Effects of age, disease and inactivity on muscle function and balance related to risk of falls

Dr Dawn Skelton
Project Co-ordinator PRoFaNE
Prevention of Falls Network Europe
School of Nursing, Midwifery and Health Visiting
University of Manchester
Director
Later Life Training Ltd
Falls in the UK

- 11 million people aged > 65 yrs
- 28,000 women aged > 90 yrs

- Fractures costs £1.6 billion pa
- 1 Hip Fracture every 10 mins
  - Cost £12-15 k
- 1 Wrist Fracture every 9 mins
  - Cost £480
- 1 Spine Fracture every 3 mins

- 500 admitted to Hospital every day
- 33 never go home

Annual European Home and Leisure Accident Surveillance Survey (EHLASS) Report UK 2000
Burden on health care resources

Mean LOS all ages 7.9 days
Mean LOS # femur 25.7 days
Mean LOS falls 9.67 days
More Older People Living Longer

2004:
4 people working to support 1 retired
16% of people aged >65 yrs
4% of people aged >80 yrs

2050:
2 people working to support 1 retired
30% of people aged >65 yrs
11% of people aged >80 yrs
ACTIVITY AND OLDER PEOPLE - SPIRAL OF DECLINE

- Elite Older Athlete
- Physically Active
- Independent but Active
- Physically Frail
- Physically Dependent
- Disabled

- Medications
- Fear of Falling
- Ageism
- Disengagement
- Owning Up
- Disability Threshold
Physical activity is disappearing from everyday life

- Labour saving devices
- Transport patterns
- Sport as entertainment
- The impact of technology
- Increase in sedentary behaviour
Routine activity
6 minutes walk or 15 minutes wait?
Why? If you don’t have to!......
A VISCIOUS CYCLE OF INACTIVITY

Physical deterioration
- Heart disease
- High blood pressure
- Aches and pains
- Osteoporosis

Further decrease in physical activity

Social / psychological ageing
- Feeling ‘old’
- ‘Acting’ one’s age
- Increased stress
- Anxiety, depression
- Low self-esteem

Increasing age

Less exercise

Decreased physical abilities
- Increased body fat
- Sagging muscles
- Decreased energy
Physical Activity in the UK

• HEA National Survey of Activity and Health in men and women aged 50+ (conducted in 1990 and 1991)

• Questionnaires for 50-69 year olds and for those aged 70+

• Allied Dunbar National Fitness Survey (conducted in 1990 and 1991)

• Questionnaires for those aged 50-69 and for those aged 70+
• Physical Appraisals for those aged 50-74 and for those aged 75+

The combined samples give a nationally representative total of 3078 people over the age of 50. A physical appraisal was performed in 1318 people.
WHAT’S THE DIFFERENCE?

• **Physical Activity**
  – any bodily movement produced by skeletal muscles that results in energy expenditure.

• **Exercise**
  – planned, structured and repetitive bodily movement undertaken to improve or maintain one or more components of physical fitness.

_Bouchard 1990_
HOW MUCH IS ENOUGH?

• Regular for health - activities are performed most days of the week, preferably daily
  (WHO, BHF, Dept. of Health)

• Adult population - physical activity of a moderate intensity for half an hour, on at least five days of the week.
  (Department of Health 1999)

• Maintenance of Independence - once/twice a week minimum
  (Consensus)
SEDENTARY WAYS

- 40% of people aged 50 or over in the UK are *sedentary*

- 60-85% are sedentary in ethnic minority groups

- Between the ages of 45 and 74 the amount of people taking enough activity to benefit health declines from 1 in 3 to 1 in 7.
SEDENTARY WAYS

• $\frac{1}{2}$ of sedentary >50’s and $\frac{2}{3}$ of >70’s believe they take part in enough physical activity to keep fit.

• As a result of inactivity, a third of over 70’s cannot walk a quarter of a mile on their own.
Inactivity as a major risk factor

Risk factors for coronary heart disease

Death from CHD under 75: related risk factors

National Heart Forum (in press)

CHD attributable to physical inactivity (37%)

CHD attributable to obesity (6%)

CHD attributable to blood pressure > 140/90mmHg (13%)

CHD attributable to blood cholesterol > 5.2 mmol/l (46%)

CHD attributable to smoking (19%)

All CHD

This diagram represents an estimation of how much each risk factor contributes to death rates from CHD. The overlapping areas represent those who had more than one risk factor.
ACTIVITY AND SURVIVAL

• Activity >2000 calories a week (30% lower mortality)
  – Hypertensive men who exercised had half the mortality rate
  – Smokers who exercised had 30% lower mortality

(Paffenberger et al., 1986) - 16,936 Harvard Graduates

• Lowest fitness category at follow-up
  - died 3.5 (men) to 4.5 (women) x rate of fit people
  - higher incidence of cancer and Cardiovascular disease

(Blair et al., 1989) - 13,344 healthy men and women
Inactivity related disease?

- **No standing activity leads to active loss of bone and muscle**

- 1 wk bed rest ↓ strength by ~20%
- 1 wk bed rest ↓ spine BMD by ~1%
- Nursing home residents spend 80-90% their time seated or lying down
Sedentary vs active lifestyles

• >3 hrs per week targeted exercise
  – myocardial infarct - 3 x less likely
  – Osteoporosis - 2 x less likely
  – Fall-related injuries - 2 x less likely
  – Hip fracture - 2 x less likely

• WHO, 1996 “regular physical activity helps to
  – “preserve independent living” and
  – “postpone the age associated declines in balance and co-ordination that are major risk factors for falls”
Physical activity and public health – the benefits

• Coronary Heart Disease £ 10 billion
  – 37 % attributable to inactivity
• Diabetes £5.2 billion
  - 56% preventable
• Obesity £2.5 billion to NHS and economy
• Falls and fractures among older people £1.7 billion – 46% preventable
• Mental Health  - £32 billion (1996 – 7)
National Service Framework For Older People 2001 - Exercise Evidence

Standards

- 3 Intermediate Care
- 5 Stroke
- 6 Falls
- 7 Mental Health
- 8 Promotion of Health and active life in old age
Ice?

No, I think it was the Scotch
Inactivity determined disability?

![Falls](image)

- Falls (Men)
- Falls (Women)

Age (years):
- 65-74
- 75-84
- 85+

Rates per million:
- 0
- 200
- 400
- 600
- 800
- 1000
- 1200
- 1400
- 1600

- Falls Men
- Falls Women
Finding the fallers?

- 70-80% of falls go unreported
- 40% of falls occur in the home
- 5-10% of outdoor falls occur on the bus
- 40% of nursing home admissions are due to falls and balance problems
- 10% of all call-outs for London Ambulance Service are for people aged 65+ who have ‘fallen’.

> 40% are not taken into Hospital
Fracture Prevention Triangle

FRAGILITY

FRACTURE

FALLS FORCE

National Institute for Health, USA 1999
Particularly in Residential Settings

- 75% fall annually (1.5 falls per bed per year)
- 35% of falls result in serious injury
- up to 8% of falls result in fractures
- Hip fracture incidence higher

SCARE Briefing - http://www.elsc.org.uk/briefings/briefing01/
Latest figures suggest growth in the rate of fractures

ESTIMATED INCIDENCE IN HIP FRACTURE IN ENGLAND AND WALES

People (000s)

No moderate activity for more than half an hour reported in previous 4 weeks:
Health Survey for England 1998

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</table>
THE THREE DIMENSIONS OF HUMAN FRAILTY

TIME

HUMAN FRAILTY
(Spirduso, 1995)

DISEASE

DISUSE
AGEING AND MUSCLE

- ↓ Muscle mass
- ↓ Size of Type 2 fast fibres
- ↓ Turnover of contractile protein
- ↓ Mitochondria
- ↓ Proprioception
- ↑ Connective tissue and fat
- ↓ heat production
- ↑ Susceptibility to injury and damage
  - ↑↑ FALLS
- ↓ Max. heart rate
- ↓ Max. stroke volume
- ↓ Max. cardiac output
- ↓ Aerobic Power
- ↑ Systolic B.P.
- ↑ Postural Hypotension
- ↑ Fatigue
- ↑ Breathlessness
Maximal oxygen consumption (VO2 max) in men and women aged 50-74

Me

Women

VO 2 max to walk comfortably at 3 mph

Maximal oxygen uptake (ml/kg/min)
Isometric knee extension strength in men and women aged 50-74

Knee extension strength (N/kg)

Age (years)

Strength to be confident of rising from low chair without using arms
Fibre type grouping

Young muscle

Old muscle
Young muscle

Angular shape

Old muscle

“Crushed” and “banana”-shaped
Functional Consequences of an ageing muscular system

- Weaker muscles
- Slower muscles
- Fatigue
- Poorer temperature maintenance
- Poorer immune function
- Poorer functional reserve

**APPROACH**

- Target major functional muscle groups
- Time for rest
- Fartlek training approach
- Effective warm-up, warm-down and stretches
The same difference in muscle size is seen between a 30 and an 80 yr old

(Adapted from Sipilä & Suominen Muscle Nerve 1993;16:294)
Muscle Related Risk Factors

**STRENGTH**

Fallers (n=39) versus non-fallers (n=15)

- **Isom. Quadriceps**
- **Hamstring**
- **Eccentric Quadriceps**
- **Ankle Plantarflexion**
- **Ankle Dorsiflexion**

**Strength (N or N/m)**

- **Fallers'**
- **Non-fallers'**

*p < 0.05*
Muscle Related Risk Factors

POWER  fallers (n=39) versus non-fallers (n=15)

Skelton, Age Ageing 2001
ASYMMETRY fallers (n=39) versus non-fallers (n=15)
Comparison of fragile osteoporotic bone with strong, dense bone

Strong, dense bone

Fragile, osteoporotic bone
Figuur 2. De typische houding van de patiënt met osteoporose.
Young healthy spine  

Osteoporotic spine
Gwen Fitzpatrick lost sixteen inches in height due to vertebral fractures; during 30 years of fractures no treatment was provided to prevent further bone loss.
Sensory Input → Stability

Three main sources of input

- Visual information
- Vestibular information
- Proprioceptive information
Visual sensory input

• Most important sense for maintenance of upright posture in old age

• Half of people over 50 who wear glasses admit to not being able to see well!

• Information about head and eyes in relation to environment - i.e. increased sway when eyes closed
Proprioceptive - Somatosensory

- Information about where the body is in space - kinaesthetic awareness

- Proprioceptors
  - Mechanoreceptors (angles) in joints, ligaments, tendons and muscles - Golgi tendon organs (degree of shortening)
  - Pressure and vibrator receptors in the skin
  - Orientation of head in space – labrynthine receptors
Vestibular sensory input

- Inner ear - Semi-circular canals
- Canal fluid, granules, hairs
- Information about direction and speed of head
- Combines with other sensory information from eyes, muscles, skin
Effects of Ageing on Nervous system

- ↓ Neurones (somatosensory, vestibular and visual)
- ↓ Spinal Cord Axons
- ↓ Speed of transmission
- ↓ Speed of central processing
- ↓ Mass and strength in eye muscles
- ↓ Elasticity in lens, ↓ Hydration of the eye, ↑ Eye Infections
- ↑ Viscosity of fluid in inner ear, ↑ medications that affect vestibular system
- ↓ number and efficiency of Proprioceptors, ↑ medications that reduce efficiency of proprioceptors, ↑ oedema
Effects of Ageing/Disease on Nervous System

- Short term memory
- Cognition – slower pace of learning and processing
- Parkinsons Disease
- Dementia’s
- Oedema
- Diabetes
- Arthritis
- Medications
Functional Consequences of an ageing nervous system

- Poorer short term memory
- Slower learning and performance
- Poorer kinesthetic awareness
- Poorer reaction / coordination integration
- Poorer complex task performance
- Poorer balance
- Difficulty comprehending floor patterns/textures

APPROACH

- Simple movement tasks, repetition and rehearsal
- Longer transition times
- Effective verbal and visual cueing
- Functional moves
Posture / lung function
Posture / biomechanics
Functional Ability in older age

EVEN HEALTHY OLDER PEOPLE LOSE...

- Strength (1% to 2% p.a.)
- Power (3% to 4% p.a.)
- Bone density (Women: 1% to 3%, Men: 0.4% p.a.)
- Ligament tensile strength (50% by 60+)
- VO2max (1% p.a.)
- Pacemaker cells (50% by 60+)
- Motor neurones/axons (37% by 60+)
- Maintenance of temperature control

Sedentary behaviour increases the loss of performance...
Determinants associated with physical activity

- Ethnicity
- Gender
- Educational level
- Smoking status
- Overweight
- Medical condition
- Perceived lack of ability
- Motives to improve appearance or fitness

- Fear of Injury
- Transportation problems
- Safety concerns
- Social Support
- GP and family advice
- Myths and mistaken beliefs
Barriers to Physical Activity

- Inconvenient locations
- Safety of locations
- Cost
- Social embarrassment
- Unpleasantness of exertion
- Myths and perceptions
Barriers to exercise referral

• Exercising GP’s 3 x more likely to promote activity than sedentary GP’s
• Lack of staff time and resources
• Uncertainty about effectiveness
• Patient resistance/reluctance to change
• Insufficient knowledge
• Low priority
PHYSICAL ACTIVITY and HEALTH

Disease Prevention

Maintenance of Independence

Age
## The Benefits of Physical Activity

### Prevention of:

**disease**  
Coronary Heart Disease, Osteoporosis, Obesity, Stroke, Depression, Type 2 Diabetes, Hypertension, Colon Cancer

**disability**  
Arthritis, Intermittent claudication, Angina, Sleep, low back pain

**complications of immobility**  
Constipation, Deep vein thrombosis, Oedema, Pressure sores

**isolation**  
Socialisation, Self-efficacy, Confidence

**dependence**  
Functional ability, Falls, Autonomy, Dignity, Caring skills

**Rejuvenation**
BENEFITS OF REGULAR EXERCISE

IMPROVES OR MAINTAINS

- Good posture & body image
- Intake of nutrients and immunity to infection
- Cerebral function, mood, memory
- Sleep pattern and duration
- Social contacts

REDUCES OR PREVENTS

- Likelihood of falls and fractures
- Breathlessness, Obesity
- Constipation, incontinence, urinary urgency
- Anxiety, Depression, Stress

INDEPENDENCE AND QUALITY OF LIFE

DEPENDENCE AND ISOLATION
CHAIR BASED EXERCISE

Improvements in wide range of ages /settings:

- **Strength and Power** (Fiatarone 1990, 1994; Skelton 1995, 1996)
- **Flexibility and Functional Ability** (McMurdo 1993; Skelton 1995, 1996)
- **Arthritic Pain** (Hochberg, 1995) and **Postural Hypotension** (Millar, 1999)
- **Depression** (McMurdo, 1993)
- **Rehabilitation following hip fracture** (Nicholson, 1997)
- **Risk of future falls** (Allen, 1999)
Physical activity and health

**Dose response curve**

- The lower the baseline level of physical activity, the greater the health benefit associated with an increase in physical activity

*(Haskell 1994)*

Figure 1.—The dose-response curve represents the best estimate of the relationship between physical activity (dose) and health benefits (response). The lower the baseline physical activity status, the greater will be the health benefit associated with a given increase in physical activity (arrows A, B, and C).
Do older people take up physical activity?

King (1998) reviewed the main RCT trials

- **Attendance** averaged 75%
  - Half of the interventions used strategies to promote participation
    - behavioural strategies
    - telephone assisted
    - range of activities - home, supervised

- **Maintenance** better than for younger adults
ADDRESSING NEEDS

- Fun/ enjoyment
- Social benefits
- Mental health benefits
- Physical enhancement
- Enjoying the grandchildren
- Getting into the bath
- Cutting toe-nails
- ‘Caring’ skills

Adherence to exercise and activity is good  (King, 1999)
We are all *trippers*....but when do we become fallers?
Consequences of Falls

• **Injuries** include:
  – Cuts and lacerations,
  – Deep bruises,
  – Soft Tissue Injuries,
  – Dislocations,
  – Sprains
  – Increase in joint pain

• **20%** of injurious falls result in **fractures** requiring hospital treatment.

• Long lie’s & complications

• **Post fall syndrome**
Pitfalls of falls exercise research

- Unselected subjects
- Insufficient duration
- Insufficient intensity
- Insufficient tailoring or specificity of training
- Adherence
- Inadequate fall history
RCT of Brisk Walking
- Ebrahim et al. (1997)

- Women, upper arm fracture
- Excluded
  - bisphosphonates, survival < 1yr, cognitive impairment, too frail
- Intervention: Brisk walking
- Control: exercise of upper arm
- Falls risk (Brisk walking > control)
EFFECTIVE DURATION OF ACTIVITY

- Strength, Power, Static balance, Gait
  - 8-12 weeks
- Dynamic balance, Endurance, Dizziness and Postural Hypotension, Transfer skills, Mood, Depression
  - 12-36 weeks
- Risk of falls, anxiety, self-esteem
  - 36-52 weeks
- Bone strength (hip, spine and wrist)
  - >1 year
Lessons that last a lifetime
Specificity of training

<table>
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<tr>
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<th>Training Details</th>
<th>Outcome</th>
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<tr>
<td>FICSIT, Province, 1995</td>
<td>7 sites: Strength, balance, endurance</td>
<td>10% lower risk of falling</td>
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<tr>
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<td>4 sites: Balance</td>
<td>25% lower risk of falling</td>
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<tr>
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<td>1 site: Tai Chi (15 weeks, 2x/pw unselected older people + daily 15 mins) Wolf, 1996</td>
<td>47.5% lower risk of falling</td>
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Addressing balance in all settings

Improvements in
- Ankle Strength
- Lower limb Power
- Balance (TUSS and sway)
- Balance confidence
- FR and TUG

Aerobic class with step and site specific impact in over 50s

Welsh & Rutherford, 1996
HRT and Exercise

Notelovitz et al, 1991
Hip Protectors

- Effective
- Recommended in residential settings (low bone density, prone to falls)
- Compliance low
- Confidence improvements

- “I need to get a new pair for tennis, as that’s the only time I fall now!”
The Bottom Line

• "Able to discuss problems with each other and the teacher"
• "Doing exercises with people is much nicer than doing them on my own"
• "The class for me is very enjoyable. My confidence has improved"
• "Being partially crippled because of arthritis, since doing these exercises my condition is greatly improved"
• "I am able to get out of the chair much easier"
• "Able to walk without the fear of falling"
“Man does not cease to play because he grows old. Man grows old because he ceases to play”

George Bernard Shaw