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UHN Toronto Rehabilitation Institute

# A smartphone app for post Stroke Arm Recovery

Steven Wolf
Gert Kwakkel
Michelle McDonnell
Mark Bayley

VUmc VU University Medical Center Amsterdam

University of South Australia

# OBJECTIVES

**By the end of the presentation, participants should be able to:**

1. **Discuss strategies for predicting recovery of the arm post stroke**
2. **Use a smartphone app to identify the best practices for each stroke patient depending on the time post-stroke and their severity of impairment**

# Case study 1 - Kevin

- 56 yr old man suffered
- R middle cerebral artery territory ischemic stroke on February 20 2017

# Current arm function

- Shoulder shrug and some active shoulder flexion
- Movement patterns dominated by compensatory trunk lean and shoulder shrug and no active hand movement
- Experiences pain at rest, during night and on external rotation
- No swelling or significant spasticity
- No finger extension

# Case Scenario

- What is probability of Kevin having some hand dexterity at 6 months
- What treatments are evidence based for Kevin at this stage

# Historical Perspective

- March 10, 2010 –Nottingham – Grantham – Norwich (UK) ……Wolf, van Vliet, Pomeroy
- March 24, 2010 – Canadian Stroke Network (Ottawa, Canada)
- April – September, 2010 ---assemble team
- October 24, 2010 – Wolf/Bayley ASNR/ACRM meeting, Montreal)
- October 2011 – review stroke guidelines (Canada, USA, UK, Scotland, The Netherlands, Australia, New Zealand)
- October 2011 – define working groups to seek evidence (PEDro, PubMed, Cochrane, etc.) and define interventions; Outcome group to define associated outcomes

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# Historical Perspective: continued

- 2011-2013: meet annually for updates and multiple international Web EX calls
- 2014: Bayley secures funds for securing app company
- 2015: App prototype completed
- April 10 2017 Launch on the App store and Google play

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# Developing the Algorithm

| | | |
|---|---|---|
| Janice Eng, PhD, OTR, PT | University of British Columbia, Canada | 1 |
| Carol Richards, Ph.D., PT | Laval University, Canada | 1 |
| Sarah Blanton, DPT | Emory University, USA | 2 |
| Michelle, McDonnell, PhD, PT | University of South Australia<br>Australia | 2 |
| Marilyn MacKay-Lyons, PhD, PT | Dalhousie University, Canada | 3 |
| Gert Kwakkel, Ph.D | Vrije University Medical Center<br>The Netherlands | 3,6 |

# Developing the Algorithm

| | | |
|---|---|---|
| Carolyn Baum, Ph.D, OTR/L | Washington University, USA | 4 |
| Lisa Connor, Ph.D, OTR/L | Washington University , USA | 4 |
| Katherine Lang, PhD, PT | Washington University, USA | 4 |
| Nancy Salbach, Ph.D. PT | University of Toronto, Canada | 5 |
| Carolee Winstein, PhD, PT | University of Southern California, USA | 5 |
| Mindy Levin, PhD, PT | McGill University, Canada | 6 |
| Mark Bayley, MD | University of Toronto, Canada | 6 |
| Charlotte Hager, PhD | University of Umea, Sweden | 6 |

# Developing the Algorithm

| | | |
|---|---|---|
| Cathy Stinear, Ph.D. | University of Auckland, New Zealand | 7 |
| Leanne Carey, PhD, OT | La Trobe University, Australia | 7 |
| Judith Deutsch, Ph.D., PT | Rutgers University, USA | 7 |
| Paulette van Vliet, PhD, PT | University of Newcastle, Australia | 8 |
| Valery Pomeroy, Ph.D., PT | University of Norwich, UK | 8 |
| Steven L. Wolf, Ph.D., PT | Emory University, USA | 8 |
| Catherine Salter, PhD, PT | University of Western Ontario Canada | ALL |
| Robert Teasell, M.D. | University of Western Ontario Canada | ALL |
| Total Team | | ALL |

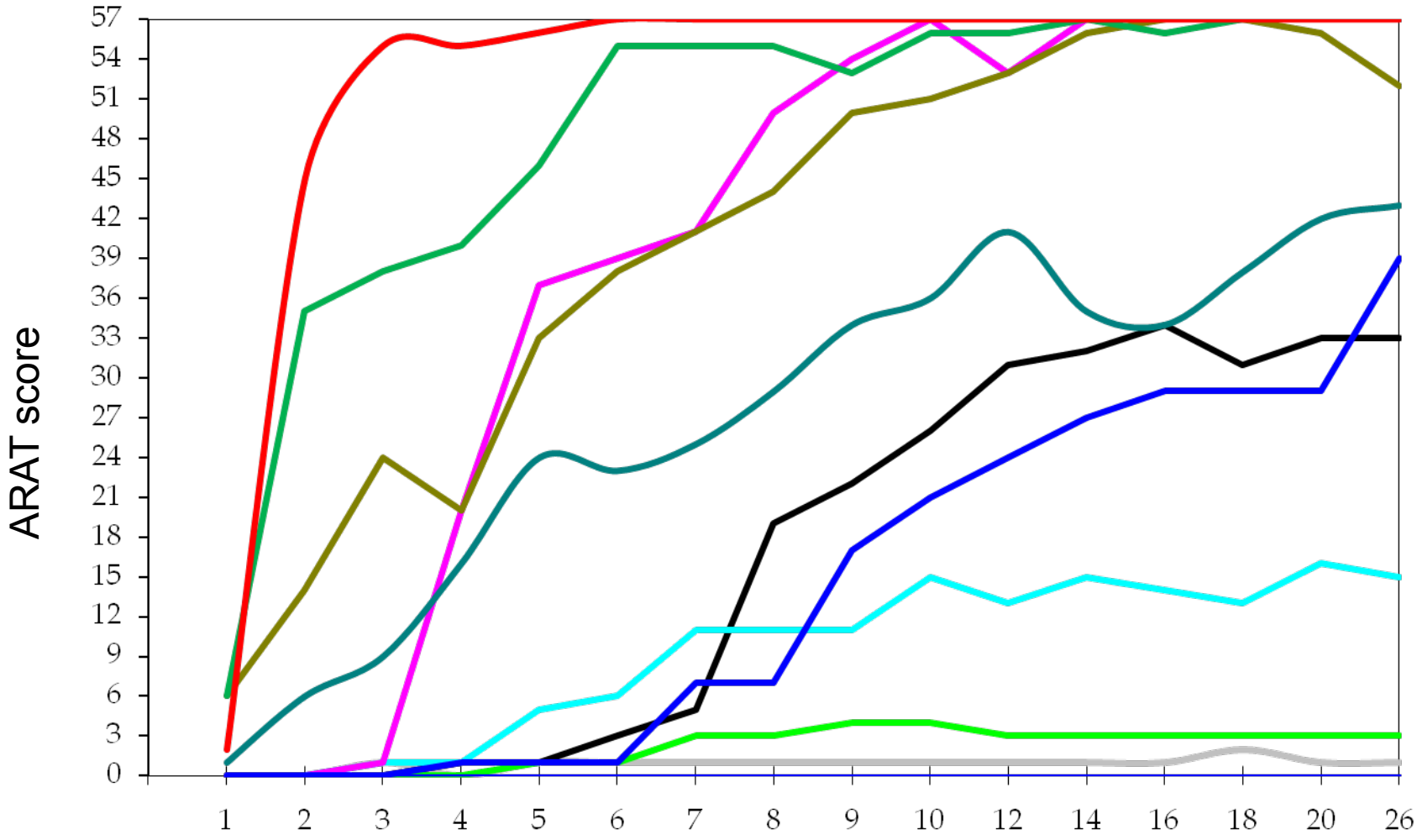
# Developing the Algorithm

| Contributing clinicians and scientists: | | |
|---|---|---|
| Catherine Buetefisch, MD, PhD | Emory University | |
| John Chae, MD | Case Western Reserve University | |
| Alex Dromerick, MD | Georgetown University | |
| Pamela Duncan, PhD, PT | Wake Forest University | |
| Mark Goldstein, E ED | APTA | |
| Ralph Nitkin, PhD | NIH | |
| Nicole Korner Bitensky, PhD, OTR/L | McGill University | |
| W. Zev Rymer, MD, PhD | Northwestern University | |
| Krish Sathian, MD, PhD | Emory University | |
| Susan Baracca, PhD, PT | McMaster University | |

# Objective 1

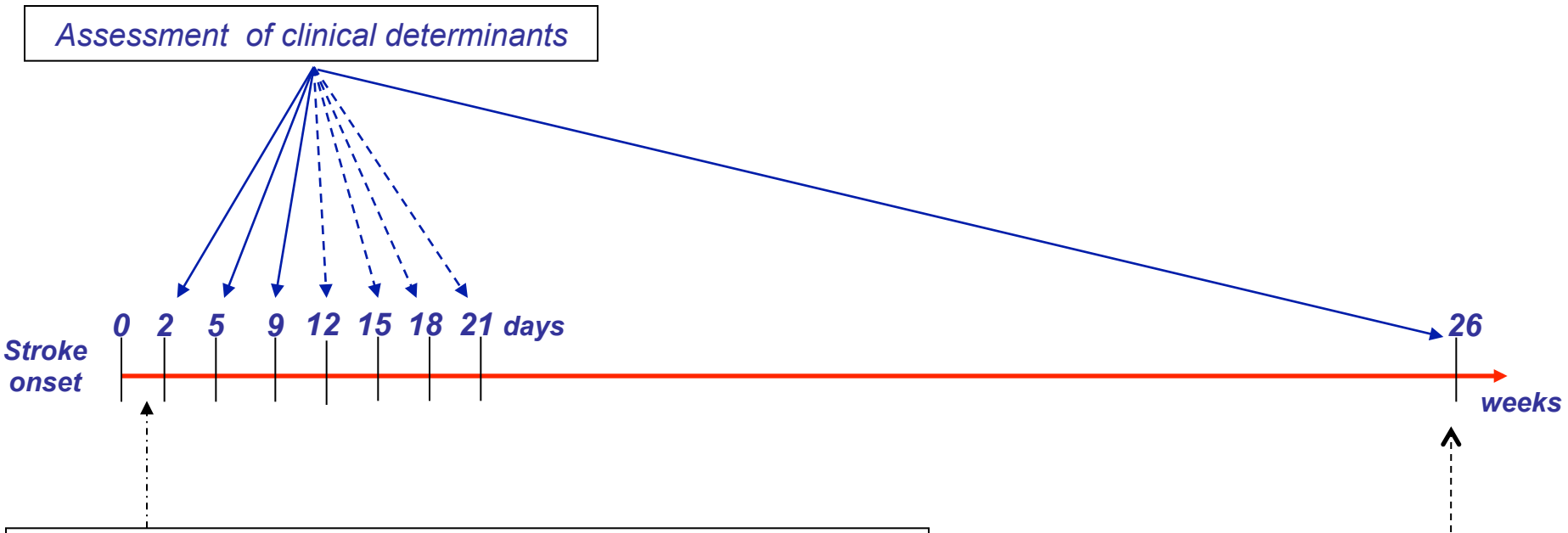
- **Discuss strategies for predicting recovery of the arm post stroke**

# Random selection of patients with an upper limb paresis post stroke (N=10)




**Courtesy of G. Kwakkel (2015)**

# The EPOS cohort study (9 hospital stroke units)




*Inclusion criteria:*

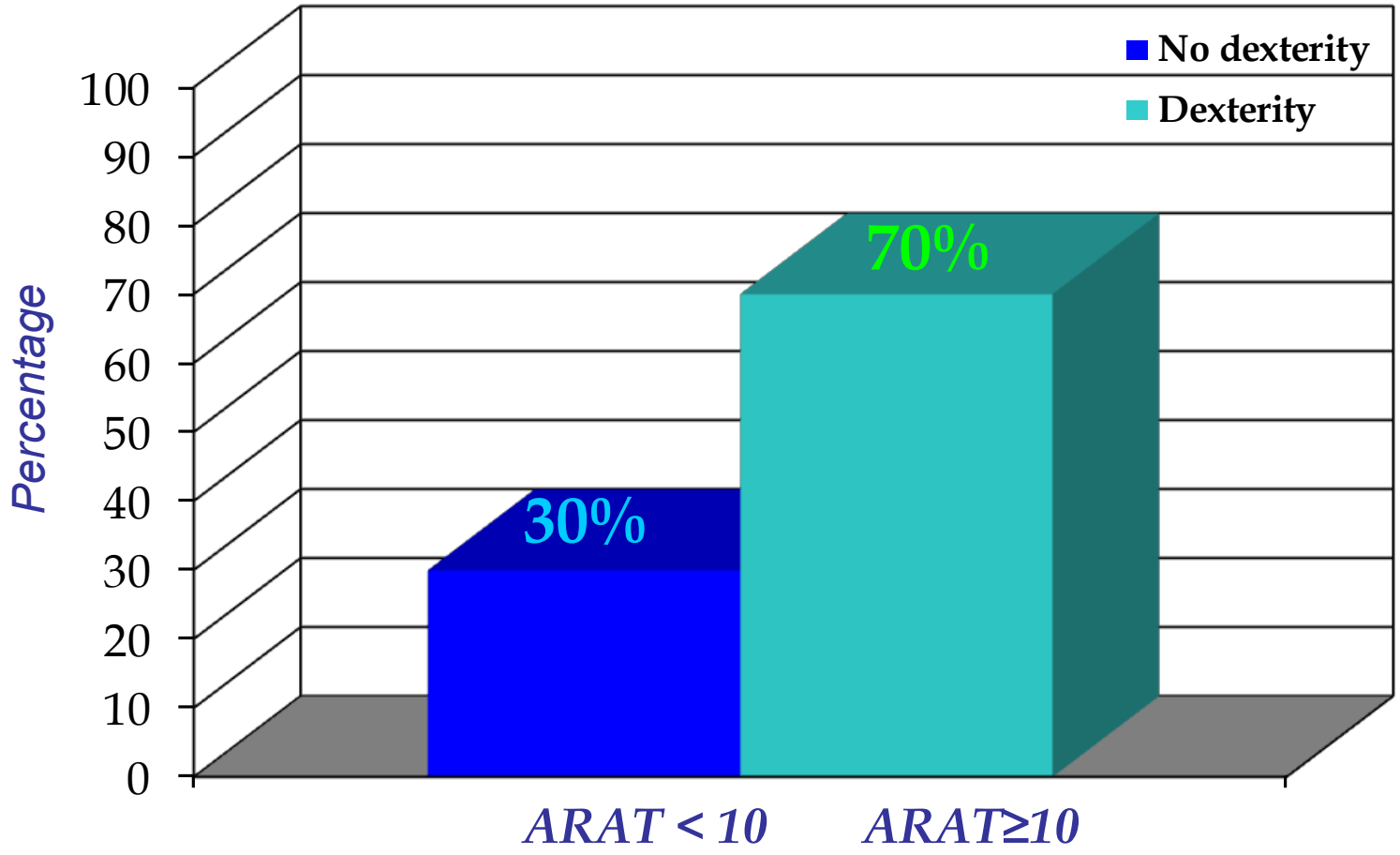
- *Diagnosed with an ischemic, first-ever hemispheric stroke;*
- *Type and localization determined by CT or MRI scan;*
- *Suffering from monoparesis or hemiparesis*
- *First assessment < 72 hours post stroke;*
- *No or unsuccessful rTPA;*
- *No pre-morbid disability (BI ≥19);*
- *18 years or older;*
- *Able to understand and provide verbal or written informed consent to participate.*

Outcomes:

**Upper limb (ARAT)**

*Nijland RH et al, Stroke 2010;41(4):745-50.*

# Outcome on ARAT 6 months post stroke (N=188)




Nijland RH et al, Stroke 2010;41(4):745-50.

# Probabilities of achieving some dexterity at 6 months after stroke (N=188)

ARAT ≥ 10 at 6 months

| Finger Extension | Shoulder Abduction | True Negatives N | False Negatives N | False Positives N | True Positives N | Prob. |
|---|---|---|---|---|---|---|
| **Model at day 2:** | $P=1/(1+1*(EXP(-1.119+2.807*X_1+2.149*X_2)))$ | | | | | |
| FM-FE ≥1 | MI-SA ≥9 | | | | | |
| + | + | 38 | 12 | 8 | 98 | 0.98 |
| + | - | | | | | 0.89 |
| - | + | | | | | 0.71 |
| - | - | | | | | 0.25 |

*34% full recovery*

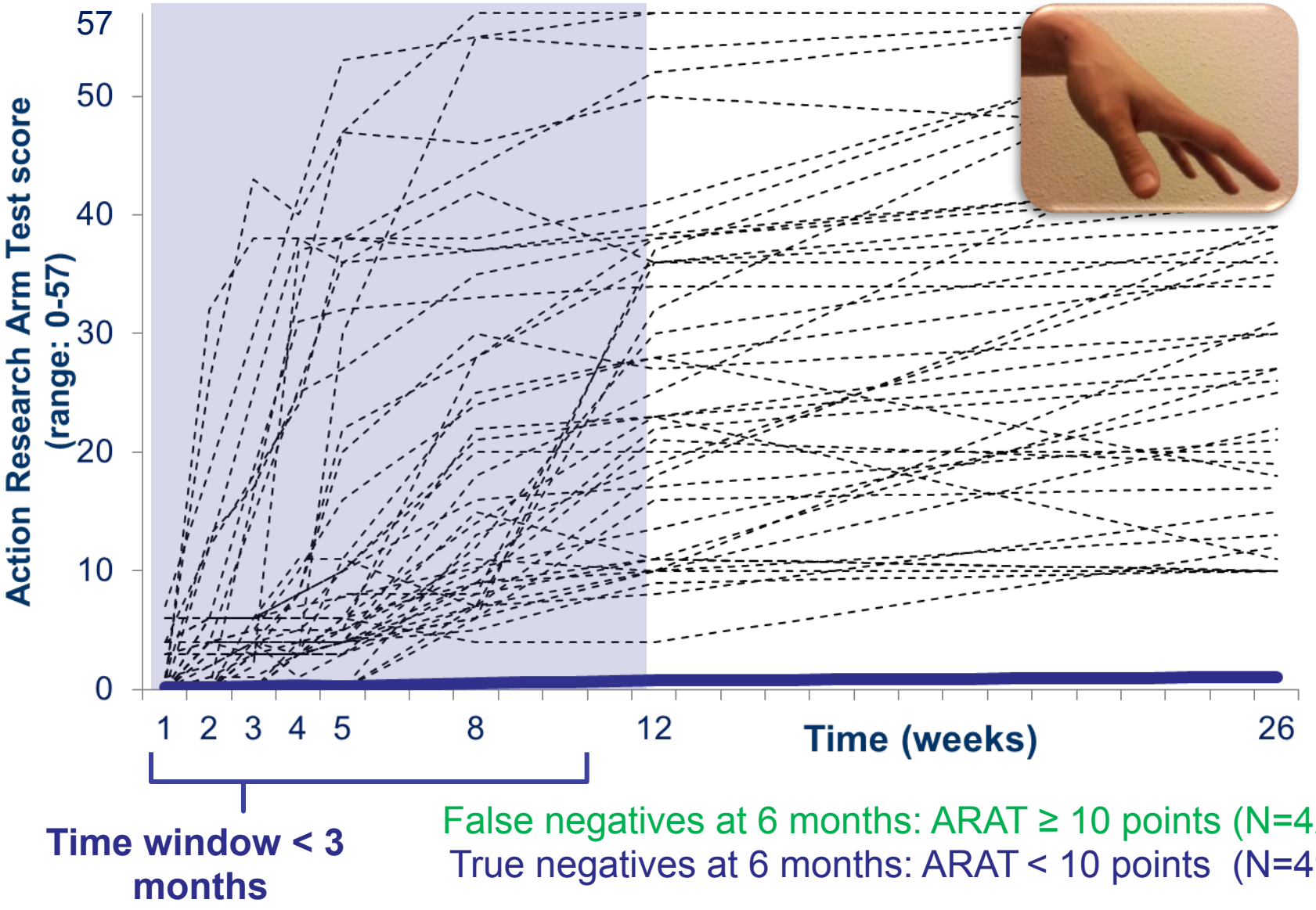
*Nijland RH et al, Stroke 2010;41(4):745-50.*

## Probabilities of achieving some dexterity at 6 months after stroke (N=188)

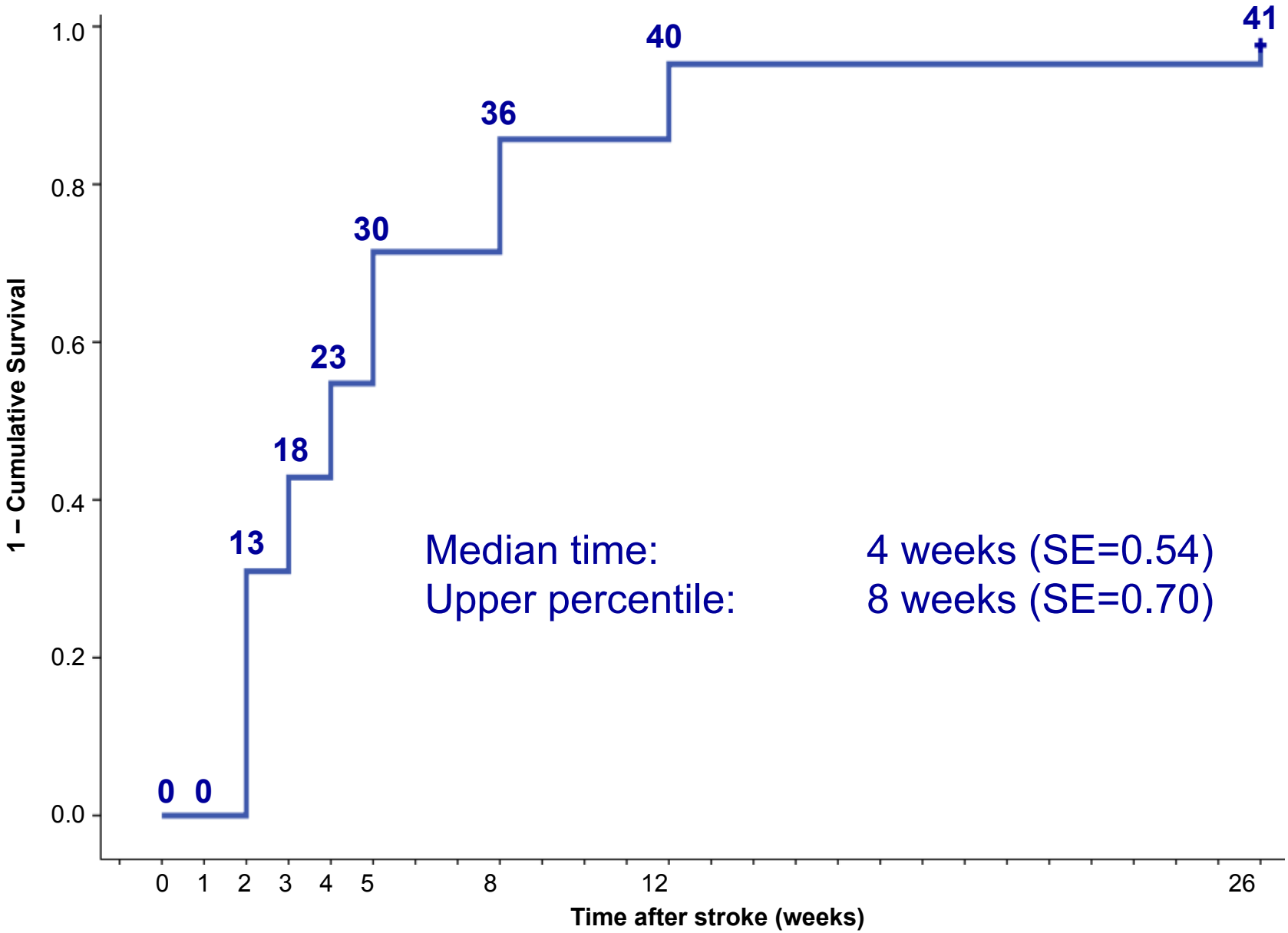
| Finger Extension | Shoulder Abduction | True Negatives N | False Negatives N | False Positives N | True Positives N | Prob. |
|---|---|---|---|---|---|---|
| **Model day 5** | | | $P=1/(1+1*(EXP(-1.874+3.070*X_1+3.075*X_2)))$ | | | |
| FM-FE ≥1 | MI-SA ≥9 | | | | | |
| + | + | 38 | 6 | 8 | 104 | 0.98 |
| + | - | | | | | 0.78 |
| - | + | | | | | 0.78 |
| - | - | | | | | 0.14 |
| **Model day 9** | | | $P=1/(1+1*(EXP(-1.815+3.224*X_1+2.449*X_2)))$ | | | |
| FM-FE ≥1 | MI-SA≥9 | | | | | |
| + | + | 38 | 6 | 8 | 104 | 0.98 |
| + | - | | | | | 0.80 |
| - | + | | | | | 0.65 |
| - | - | | | | | 0.14 |

*Nijland RH et al, Stroke 2010;41(4):745-50.*

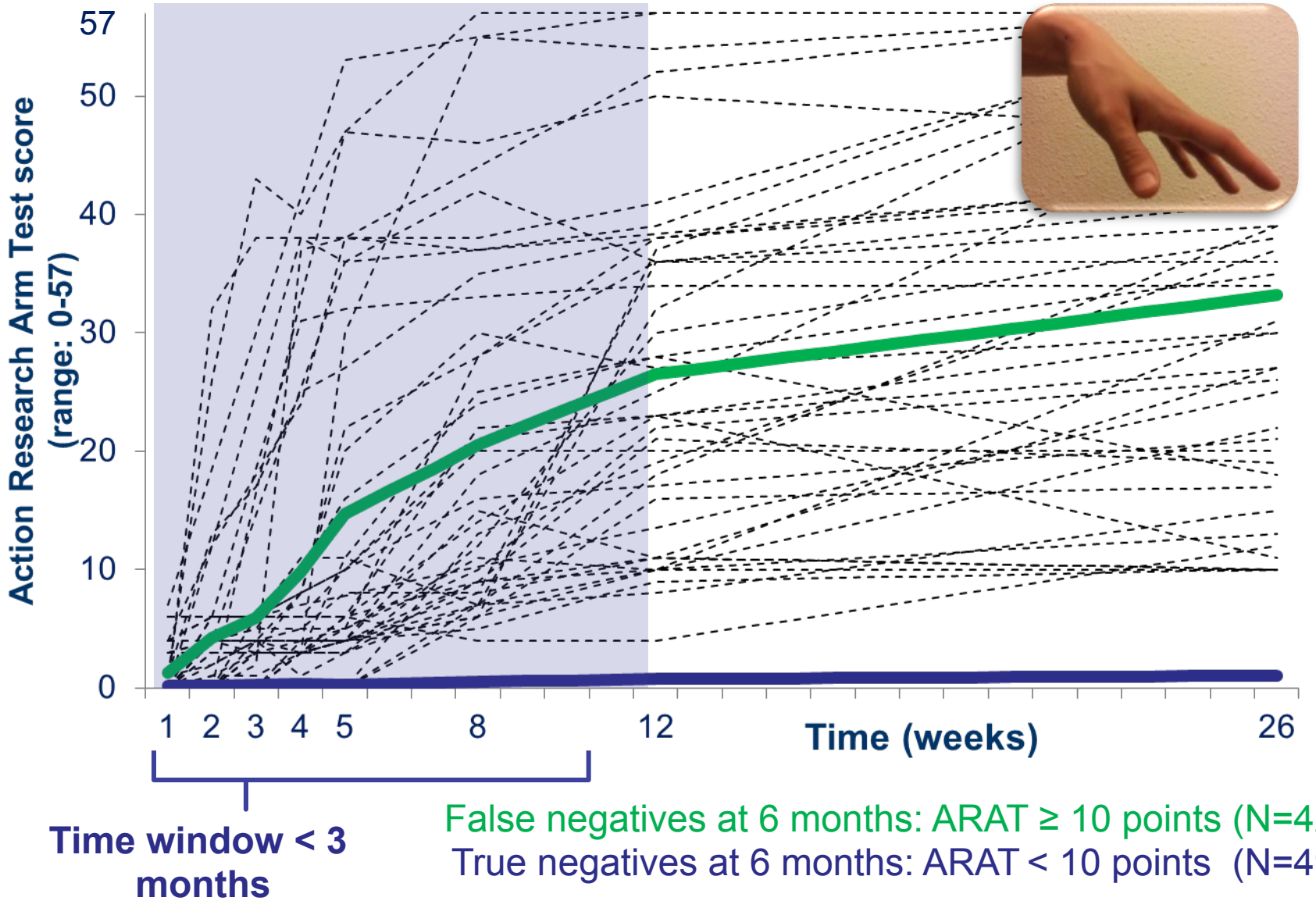
# Return of voluntary finger extension: Prognosis for recovery of upper limb capacity (N=91)



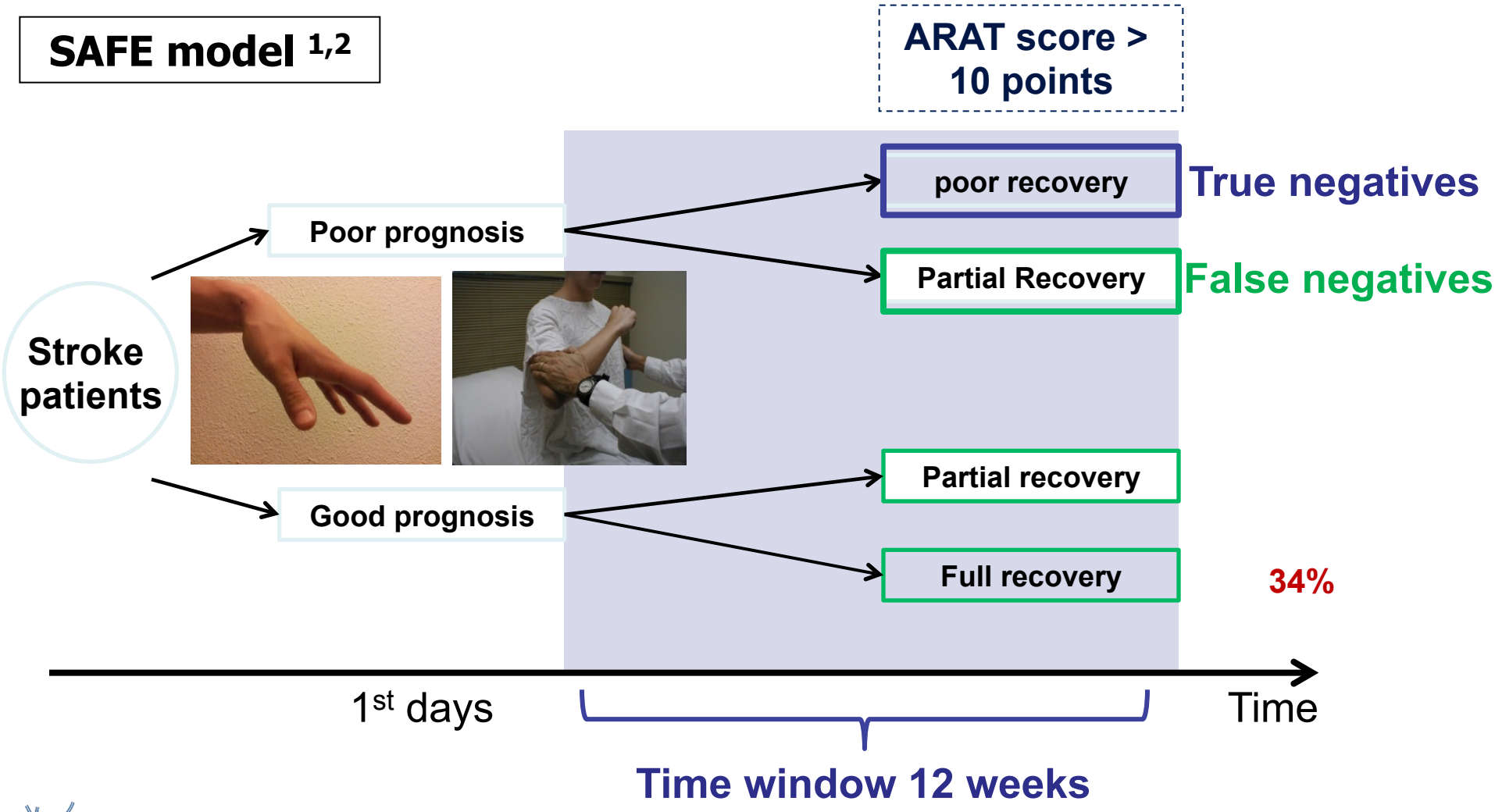
# Kaplan-Meyer curve for return of voluntary finger extension (N=42)



# Return of finger extension: Prognosis for recovery of upper limb capacity (N=91)



# Prognosis for recovery of upper limb capacity following ARAT





1 Nijland et al. Stroke 2010:41(4):745-750;
2 Stinear et al. Lancet Neurol 2010;9:1228-1232;
Winters et al. [in preparation]

# Iddentifying false negatives in those with an initial prognosis following SAFE (N=91)

- Multivariable regression analysis
- Probabilities of regaining upper limb capacity at 6 months

| Lower limb motor function (MI) | Visuospatial neglect (LCT) | Somatosensory deficit (EmNSA) | Predicted probability |
|---|---|---|---|
| **Good** | **No** | **No** | **0.94** |
| **Poor** | **Yes** | **Yes** | **0.04** |

MI: Motricity Index leg; cutoff: 35 points;
LCT: Letter Cancellation Test, cutoff: asymmetry 2 points;
EmNSA: Erasmus MC modified Notthingham Sensory Assessment, cutoff 33 points.

# OBJECTIVE 3

**Use a smartphone app to identify the best practices for each stroke patient depending on the time post-stroke and their severity of impairment**

# Decision making process

- Why an algorithm?
  - Decision  making process
  - Based on clear assessment criteria, chosen because of the prognostic indicators
  - Considered the evidence for interventions in the early rehab phase (up to 12 weeks), then after this when rehab may be provided in a less intense manner

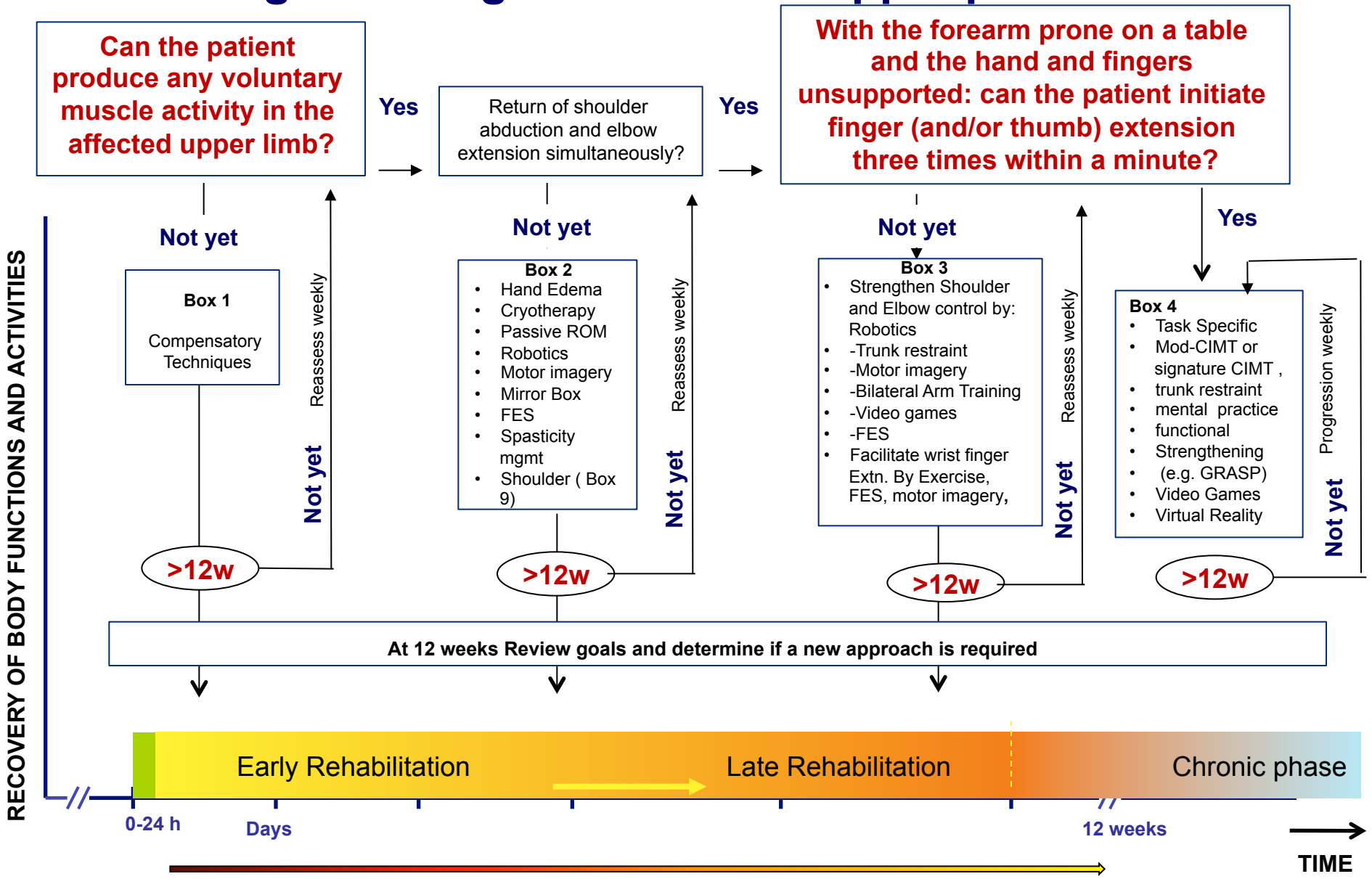
# App Development

- Interviewed 5 app developer groups
- Selected Pivot Design Group (www.pivotdesigngroup.com ) in Toronto because of their experience in app development in Health
- Worked with them to develop a prototype to show to team members for feedback

# App Developers role

- User Experience- interviewed therapists
- Developed prototype designed for smartphones that could be used nearby the patient
- Excellent awareness of how to incorporate considerations like tailoring the evidence using “filters”
- Advised on role of icons and star system

# Prognostic algorithm for the upper paretic limb




Courtesy of G. Kwakkel

# Post Stroke Arm Algorithm

Can the patient produce any voluntary muscle activity in the affected upper limb?

Yes

In a seated position, can the patient produce any shoulder abduction, and/or produce any elbow extension?

Yes

With the forearm prone on a table and the hand and fingers unsupported, can the patient initiate finger (and/or thumb) extension three times within a minute?

Yes

Not yet

**Box 1**
Compensatory Techniques
Hand Edema
- Passive ROM

FES-
Spasticity mgmt
US Neglect
Mirror Box
Shoulder ( Box 9)

Reassess weekly

Not yet

>12w

Not yet

**Box 2**
Hand Edema
- Cryotherapy
- Passive ROM

Robotics
Motor imagery
Mirror Box
FES
Spasticity mgmt
Shoulder ( Box 9)

Reassess weekly

Not yet

>12w

Not yet

**Box 3**
**Strengthen Shoulder and Elbow** control by:
Robotics
-Trunk restraint
-Motor imagery
-Bilateral Arm Training
-Video games
-FES
**Facilitate wrist finger Extn. By** Exercise, FES, motor imagery**,**

Reassess weekly

Not yet

>12w

Yes

**Box 4**
Task Specific
Mod-CIMT or signature CIMT , trunk restraint
mental practice
functional Strengthening
(e.g. GRASP)
Video Games
Virtual Reality

Progression weekly

Not yet

>12w

Box 9
(applicable to all
Shoulder Pain
prevention and
management

At 12 weeks Review goals and determine if a new approach is required

Can the patient produce any voluntary muscle activity in the affected upper limb?

Yes

In a seated position, can the patient produce any shoulder abduction against gravity, and/or produce any elbow extension without gravity?

Yes

With the forearm prone on a table and the hand and fingers unsupported, can the patient initiate finger (and/or thumb) extension three times within a minute?

Yes

Not yet

**Box 5**
Compensatory Techniques
Hand Edema
- Cryotherapy
- Passive ROM

FES
Strengthening
Shoulder prevention ( Box 9)

Not yet

**Box 6**
Mirror Box
Hand Edema
- Passive ROM

Bilateral UE task
FES
Spasticity mgmt.
Strength/Cardio
Shoulder (Box 9)

Not yet

**Box 7**
**Strengthen Shoulder and Elbow control by**: Robotics
-Trunk restraint
-Motor imagery
-Bilateral Arm Training
-Video games
-FES
**Facilitate wrist finger Extn by** Exercise, FES, motor imagery**,**

**Box 8**
Task Specific Training
CIMT,
trunk restraint
mental practice
functional Strengthening
(e.g. GRASP)
Videogames and VR
Self management

During late phase goal Achievement and progress must be reviewed regularly to determine if progress is still being made if not convert to independent program

# Step 1

Can the patient produce any voluntary muscle activity in the affected upper limb?

Yes, or not yet?

# Step 1

Can the patient produce any voluntary muscle activity in the affected upper limb?

Yes, or not yet?

- Determined on initial assessment, in any position

# Step 2

In a seated position,  can the patient produce any shoulder abduction against gravity?

Yes, or not yet?

# Step 3

With the forearm prone on a table and the hand and fingers unsupported, can the patient initiate finger (and/or thumb) extension three times within a minute?

Yes, or not yet?

# The interventions

- Reviewed the research evidence from a number of sources
  - Strokengine has already reviewed the literature
  - Compiled lists of interventions based on expert opinion from the working party
  - Each working group further reviewed the literature, new searches until March 2015

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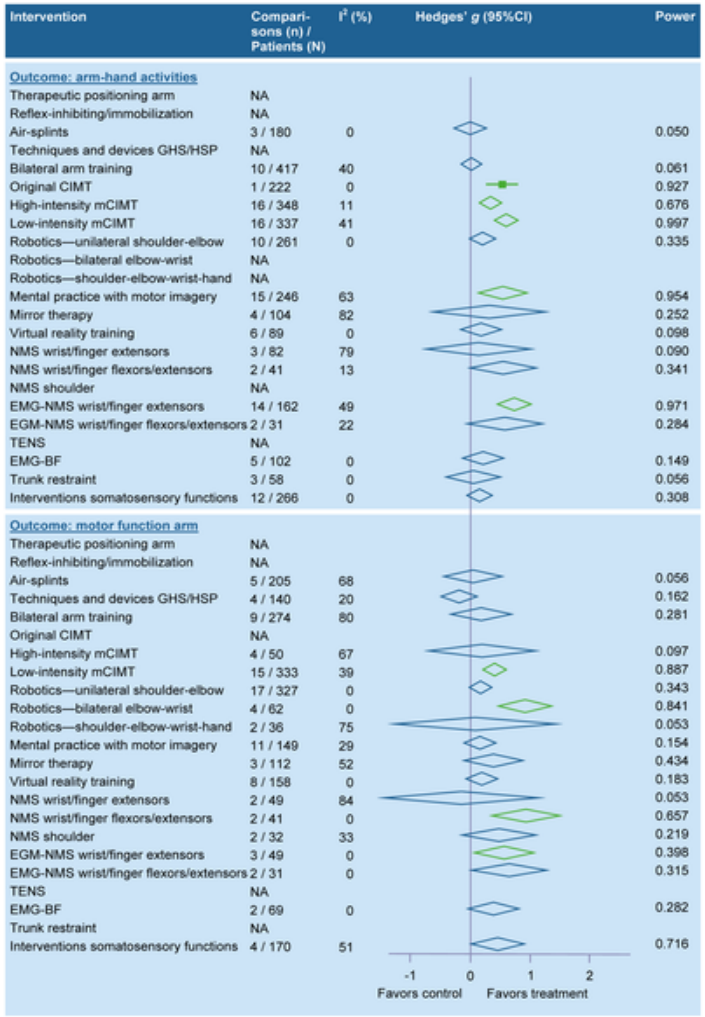
# Figure 3. Summary effect sizes for physical therapy interventions – arm-hand activities.




**Veerbeek JM**, van Wegen E, van Peppen R, van der Wees PJ, Hendriks E, et al. (2014) What Is the Evidence for Physical Therapy Poststroke? A Systematic Review and Meta-Analysis. PLoS ONE 9(2): e87987. doi: 10.1371/journal.pone.0087987 http://127.0.0.1:8081/plosone/article?id=info:doi/10.1371/journal.pone.0087987

PLOS ONE

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# Evidence

| Level of Evidence Grading System for Recommendations | |
|---|---|
| **A** | At least one randomized controlled trial, meta-analysis, or systematic review |
| **B** | At least one cohort comparison, case studies or other type of experimental study. |
| **C** | Expert opinion, experience of a consensus panel |
| **NE** | No evidence provided. |

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# Generating "Outcomes" for Interventions within each "box"

- **Create Outcomes Working Group chaired by Bob Teasell, M.D. (EBRSR).**
- **Review outcomes associated with every paper for each intervention for which substantial levels of evidence were deemed high by each group charged with reviewing evidence for interventions within its "box".**
- **Prioritize suggested outcomes based upon the context for how outcomes used in those studies and affirming evidence to support their validity and appropriateness.**

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# Weblink

- Go to: weblink viatherapy.org

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# Case study 1 - Kevin

- 56 yr old man suffered R middle cerebral artery territory ischaemic stroke on 4/2/15
- UL goals
  - Achieve independence with dressing, showering
  - Use L arm for meal preparation
  - Maintain active and passive ROM L arm

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# Current function

- Shoulder shrug and some active shoulder flexion
- Movement patterns dominated by compensatory trunk lean and shoulder shrug
- Experiences pain at rest, during night and on external rotation
- No swelling or significant spasticity

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# Kevin

# Case study 2 - Mik

- 82 yr old man suffered R middle cerebral artery territory ischaemic stroke on 16/3/15
- UL goals
  - Eat with cutlery and feed himself
  - Dress himself independently
  - Return to making things in his shed

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# Current function

- Active shoulder Flexion and Abduction
- Weaker proximally than distally
- Good sensation, no increased muscle tone
- Able to perform some fine motor tasks but slow and poor coordination

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# Mik again

In a seated position,  can the patient produce any shoulder abduction against gravity?

Yes, or not yet?

# Mik

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# Questions

- What are the key treatments
- What are the contraindications
- What is the dose
- What are outcome measures for this intervention

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# Filters

- Add Filters
- Can be administered in a group

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# Conclusions

- The prognostication  for arm recovery is possible early post stroke using shoulder abduction and finger extension but most evident by 12 weeks
- The viatherapy app provides clinicians with guidance based on stage of recovery and time post stroke

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