



Strength Training for Health

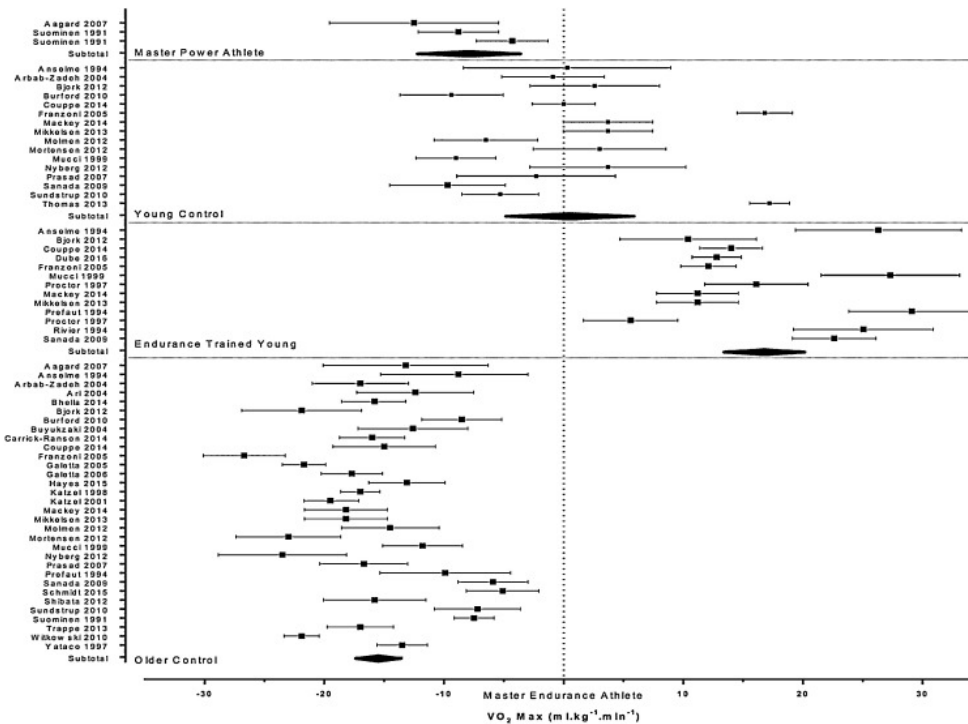
An Evidence-Based Review with Recommendations

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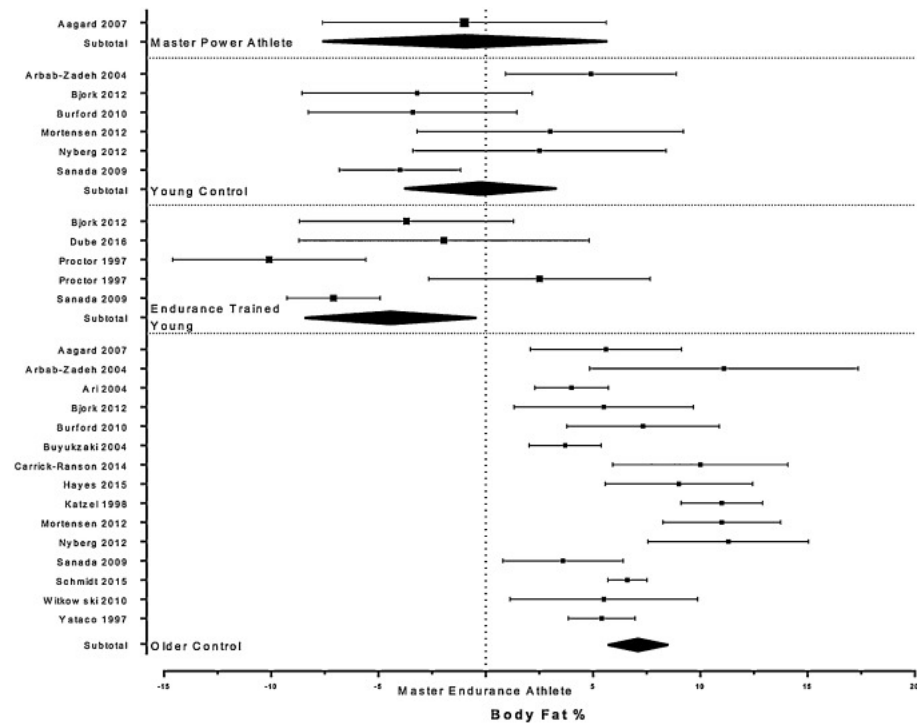
Disclosure

- ▶ Neither I, Robert Kiningham, nor any family member(s), have any relevant financial relationship to be discussed, directly or indirectly, referred to, or illustrated with or without recognition, within the presentation.

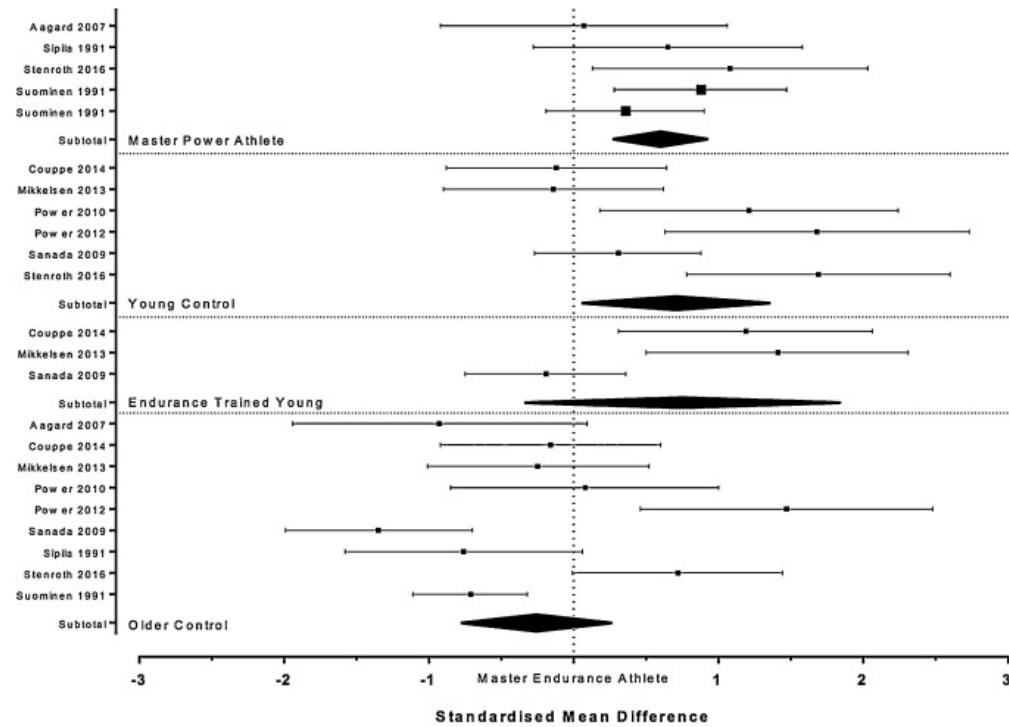
Effect of Age on Cardiovascular Fitness



Effect of Age on % Body Fat



Effect of Age on Strength



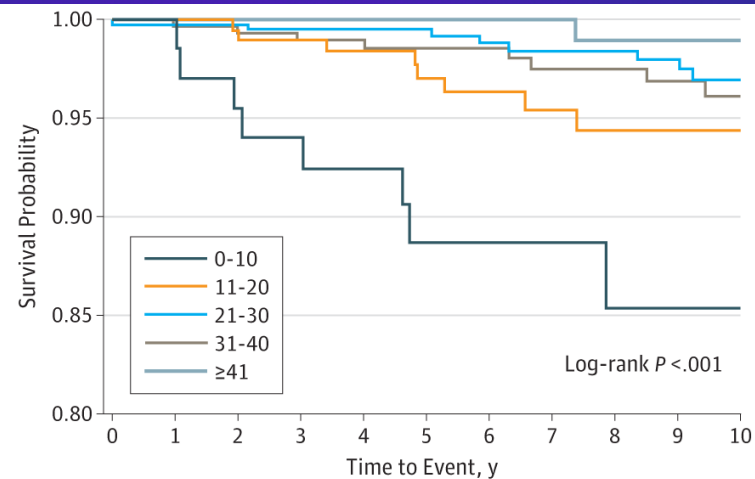
Association Between Push-Up Capacity and Future CVD Events

- ▶ Design: Retrospective cohort
- ▶ Population: Active career firefighters (≥ 18 yrs, no job restrictions)
 - ▶ 1104 firefighters, Avg age 39.6, BMI 28.7
- ▶ Independent variables
 - ▶ Number of push-ups at 80 beats per minute
 - ▶ Estimated VO₂ max on exercise tolerance test
- ▶ Covariates
 - ▶ Smoking, marital status, educational level, alcohol intake, age, BMI, resting BP, lipids, glucose

Association Between Push-Up Capacity and Future CVD Events

- ▶ Primary Outcome: Incident CVD-related events
- ▶ Follow-up: 10 years
- ▶ Push-up capacity significantly inversely related to baseline age, lipid panel (TC, TG, LDL), fasting glucose, DBP and SBP, and smoking status. Positively associated with estimated V02 max.
- ▶ Participants who could do more than 40 push-ups had a 96% reduction in incident CVD events compared to those who could do less than 10 push-ups
- ▶ Regression analysis (adjusting for BMI and age): Independent association of push-up capacity with incident CVD events.
 - ▶ Group who could do 21-30 push-ups vs. less than 10 push-ups, HR 0.25

Association Between Push-Up Capacity and Future CVD Events



No. at risk											
0-10	75	68	63	60	53	39	32	28	26	23	17
11-20	200	200	186	184	172	139	118	96	89	78	63
21-30	389	386	382	375	368	310	275	238	227	202	155
31-40	285	283	276	271	267	232	208	179	169	148	120
≥41	155	153	151	149	147	129	112	99	92	86	63

Figure Legend:

Kaplan-Meier Curves for the Cumulative Risk of Cardiovascular Disease Outcome in 5 Push-up Categories Push-up categories are by numbers of push-ups performed during baseline examination.

JAMA Netw Open. 2019;2(2):e188341. doi:10.1001/jamanetworkopen.2018.8341

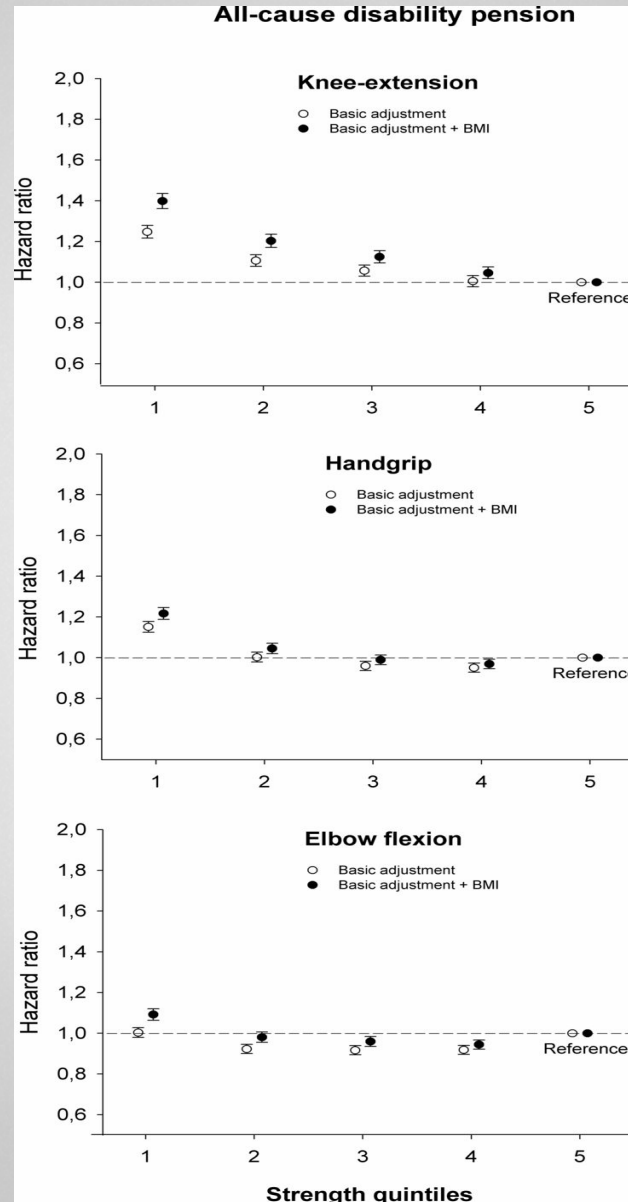
Muscle Weakness in Adolescence and Adult Disability

- ▶ Design: Cohort
- ▶ Subjects: Males aged 16-19 years recruited from the Swedish military conscription registrar between 1969-1994.
- ▶ Independent variables
 - ▶ Knee extension strength
 - ▶ Handgrip strength
 - ▶ Elbow flexion strength
 - ▶ Aerobic fitness (bicycle ergometer)

Muscle Weakness in Adolescence and Adult Disability

- ▶ Dependent (outcome) variable: Receiving Disability Pension (DP)
- ▶ N = 1,212,503 men with average f/u of 29.6 years
- ▶ Results
 - ▶ Muscle weakness was consistently associated with men's risk of obtaining DP due to all causes, with knee extension weakness having the greatest association (HR 1.40), adjusted for childhood socioeconomic status, age at conscription, conscription center, conscription year, and BMI

Associations of different measures of muscular strength with all-cause disability pension (DP) (n=1 212 503).

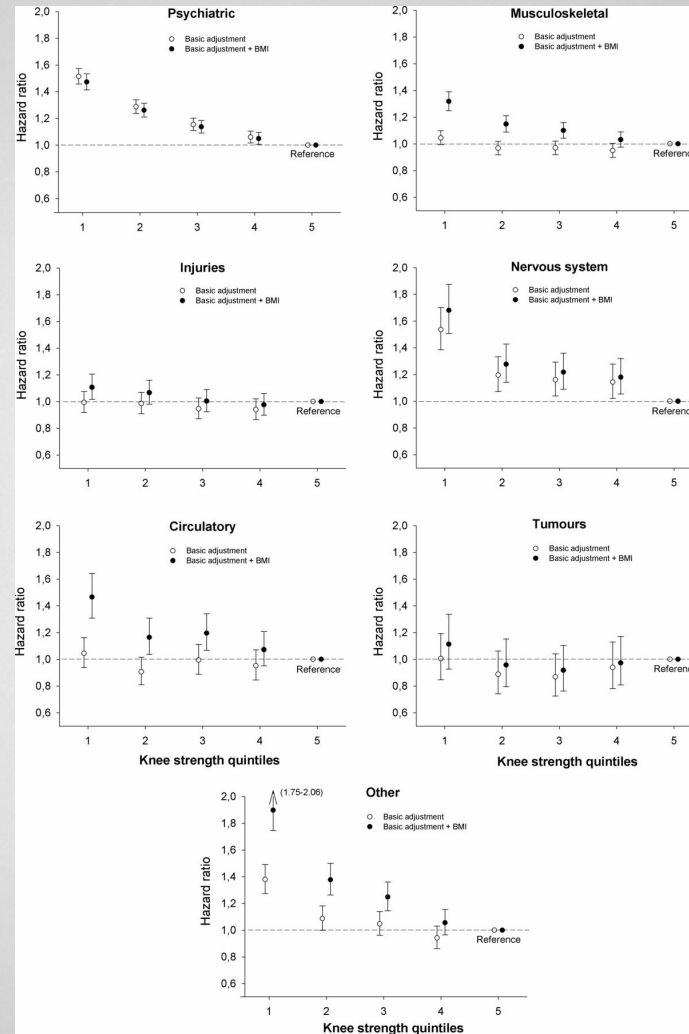


Hanna Henriksson et al. Br J Sports Med 2019;53:1221-1230

Muscle Weakness in Adolescence and Adult Disability

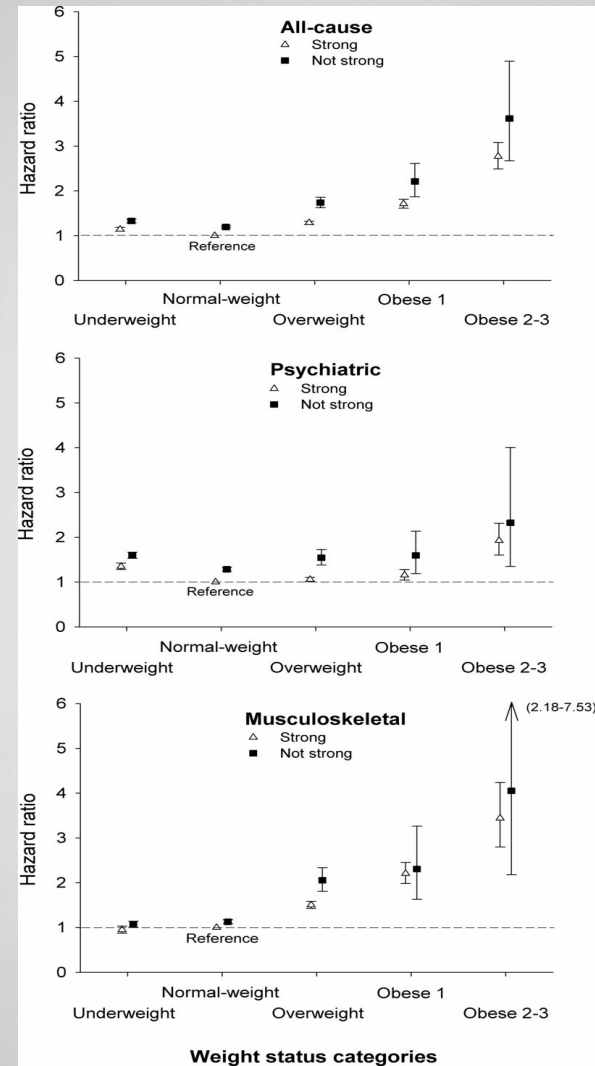
- ▶ Risk associate with muscular weakness was strongest for DP due to psychiatric (HR 1.47), nervous system (HR 1,68), and “other” causes (HR 1.9)
- ▶ Men who were unfit and weak had the highest risk of DP for all-causes, psychiatric causes, and musculoskeletal causes
- ▶ Muscular strength appeared to mitigate the risk of DP across BMI categories
- ▶ Being fit and strong attenuated the risk of DP in both the normal weight and obese groups.

Associations of knee extension muscular strength with specific causes of disability pension (DP) (n=1 212 503).



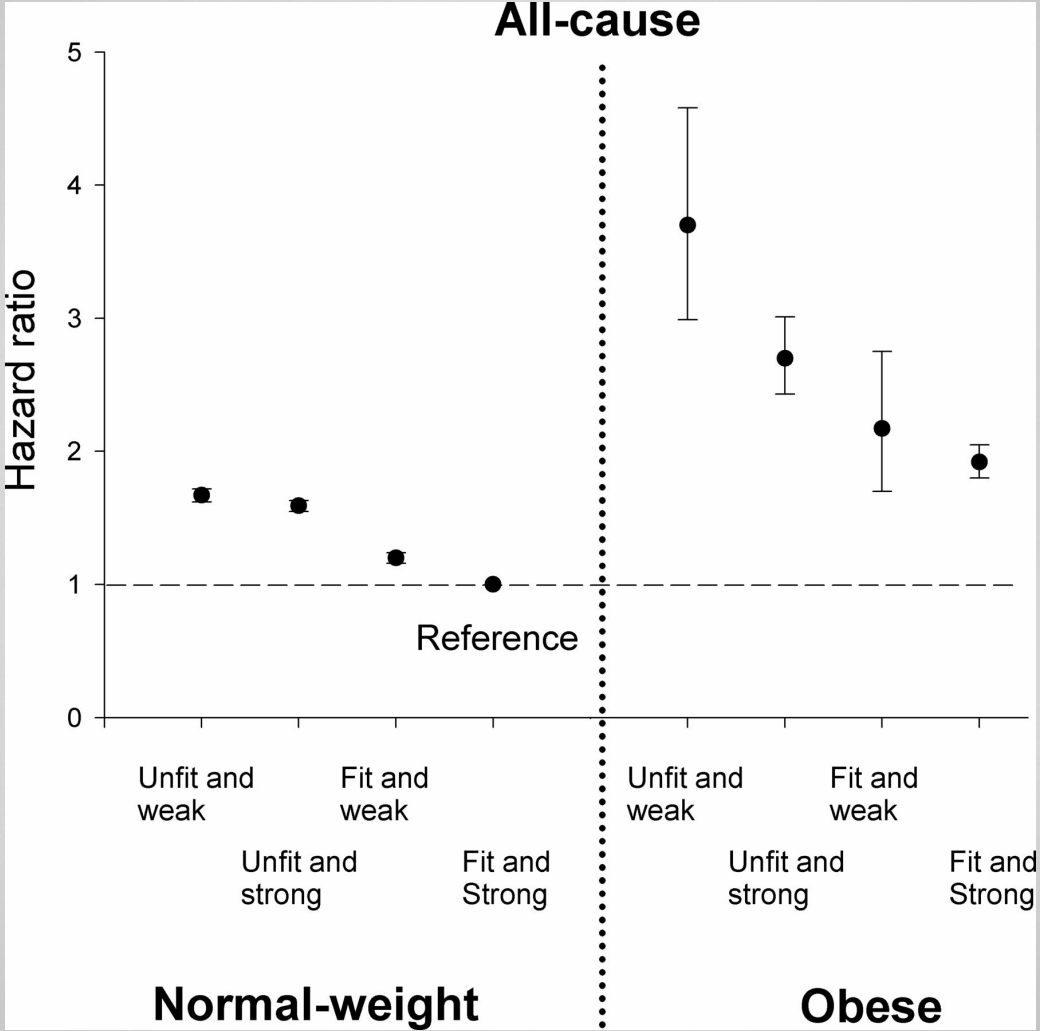
Hanna Henriksson et al. Br J Sports Med 2019;53:1221-1230

Associations of knee extension muscle strength with disability pension (DP) due to all cause, psychiatric and musculoskeletal causes throughout body mass index (BMI) categories (n=1 212 503).



Hanna Henriksson et al. Br J Sports Med 2019;53:1221-1230

Associations of the combination of knee extension muscle strength and aerobic fitness with all-cause disability pension (DP) for normal weight (n=8 78 967) and obese class 1–3 individuals (n=17 912).



Strength, Resistance Training and Health

- ▶ Resistance training: Specialized method of conditioning whereby an individual is working against resistive loads to enhance muscular fitness and athletic performance. Includes use of body weight, weight machines, free weights, elastic resistance bands, medicine balls, etc.
- ▶ Strength training is a type of physical exercise specializing in the use of resistance to induce muscle contraction, which builds the strength, anaerobic endurance, size of skeletal muscles and bone density
- ▶ Weightlifting: A sport the involves the performance of specific lifts (snatch and clean and jerk) in competition



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- ▶ Greater muscular strength is associated with greater ease performing daily tasks for people of all ages
- ▶ Muscle strengthening provides reductions in blood pressure equivalent to aerobic activities
- ▶ Muscle-strengthening activities can help maintain lean body mass during a program of weight loss, but by themselves result in little weight loss

2018 Physical Activity Guideline Advisory Committee Scientific Report



- ▶ Muscle-strengthening activities for older adults, often in combination with balance training, are associated not only with improved physical function but also with reduced risks of falls and reduced risk of injury due to falls

Strength, Resistance Training and Health

- ▶ Associations between strength measures and health outcomes in adults
 - ▶ CVD, all-cause mortality, falls
- ▶ Evidence that increasing strength decreases risk in adults: Secondary and primary prevention
 - ▶ CVD, DM2, COPD, Osteoporosis, Overweight/Obesity, Falls



Strength, Resistance Training and Health

- ▶ Association of strength measures and health in youth
- ▶ Resistance training in primary and secondary prevention of injuries



Muscle Strength and Health

- ▶ Muscle mass declines between 3-8% each decade after age 30, averaging approximately 0.2 kg of lean weight muscle loss per year
- ▶ Muscle loss accelerates after age 50 to 5-10% a year
- ▶ Age –related sarcopenia has been associated with
 - ▶ Bone loss
 - ▶ Fat gain
 - ▶ Type 2 diabetes
 - ▶ Metabolic syndrome
 - ▶ All-cause mortality

Muscle Mass and Strength and All-Cause Mortality

- ▶ Design: Cohort
- ▶ Population: NHANES participants with baseline PE and measurements of body composition and strength, N=4272 (2116 M, 2156 F)
- ▶ Independent variables: LTPA over past 30 days per interview (3 categories), Sedentary time previous 30 days per interview, muscle mass (MM) as appendicular lean mass (ALM), knee extensor strength
- ▶ Dependent (outcome) variable: All-cause mortality

Muscle Mass and Strength and All-Cause Mortality

► Results

- Low muscle mass: 23.1% by ALM, 17% by ALM/BMI
- Low muscle strength on knee extension: 19.4%
- Subjects with LMM by ALM/BMI more likely to have CVD, DM2, higher BMI, fat mass, SBP, TG, fasting glucose, and lower HDL
- Low muscle strength, but not low muscle mass, was strongly associated with all-cause mortality (OR 2.34), regardless of presence or absence of metabolic syndrome, high sedentary time, and level of LTPA, even in adjusted models

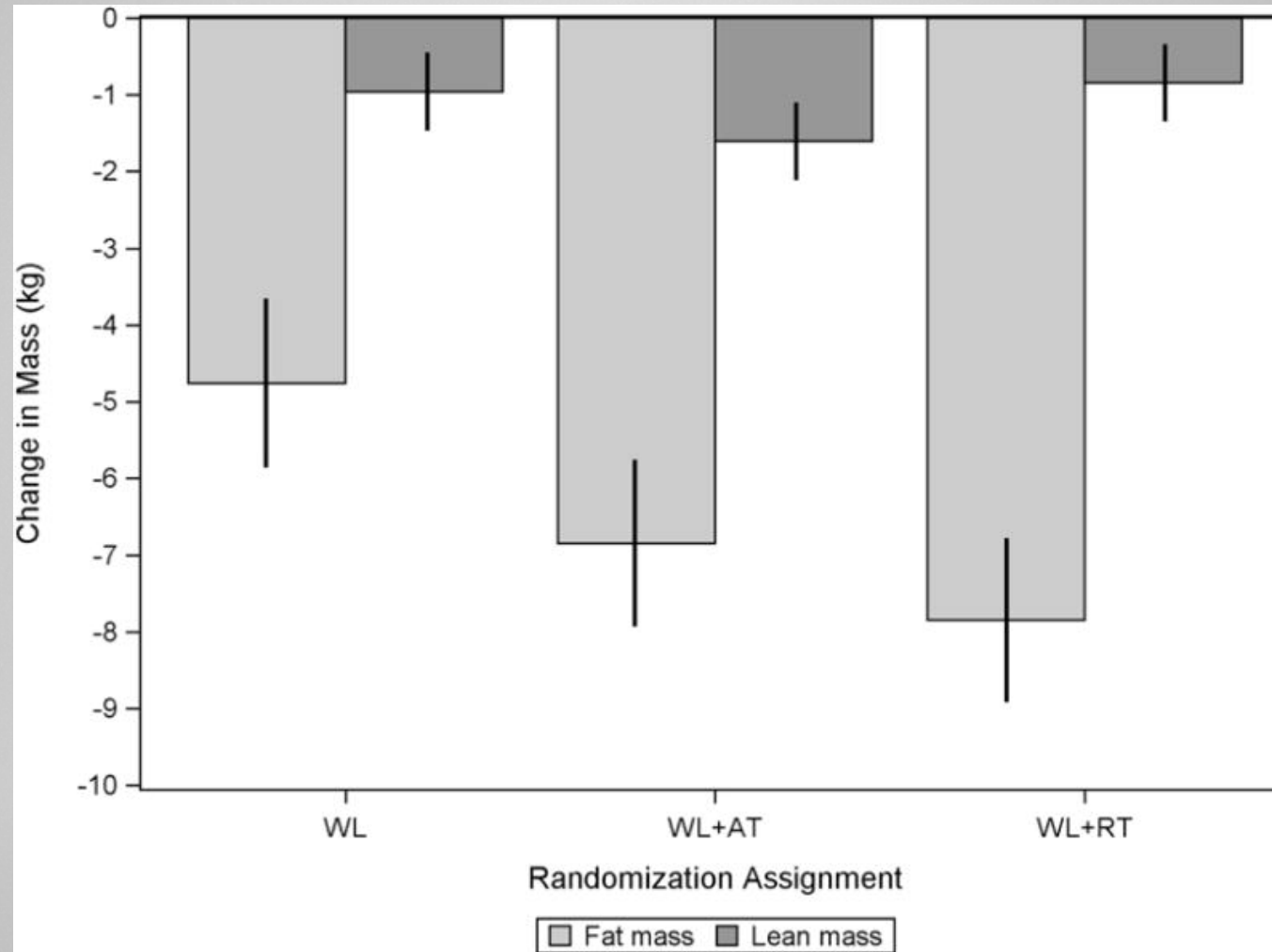
Muscle Strength and Obesity

- ▶ Muscle protein breakdown and synthesis are responsible for energy expenditure in resting muscle
- ▶ Muscle loss is the greatest contributor to the age-related decline in resting metabolic rate
- ▶ Resting metabolic rate average decline is 2-3% per decade in adults
- ▶ Resting metabolism accounts for about 65-70% of daily calorie expenditure among sedentary men and women

Resistance Training and Body Composition

- ▶ RT can increase lean weight while decreasing fat weight
 - ▶ Average of 1.4 kg lean weight increase with 1.8 kg fat weight decrease
- ▶ RT prevents or attenuates the increase in visceral fat that occurs with aging
- ▶ RT may decrease fat infiltration into muscle and hepatocytes
- ▶ RT attenuates lean mass loss with weight loss due to caloric restriction

Effect of Exercise Type during Intentional Weight Loss on Body Composition in Older Adults with Obesity



Muscle Strength and Metabolic Syndrome and DM2

- ▶ Cross-sectional studies show that muscular strength is inversely related to the metabolic syndrome and all-cause mortality
- ▶ Low strength, low muscle mass, and high insulin levels are the strongest set of risk factors associated with the development of metabolic syndrome, independent of abdominal fat and other risk factors
- ▶ Low muscle strength has been found to be an independent risk factor for the development of diabetes in prospective cohort studies

Resistance Training and DM2

- ▶ Skeletal muscle is the major tissue for glucose uptake and clearance
- ▶ RT increases lean body mass and decreases abdominal fat
- ▶ RT improves insulin resistance and glycemic control even without significantly increasing lean body mass
 - ▶ RT induces qualitative improvements in muscle metabolic properties



Resistance Training and DM2

- ▶ RT by people with DM2 has been shown to decrease HgbA1C by 0.5, roughly comparable to aerobic training (AT).
 - ▶ A combination of RT and AT may be more effective in lowering HgbA1c than either modality alone
- ▶ The most important component of a RT program to improve insulin resistance and glucose tolerance is the intensity of the exercise

Westcott W. Curr Sports Med Rep 2012;11:209-216

Lee J, et al. Diabetes Ther 2017;8:459-473

Resistance Training and CVD Risk Factors



- ▶ Meta-analysis of RCT found RT reduces resting BP an average of 6 mm Hg systolic and 4.7 mm Hg diastolic, comparable to decreases found with AT
- ▶ RT generally has a favorable impact on lipid profiles, with lowering of TG and LDL and increase in HDL, but not consistently.
- ▶ RT reduces abdominal obesity
- ▶ RT improves insulin sensitivity

Cornelissen VA, et al. J Hypertens 2005;23:251-259

Hurley BF, et al. Sports Med 2011;41:289-306

Resistance Training and Bone Health

- ▶ Muscle loss (sarcopenia) is associated with bone loss (osteopenia)
- ▶ Adults who do not perform RT experience 1-3% reduction in BMD a year
- ▶ Significant increases in BMD have occurred after 4-24 months of RT
- ▶ Young men may increase BMD by 2.7 to 7.7% with RT.
- ▶ “RT is positively associated with high BMD in both younger and older adults and may have a more potent effect on bone density than other types of physical activity such as AT and weight bearing exercise”

Layne J, et al Med Sci Sports Exerc 1999;31:25-30

Westcott WL. Curr Sports Med Rep 2012;11:209-214

High Intensity RT and BMD

The LIFTMOR Trial

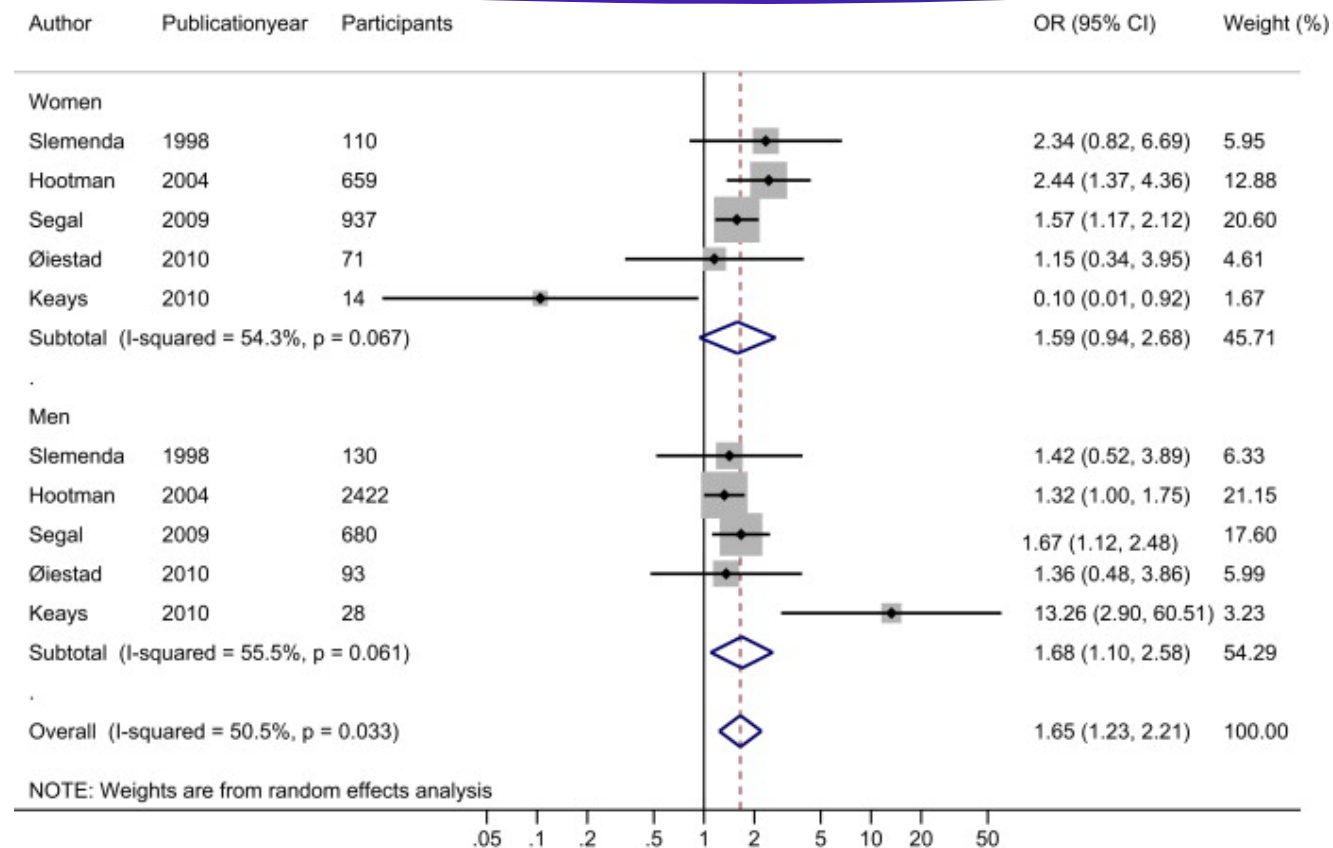
- ▶ Design: Single-blinded RCT
- ▶ Subjects: Postmenopausal women >58 yrs with low BMD
- ▶ Intervention: 8 month, 2/wk, 30-minute supervised HIRT program
 - ▶ Three resistance exercises: deadlift, overhead press, back squat) 5 sets of 5 repetitions at 80-85% 1RM
 - ▶ Jumping chin-ups with drop landings
- ▶ Control group: 8 month, 2/wk, 30-minute home-based low-intensity exercise program designed to improve balance and mobility
 - ▶ Walking, low-load (max 3 lb DB) resistance training and stretches

High Intensity RT and BMD

The LIFTMOR Trial

- ▶ Dependent (outcome) variable: lumbar spine and proximal femur BMD
- ▶ Results
 - ▶ 101 subjects, 49 HIRT and 52 CON, avg age 65 yrs, BMI 24
 - ▶ Lumbar spine BMD increased $2.9 \pm 2.8\%$ in HIRT group and decreased $1.2 \pm 2.8\%$ in the CON group ($p < 0.001$)
 - ▶ Femoral neck BMD increased $0.3 \pm 2.6\%$ in HIRT group and decreased $1.9 \pm 2.6\%$ in the CON group ($p = 0.004$)
 - ▶ Compliance was high in both groups
 - ▶ One adverse event (low back strain in HIRT group resulting in 2 missed sessions)

Knee Extensor Strength and Risk of Developing Knee OA



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- ▶ Muscle-strengthening activities for older adults, often in combination with balance training, are associated not only with improved physical function but also with reduced risks of falls and reduced risk of injury due to falls

Improving Physical Function and Decreasing Fall Risk

- ▶ Physical function decreases and fall risk increases with aging due to sarcopenia and neuromuscular deficits
- ▶ Multicomponent programs combining aerobic, muscle strengthening, balance, and flexibility exercises reduce the risk of fall-related injuries by 32-40% and fall-related fractures by 40-66%
 - ▶ Similar findings for “high risk” for falling adults and unspecified risk adults



Improving Physical Function and Decreasing Fall Risk

- ▶ Programs without strength training are not as effective in preventing falls
- ▶ Research does not support the use of low-intensity walking as a primary mode of physical activity to reduce the risk of fall-related injuries and fractures among older adults



Recommended Exercise Program for Older Adults to Improve Function and Reduce Fall Risk

- ▶ RT 2-3/wk, 3 sets of 8-12 repetitions, start at 20-30% 1RM and advance to 80-85% 1RM
- ▶ Optimize functional capacity by including functional exercises (e.g., sit-to-stand)
- ▶ Endurance training should include walking with changes in pace and direction. RPE 12-14 on BORG scale
- ▶ Incorporate balance training and core strengthening



Youth Muscular Strength and Health

- ▶ Inverse association between youth muscular strength and
 - ▶ Adiposity
 - ▶ CVD and metabolic risk factors
- ▶ Positive association between muscular fitness and
 - ▶ Bone health
 - ▶ Self-esteem
- ▶ Poor muscular strength associated with
 - ▶ Disability 30 years later
 - ▶ CVD later in life
 - ▶ Premature death due to all causes, suicide and CVD



Youth Resistance Training

- ▶ Accelerates the development of a functional foundation of strength
- ▶ Optimizes performance
- ▶ Reduces injury risk during sport sampling in childhood and specialization during adolescence

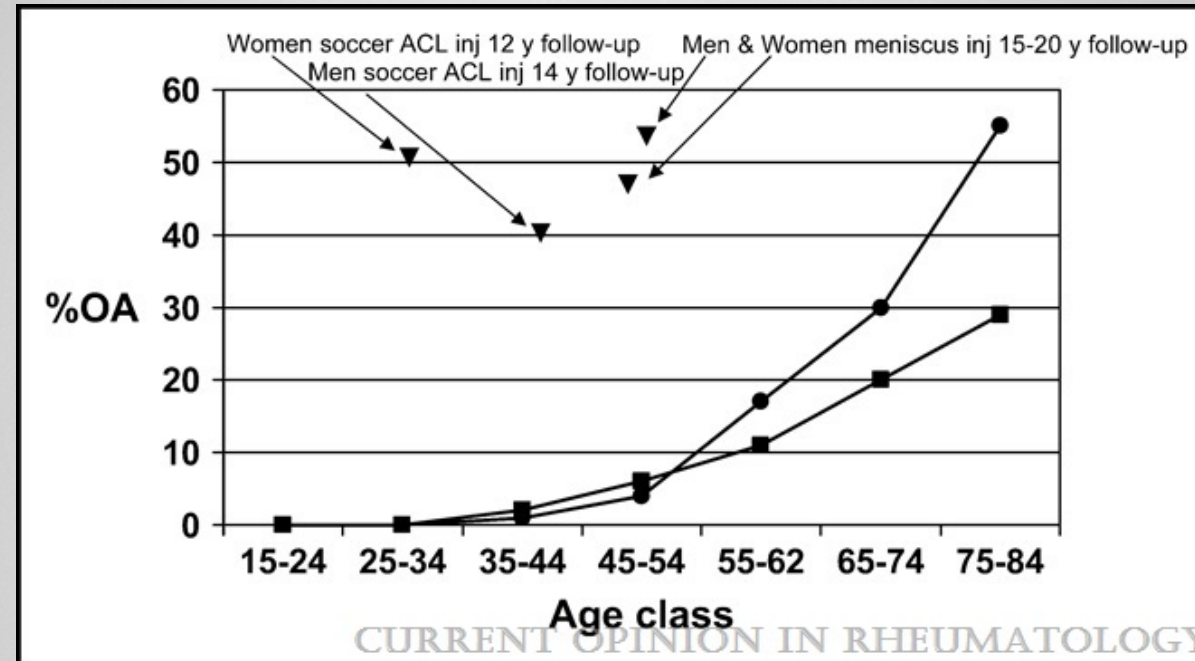
Youth Resistance Training



- ▶ No scientific evidence that resistance training has an adverse effect on linear growth during childhood, or reduced eventual adult height
- ▶ Mechanical stress provided by resistance training may in fact be beneficial for bone formation and growth
- ▶ Children are at lower risk of resistance training-related injuries than adults

Lloyd RS, et al. Position Statement on Youth Resistance Training: The 2014 International Consensus.
Br J Sports Med 2014;48:498-505

Knee OA After Injury



- Prevalence of radiographic knee osteoarthritis in population and after injury Kindly provided by Stefan Lohmander, Department of Orthopedics, Lund, Sweden. From [10••,11,12••,13••].

Risk Factors for Youth-Sport Injuries

- ▶ Low fitness level
- ▶ Muscle weakness and imbalance
- ▶ Errors in training

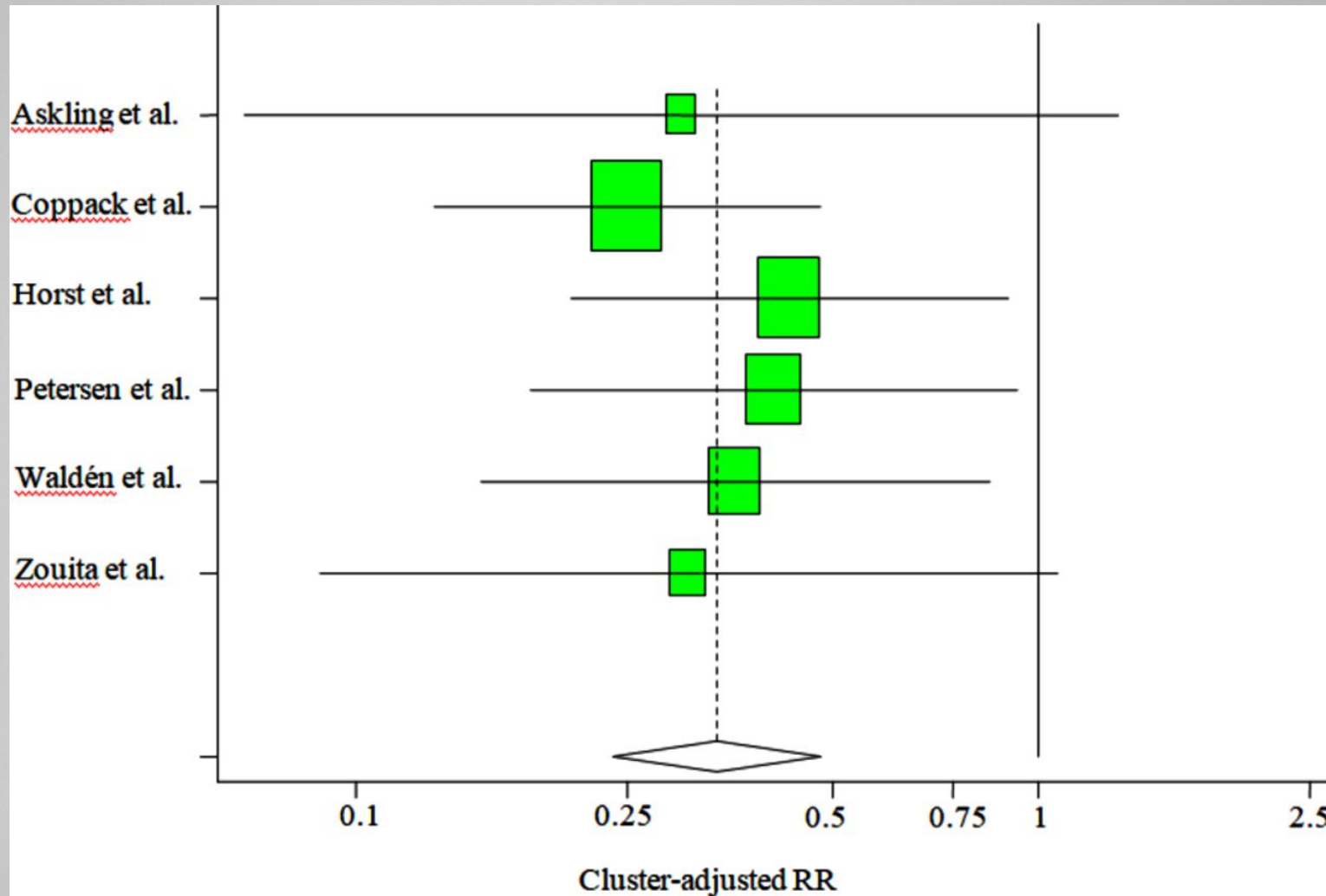


Prevention of Youth-Sports Related Injuries

- ▶ Resistance training reduces both overuse and acute youth sports-related injuries by 50 to 66%
- ▶ The most successful injury prevention programs are multicomponent
 - ▶ Increase muscle strength
 - ▶ Enhance movement mechanics
 - ▶ Improve functional abilities



Forest plot of included strength training sports injury prevention programmes.



Jeppe Bo Lauersen et al. Br J Sports Med 2018;52:1557-1563

Summary: Adults



- ▶ Poor strength, particularly knee extensor strength, is associated with increased risk of CVD, all-cause mortality, overweight/obesity, DM2, knee OA and disability
- ▶ Resistance training recommended for the prevention and management of type 2 diabetes and the metabolic syndrome.
- ▶ Resistance training attenuates the lean body loss with diet-induced weight loss.
- ▶ Muscle strengthening activities, particularly in combination with multicomponent exercise programs, can reduce fall risk by 40% in older adults

Summary: Children and Adolescents

- ▶ Poor strength associated with
 - ▶ Adiposity
 - ▶ CVD and metabolic risk factors
 - ▶ Inactivity
 - ▶ Increased risk of injury
- ▶ Muscle fitness associated with
 - ▶ Bone health
 - ▶ Self-esteem
 - ▶ Physical activity
 - ▶ Decreased risk of injury

