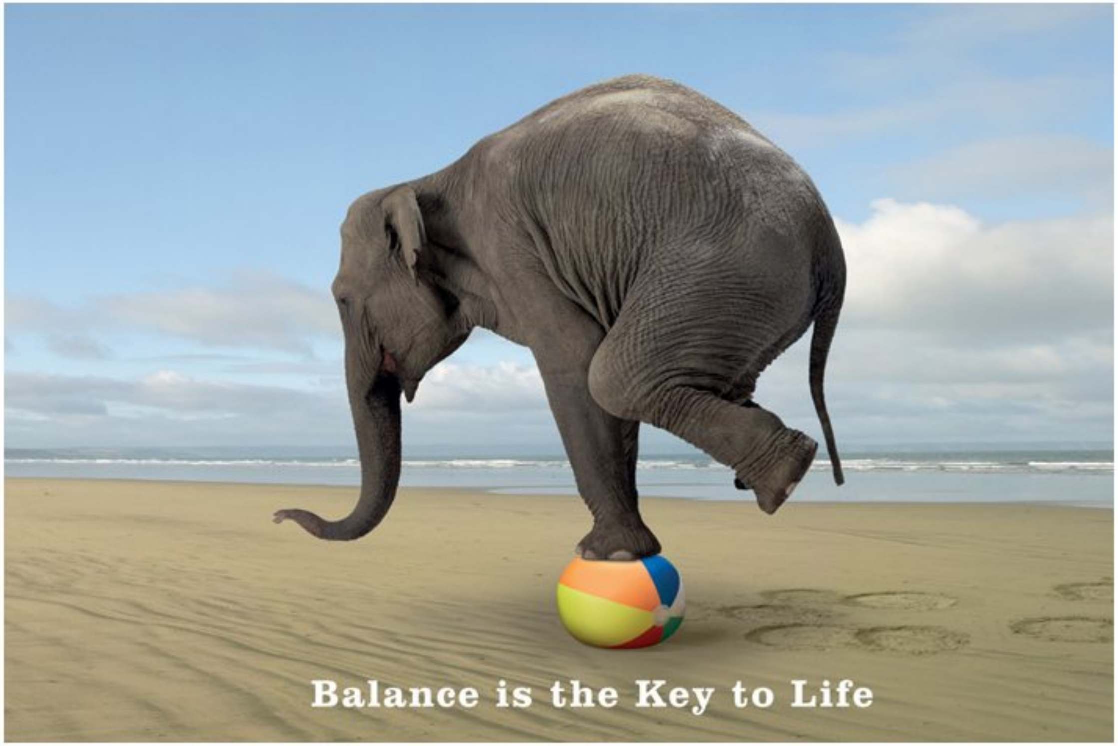


Health vs. Performance

Lower loads with high activation can provide recruitment of both ST and FT fibers with rehabilitation exercises

It is unnecessary to use high intensity resistance for general musculoskeletal health.

All we need is periodic unaccustomed stress


Balance is the Key to Life

Canadian Society for Exercise Physiology Instability Resistance Training Position Stand 2010

- Behm David G., Drinkwater Eric, Willardson Jeffrey M., Cowley Patrick M. Canadian Society for Exercise Physiology Position Stand on The Use of Instability to Train the Core In Athletic and Non-Athletic Conditioning. *Applied Physiology, Nutrition and Metabolism 35: 109-112, 2010*

- Behm David G., Drinkwater Eric, Willardson Jeffrey M., Cowley Patrick M. The use of instability to train the core musculature. *Applied Physiology, Nutrition and Metabolism 35: 95-108, 2010*