Are we walking in the right direction?

Julie Jones
What we are going to get through..

- Gait – what’s behind the walk
- Look at the evidence base, explore what we know and what we do not know about:
  - Exercise therapy
  - Cueing
  - Tai Chi
  - Aerobic exercise
- My research interests
Who am I?
Gait is a major determinant to quality of life but why is it a problem in PD?
The Basal Ganglia

- Modulates motor control
- Well learnt/automatic movements
- Regulation of movement
- Timing & sequencing of movement
- Motor set
- Motor learning
- Non motor regulation

Basal Ganglia

- Striatum
  - Putamen
  - Caudate

- Globus Pallidus
- Subthalamic Nucleus
- Substantia Nigra

Nonmotor Regulation

Motor Learning

Timing & Sequencing of Movement

Regulation of Movement

Well Learnt/Automatic Movements

Modulates Motor Control
Caudate and Putamen

- Linked with sleep & social behaviour
- Speed & accuracy
- Body & limb position/posture
- Motor preparation
- Sequencing, & amplitude
- Learning

[Diagram of brain structures with labels: Caudate nucleus, Rostral putamen, Caudal putamen, Globus pallidus (lateral part), Globus pallidus (medial part), Thalamus, Subthalamic nucleus, Substantia nigra]
Direct and Indirect Pathway

**Direct pathway**
- Increase firing of Striatal neurons
- Inhibits activity of Gpi
- Disinhibits Thalamic neurones
- Firing of the Thalamus
- Increased excitation to motor Cortex

**Indirect Pathway**
- Inhibits GPe
- Inhibits STN
- Excites Gpi
- Inhibits thalamic neurons
- Reduced firing of thalamus
- Reduced excitation to motor cortex
What happens in PD

Direct pathway
- Increase firing of Striatal neurons
- Inhibits activity of Gpi
- Disinhibits Thalamic neurones
- Firing of the Thalamus
- Increased excitation to motor Cortex

Indirect Pathway
- Inhibits GPe
- Inhibits STN
- Excites Gpi
- Inhibits thalamic neurons
- Reduced firing of thalamus
- Reduced excitation to motor cortex

Excitatory
Inhibitory

Nigrostriatal Pathway
But how does this impact upon gait?
Pre-Motor Cortex

- Thalamus
- Motor Cortex
  - Premotor Cortex
  - Primary Motor Cortex
  - Supplementary Motor Area
- Prep for Movt
- Inferred intentions
Primary Motor Cortex

- Thalamus
- Premotor Cortex
- Primary Motor Cortex (Controls individual movements & sequences)
- Supplementary Motor Area (Muscle force)
- Direction of movement
- Speed of movement
- Distance of movement
Supplementary Motor Area

Thalamus

Premotor Cortex

Primary Motor Cortex

Mental rehearsal of movement

Supplementary Motor Area

Responds to movement sequences
Motor Cortex

- Thalamus
- Motor Cortex
- Premotor Cortex
- Primary Motor Cortex
- Supplementary Motor Area

Prep for Movt
Inferred intentions
Controls individual movts & sequences
Muscle force
Direction of movt
Distance of movt
Speed of movt
Responds to movt sequences
Mental rehearsal of movt
Net effect in the CNS

- Alteration in selectivity, and force generation
- Reduction in control of individual muscles
- Reduction in speed, and amplitude of movement
- Alteration in sequencing of movement
- Reduction in background preparation of movement
- Behavioural context of movement
- Alteration in sequencing of movement
Therefore

- Reduction in motor neuron activity in Spinal cord
- Reduction or alteration of muscle tone and proprioception
- Reduction in generation of muscle force
Net effect in the periphery

- Reduction in muscle strength and power
- Reduction in co-ordination of muscle activity
- Reduced stability and balance
- Reduced sensitivity of proprioceptors
Value of exercise in PD (Fox et al 2006)

1. Intensive activity maximises synaptic plasticity
2. Complex activities promote greater structural adaptation
3. Rewarding activities increase dopamine levels and promote learning
4. Dopaminergic neurones are highly responsive to exercise and inactivity
5. Early initiation of exercise and slow down progression
Relationship with gait?
Gait.

• Gait – is the manner or style of walking

• Walking is more akin to the process

• Kinetics: study of forces, moments, masses and accelerations

• Kinematics: to do with motion
Gait Cycle

- Heel strike
- Opposite toe off
- Heel rise
- Opposite initial contact
- Toe off
- Feet adjacent
- Tibia vertical
Figure 4.19. The complete gait cycle: stance and swing. Walking is a purposeful disturbance in body equilibrium during which alternating leg displacement sustains body weight.
Components of gait training

- Strengthening
- Balance and stability
- Directional
- Amplitude
- Speed
- Proprioceptive
- Cognitive
So what is the evidence?
Effectiveness of LL resistive exercise

• Systematic review conducted

• Inclusion criteria:
  - Mixed gender
  - Stage I-III
  - any types of resistive exercise
  - studies which utilised gait related outcome measures
  - minimum quality score of 5
<table>
<thead>
<tr>
<th>Author and Year</th>
<th>Title</th>
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<tr>
<td>Allen et al 2010</td>
<td>The effects of an exercise program on fall risk factors in people with Parkinson’s disease</td>
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<td>Combs et al 2013</td>
<td>Community-based group exercise for persons with Parkinson’s disease: A randomized controlled trial</td>
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<td>Hass et al 2012</td>
<td>Progressive resistance training improves gait initiation in individuals with Parkinson’s disease</td>
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<td>Paul et al 2014</td>
<td>Leg muscle power is enhanced by training in people with Parkinson’s disease: a randomized controlled trial</td>
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<td>Schilling et al 2010</td>
<td>Effects of moderate-volume, high-load lower body resistance training on strength and function in persons with Parkinson’s disease: a pilot study</td>
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<td>Shen &amp; Mak 2012</td>
<td>Repetitive step training with preparatory signals improves stability limits in patients with Parkinson’s disease</td>
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<td>Shulman et al 2013</td>
<td>Randomized clinical trial of 3 types of physical exercise for patients with Parkinson’s disease</td>
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Outcome measures included

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Effects of exercise on falls risk & gait (Allen et al 2010)

48 Participants, who had health/outcome falling or were at risk

Group Exercise
40-60 mins of progressive LL and balance exercises. 3 times a week for 6/12. Once monthly exs group

Random allocation

Usual care

Falls prevention and education advice

FR score, knee extensor strength, balance tests on a sway meter, FOGQ, BBS, FES-I, PDQ-39, fall diary

Attended just over half the exs classes
Completed a mean of 70% of the prescribed exs session
Exs group 7% reduction in falls risk (P = 0.26)
Knee extension strength increased but NS
Improved sit to stand time p = 0.03
Significant improvement in FOGQ p= 0.03
Significant improvement in GI

Longer duration, and functional based exercises
To compare boxing training with traditional exercise

**Boxing Training**
24-36 sessions lasting 90 minutes over 12 weeks. Stretching, boxing (e.g. lateral foot work, punching bags), resistance exercises, and aerobic training.

**Traditional exercise**
24-36 sessions lasting 90 minutes over 12 weeks. Stretching, resistance exercises, aerobic training, and balance activities.

Random allocation

**TUG, 6MWT balance confidence, mobility, gait velocity, gait endurance, and quality of life**

The traditional exercise group demonstrated significantly greater gains in balance confidence, $P < 0.025$.

Boxing group demonstrated significant improvements in gait velocity & endurance.

Both groups demonstrated significant improvements with the balance, mobility, and QoL.
PRE and gait initiation (Hass et al 2012)

N = 18

GRF, stride length, gait speed, muscle strength

PRE exs
GI focus with velocity
Group. Seated Leg press, knee ext, flex, abd curls, back ext, calf raised and ankle exs, 18 sessions over 10 weeks

Randomly allocated

Control

• PRT group significantly improved initial stride length, gait initiation and gait velocity
• Improvements noted in FOG
• No improvements within the control

PRT group – considerably long disease duration but comparable age
Machine based
Lower Leg Muscle Power (Paul et al 2014)

40 Participants

Power training (24)
Muscle power training in pairs
Supervised by a physiotherapist
2 x week for 12/52
Maintain usual activities

Sham Exercise (24)
Independent low intensity exercise
Fortnightly phone calls
2 x week for 12/52 at home
Maintain usual activities

Random allocation

10MWT, TUG, muscle power, SLS, walking speed

- Good adherence
- Significant improvement in hip ext, flex and abduction strength 9P= 0.002, 0.01, 0.001 resp)
- Trend to improved TUG (p=0.13)
- NS result for falls rate
- No improvement in gait variables

MP deficits can be reduced with targeted short term power training
Lack of resistance lead to reduction in MP
Training specificity
**Effect of moderate, high load resistance training** (Schilling et al 2010)

Effects of moderate volume, high load 8 week resistance training on lower body strength and functional mobility

**Training group**
- 3 sets of 5-8 reps for the leg press, seated curl, calf press, twice weekly, n = 9

**Control group**
- Usual care
  - n = 9

**Random allocation**

- 1RM, Activities specific balance confidence scale, TUG, 6MT

**Significant increase in the leg press** (p = 0.001)
- Absolute strength increased by 25%
- No change in control, remain stable
- No change to TUG, 6MWT, or balance

**No functional improvements**
- Machine based
- In a gym
- Suggestive of no higher level skill acquisition
Balance and gait training (Shen and Mak 2014)

To explore whether balance and gait training with augmented feedback enhances balance confidence.

**Balance Group:**
Balance and gait training with feedback for 12 weeks.

**Control group:**
LL strength training for 12 weeks.

**4 weeks in lab supervised 3 session per week**
4 weeks at home unsupervised
5 times a week
4 weeks in lab

**Activities specific balance scale, SLS, limit of stability test, GaitRite**

- 6% increase in ABC score p = 0.025 and again at 3 (10%) and 12 (7%) months
- Both groups improved stability but only balance group maintained this at 3 months
- Both groups improved gait velocity
  Balance gp by 7% & Con gp by 9% and maintained at 3 and 12 months
- Only balance gp improved SL, which was maintained at 3 & 12 months

**Impact of feedback**
Targeted many of features of PD
Intense
Good compliance
Combined approach
3 different types of exercise (Shulman et al 2013)

To compare the efficacy of treadmill exercises, and stretches and resistance exercises in improving gait speed, strength and fitness

High intensity TT (23)
30 mins 70-80% HR reserve
3x per week for 3 months

Lower intensity TT (22)
30 mins 40-50% HR reserve
3x per week for 3 months

Stretching & resistance exs 2
set of 10 reps incidence, leg press, leg extension and curl
3x per week for 3 months

6MWT, VO2 max, and muscle strength (1RM)

- All 3 groups improved 6MWT, although only low Tt (12%) and exs group (9%) were significant
- Both TT Improved Cv fitness
- Exs group statistically significant imp in strength
- No change in the UPDRS
- No imp in depression, fatigue or QoL

Exercise can improve gait speed, strength and fitness in PD
Combined approach may be better
Conclusions

• Heterogeneity of the studies
• Strength gains can be achieved
• Functional closed-chain progressive bodyweight exercises may be most effective
• A frequency of 2-3 times per week using 2x(8-10) repetitions for at least 12 weeks
• Further work
Physiotherapy

- Hydrotherapy
- Group Exercise
- Dual Task Training
- High Intensity Training
- Balance Training
- Technology Assisted Training
- Tia Chi
- Novel
- Education
- Aerobic Training
- Treadmill Training
- Cueing

EU, NICE, and Dutch guidelines 2014, 2006, 2004 resp
Cueing

Auditory
- Bypass the internal rhythm deficit in the BG, providing this rhythm of a voluntary basis

Visual
- Utilising the visual cerebellar pathways bypassing the BG

Sensory
- Utilises the dorsolateral Pre motor control areas so bypassing the automatic pathways which go the via the SMA
• Undertook a Meta analysis which reviewed all studies which have studies the effectiveness of cueing, n =10
• Cueing results in improvements in Stride length, step length, speed, and cadence
• Visual provide better improvement in cadence
External Cueing (Rocha et al 2014)

• Sensory cues decrease cadence, but increase speed and stride length

• Combined cueing with auditory and visual also show improvements in the UPDRS and freezing

Little literature into functional benefit, or impact on QoL
Tai Chi, Yang et al (2014)

• Evaluated the evidence of the efficacy of PD, in particular motor function, balance and gait.

• N = 8

• Improvements in motor function as measured by UPDRS III

• But does not support or refute it in comparison to other therapies
Tai chi, Yang et al (2014)

- Effect at improving balance.
- Better improvements with the BBS compared to other therapies
- Not effective in gait parameters
- Improvements in functional mobility

Little benefit on walking, aerobic capacity, and muscle strength
Aerobic exercise  (Shu et al 2014)

- Systematic review incorporating 18 studies totalling 901 PwPD
- Age 67+/-303 years
- PD Duration 6.4 +/-2.7
- Only 2 studies looking at stages I-IV
Aerobic exercise  (Shu et al 2014)

• Improvements in UPDRS III
• Some effect on balance
• Superior effects at improving gait
  - all spatiotemporal gait parameters
  - 6MWT
• No difference when compared with other therapies for QoL
So where does this leave us?

We know that improvements can be made in:

- Strength
- Power
- Flexibility
- Balance
- Gait

What we don’t know:

- Which type of exercise would be best?
- Combined approach would seem best but which forms of exercise?
- At what prescription?
- How long will it last?
ParkFit (Speelman et al 2014)

540 sedentary PwPD

- Activity Coaches
- Educational workbooks & health contract
- Joint Goal setting
- Activity monitor
- Individual PT

LAPAQ, UPDRS, H&R, Disease duration, PDQ-39, TUG, NHPT, FSS, HADs, 6MWT, BMI, L-dopa

63% Physical Limitations

Effective:
- Sedentary people
- Women
- Higher disease severity
- Shorter disease duration
- Older

ParkFit 34% more active than controls

Behavioural change
PRE (Prodoehl et al 2015)

48 PwPD

UPDRS, MPPT, sit-stand, FR, TUG, BBS, walking speed

1:1 training twice weekly for 6 months, once weekly thereafter. Second session independent. Sessions last 60-90 mins

Randomly allocated

PRE Programme
- 11 Ul & LL strengthening exs
- 30-40% IRM for UL
- 50-60%1RM LL

Fitness Counts programme
- Stretching
- Non progressive strengthening
- Balance & breathing

Data collected at baseline, 6, 12, 18 and 24 Months

Statistically significant improvements in all Physical measures except 6MWT

No difference between groups

Varied approach to exercise prescription targeting multiple muscles, including motor and non motor components
Ideal world

- Aerobic
- Functional
- Behavioural
- Speed and directional
- Balance
How can we do it

- Well designed research methodologies
- Larger sample sizes
- Research function
- More research trials
My research
• Referral and access to Physiotherapy
• Physical activity
• Measurement of function
• Perceptions of physiotherapy
• Service provision
Aims

- To determine
  - Level of access to specialist PD physiotherapy
  - Proportion of patients referred
  - Timing of referral
  - Perceived role of physiotherapy
  - Factors which influence referral
Results

• Access to specialist services
  – Physiotherapy 33%
  – PDNS 79%

• Access and referral to physiotherapy

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<th>Chi²</th>
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<td>39%</td>
<td>23%</td>
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<td>Refer (&gt;50%)</td>
<td>69%</td>
<td>4%</td>
<td>p&lt;0.001</td>
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Referrals by Stage

p=0.007

NS

NS

NS

Disease Stage (McMahon and Thomas)

Geriatricians
Neurologists
Factors Influencing Referral

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<td>Other Please state</td>
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Factors Influencing Referral

- Gait: p<0.001
- Weakness: p<0.001
- Posture: p<0.001
- Tolerance: p=0.010
- Bradykinesia: p<0.001
- Rigidity: p<0.001
- Turning: p=0.061
- Anxiety: p=0.003

Bar chart showing the percentage of referrals by geriatricians and neurologists for various factors, with p-values indicating statistical significance.
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Summary

• One-third of consultants have access to specialist physiotherapy
  – Geriatricians more likely to refer

• Referrals
  – High in maintenance and complex stages
  – Low in palliative stage
  – Low neurologist referral in early stage
Summary

• Variation in perceived role of physiotherapy
  – Perceived role in education
  – But not drug education
Physical Activity