laevo
exoskelet

www.laevo.nl

achmea

the Assignment:
find a solution for
work related back
pain problems
within healthcare

the Balance Box

MSc B. Wisse

MSc R. Barents

intespring

2004 – the idea; making stuff weightless

2008 – the Balance Box

2009 – the BalanSeat for Crane Cabins

2010 – the Cockpit for TU Delft

2011 – the SpringUp – Stand up Chair

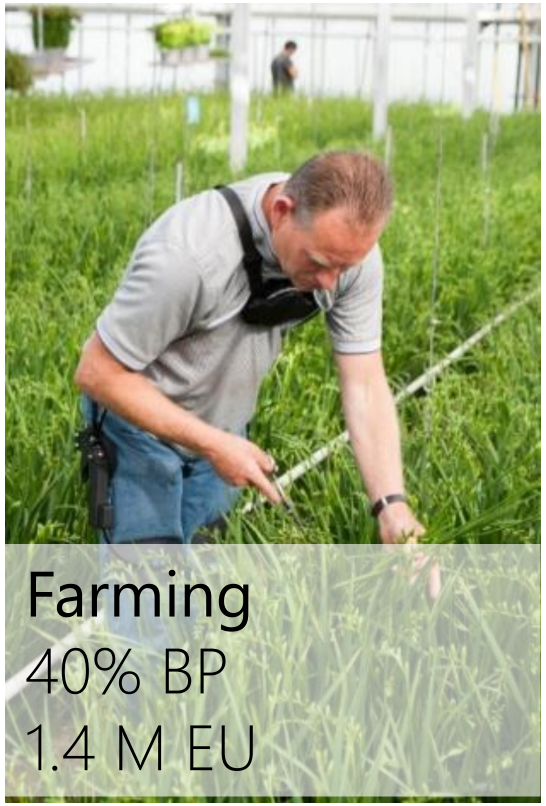
2013 – the Laevo, and the Exobuddy

MORE ENERGY, LESS BACK PAIN

the wearable solution to posture related back pain

laevo

Back pain is worldwide **biggest burden.**
Mostly caused by forward posture / **bending and lifting** at work.



BP = Back pain % = 3 month prevalence.
EU = Estimated EU size

Prototype 2010
InteSpring & TU Delft

USP: Extremely user friendly - Easy to use, implement and maintain. Do all movements in your job as usual (no sitting).

Wear like a coat

No batteries/external power

bend at the hip and squat

modular composition for
a perfect fit for everyone

2 patents (pending)

Enjoy freedom of movement


Tijdschrift voor
jaargang 40 - nr. 1 - maart 2015
HUMAN FACTORS
Nieuw bestuur Human Factors NL stelt zich voor
Innovatieve rugondersteuning
Tastillusies: systematische fouten in onze waarneming
Sitting - bad for your health?

Afbeelding 3. Testopstelling, op het scherm is de output van de Ergomix te zien, gebruikt als middel om de romphoek te controleren. Foto: Tim Bosch.

experiment gecontroleerd met visuele observaties. Door middel van groene-scherm-filmtechnieken (Ergomix, Hallbeck et al., 2010) werd de proefpersoon op een televisiescherm geprojecteerd. Hierop werden twee parallelle lijnen weergegeven die een hoek van 40 graden maakten met de verticaal. Om te zorgen dat de proefpersoon niet van houding veranderde moest deze tussen de twee parallelle lijnen blijven staan (afbeelding 3) en ontving hij hierover feedback van de onderzoeker. Tevens kon de proefpersoon zichzelf controleren via eenzelfde videoscherm.

Data analyse

Voor de EMG werd het ruwe signaal gefilterd (Bandpass, 10-400Hz) en gesampled met 2000Hz. Vervolgens werd het signaal geanalyseerd met behulp van MATLAB (The MathWorks Inc., Natrick, MA, USA). De gemiddelde, gelijkgerichte amplitude van het EMG-signaal werd berekend van de gehele taak. De amplitude werd gebruikt omdat dit signaal ruwweg evenredig oploopt met de kracht van de onderliggende spier. Echter, deze amplitudes kunnen per persoon sterk verschillen, een amplitude van bijvoorbeeld 10 mV voor persoon A hoeft niet dezelfde kracht te betekenen voor persoon B. Daarom werd er genormaliseerd naar de Maximale Vrijwillige Contractie (MVC) welke voorafgaand aan het experiment werd gemeten. Hierdoor is dan bekend welke amplitude hoort bij de maximale kracht en kan de EMG relatief in termen van kracht of activiteit worden beoordeeld.

De lichaamshoudingdata, verkregen met XSENS, werd gesampled met 120Hz. De gemiddelde romphoek (zoals eerder gedefinieerd) werd eveneens berekend met behulp van MATLAB. De statistische analyse werd gedaan met SPSS (IBM SPSS Statistics 21).

6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ELSEVIER

The effects of a passive exoskeleton on muscle activity, discomfort and endurance time in forward bending work

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ABSTRACT

Exoskeletons may form a new strategy to reduce the risk of developing low back pain in stressful jobs. In the present study we examined the potential of a so-called passive exoskeleton on muscle activity, discomfort and endurance time in prolonged forward-bended working postures.

Eighteen subjects performed two tasks: a simulated assembly task with the trunk in a forward-bended position and static holding of the same trunk position without further activity. We measured the electromyography for muscles in the back, abdomen and legs. We also measured the perceived local discomfort. In the static holding task we determined the endurance, defined as the time that people could continue without passing a specified discomfort threshold.

In the assembly task we found lower muscle activity (by 35–38%) and lower discomfort in the low back when wearing the exoskeleton. Additionally, the hip extensor activity was reduced. The exoskeleton led to more discomfort in the chest region. In the task of static holding, we observed that exoskeleton use led to an increase in endurance time from 3.2 to 9.7 min, on average.

The results illustrate the good potential of this passive exoskeleton to reduce the internal muscle forces and (reactive) spinal forces in the lumbar region. However, the adoption of an over-extended knee position might be, among others, one of the concerns when using the exoskeleton.

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1. Introduction

Work-related musculoskeletal disorders (WMSDs) affect a considerable proportion of the working population. Of all WMSDs 30% are located in the low back region (Eurostat, 2010). Low back pain (LBP) frequently results in sick leave and disability, and thus, puts a large burden on individuals and the society (Goetzel et al., 2003). The development of work-related LBP has been associated with several work factors, among others lifting and carrying of loads and awkward body postures like trunk flexion and rotation (Griffith et al., 2012; Da Costa and Vieira, 2010). Hereto, various preventive measures have been proposed, e.g. the training of workers, the adjustment of work stations, the re-organization of work processes, and the use of mechanical aids like cranes or balancers (Lavender et al., 2013). From the developments of new technologies, other potentially preventive strategies emerge. One of these could be the use of exoskeletons.

An exoskeleton is a wearable device supporting the human to generate the physical power required for manual tasks. Exoskeletons could be useful, when (i) other preventive measures are not feasible, usable or effective, and (ii) where the automation of tasks is not feasible when tasks constantly change (e.g. the job of movers, unloading loose loads from containers, patient handling). Exoskeletons could be classified as 'active' or 'passive' (Lee et al., 2012). An active exoskeleton is comprised of one or more actuators (e.g., electrical motors) that actively augments power to the human body. A passive system does not use an external power source, but uses materials, springs or dampers with the ability to store energy from human movements and release it when required.

Active exoskeletons have been particularly developed for the purpose of rehabilitating injured or disabled people. Active exoskeletons with an occupation or industrial purpose are being developed, but these are mainly in a laboratory stage now (e.g., Kadota et al., 2009; Lee et al., 2012; Luo and Yu, 2013; Looze de et al., 2015).

On the other hand, several passive systems ready to be used in work situations, have been described in the literature. These

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Fig. 1. The passive Laevo exoskeleton used in the current study.

2.4. Tasks

2.4.1. Task 1 – simulated assembly

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Version 2.2

Version 2.3

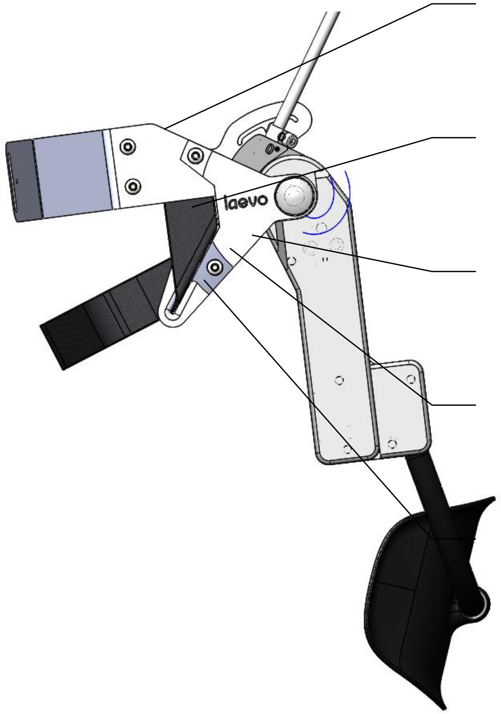
Chest pad allows more flexibility in movement
also a tighter close

Belt Buckle to have a better fit, easier to use
and easier to adjust.
It also keeps the leg pads better in place.

Back Padding is larger and has no iron support
Structure, therefore more comfort

V2.2 > 2.3 > design changes

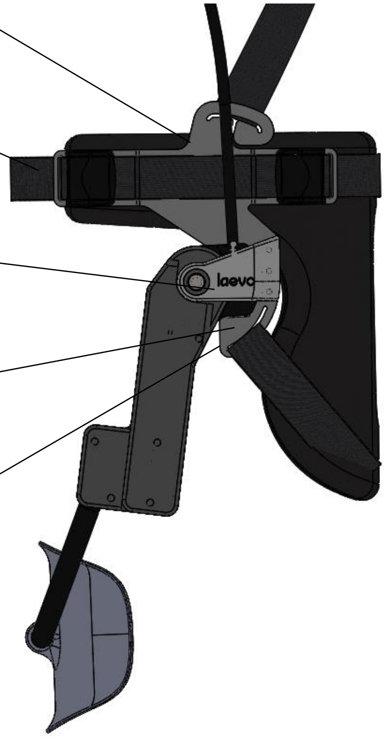
Laevo v2.2 Hippad



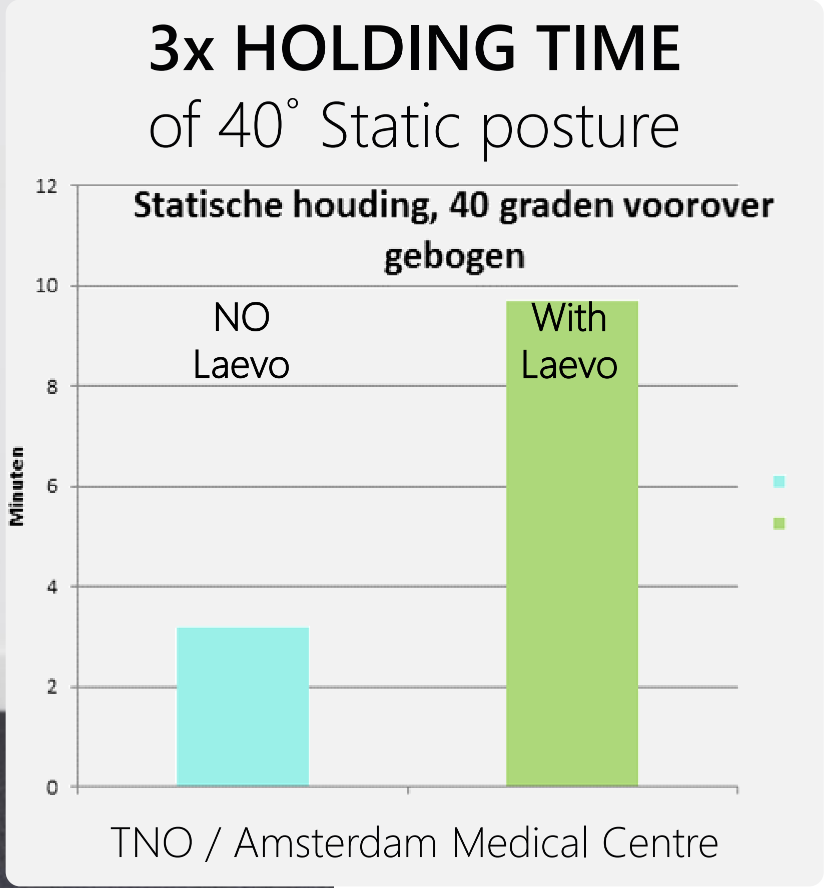
- 4 different sizes
- Limited adjustability
- Large molded part
- Optimized for small series
- Complex assembly

Laevo v2.3 Hippad

- One size fits all
- Advanced adjustability
- Small molded part
- Serial production ready
- Easier assembly



A bike for bending and lifting.



As a bike improves the efficiency of walking, Laevo supports bending the back, **reducing back strain up to 50%** (n=18, P<0.01) and energy with 20%

laevo

Product portfolio

LAEVO V2.3 € 1.699 = Laevo fully assembled

Sizes: Custom fit, XL, L, M, S

Support zone: Early (1), Middle (2) and Late (3)

Strength (zone II) 70%,80%,90%,100%

Color: special 200+ series possible

Extra suspenders € 150,--

Sizes: one size fits all

Services

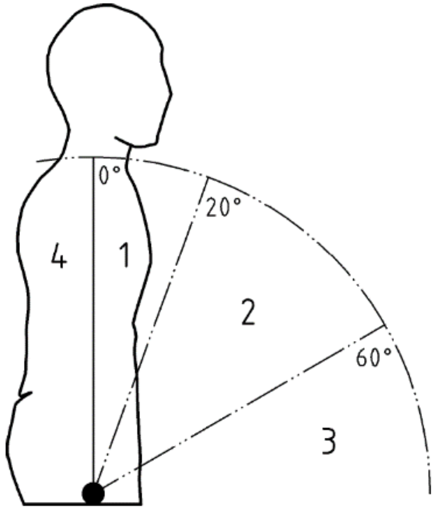
Expert time € 79/h

travel time € 39/h + €0.50/km

Products for distributors

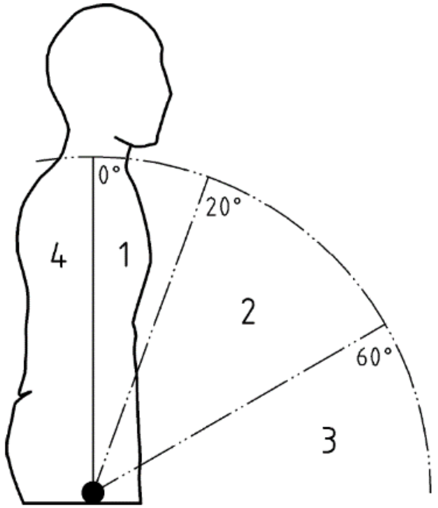
Meettool € 200,--

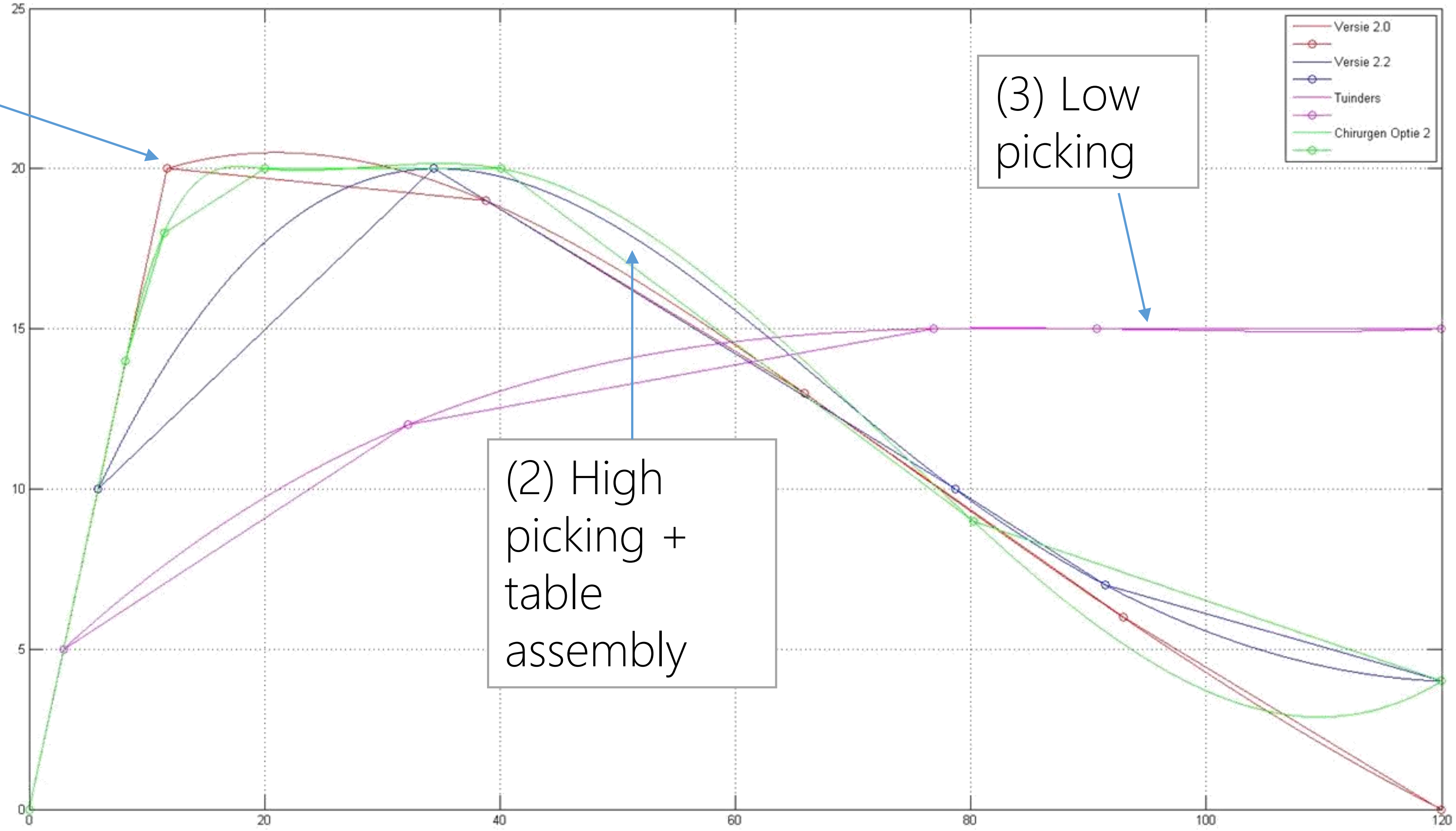
Mold € 500,--



Cam characteristics

(1) Long standing (table work)





(2) High picking + table assembly

(3) Low picking

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Employers pay 1699 Euro for a custom fit Laevo, up to 3 years useable. Employees enjoy their work & life up to old age.

Typically earned back in less than 1 year:

- 1699 Euro ≈ 1 year of 3% less absenteeism
- 1699 Euro ≈ 1 year of 3% more productivity

laevo

CUSTOMERS

STORK
DSM
STEDIN.NET
VDL Klima
RENAULT
COFELY
GDF SUEZ
DSV
Global Transport and Logistics
Royal Van Lent Shipyard
BASF
We create chemistry
Strukton
SAINT JEAN INDUSTRIES
Koninklijke Gazelle
John Deere
Vebego
DAHER
DAF
A PACCAR COMPANY
GEODIS
EXGEL®
kaji corporation

Logbook inserts by users

"My posture in a static postion is better. Also it is easier to get up straight after working in a forward bended postion"

Mr. S. Verlinden [Metalworker at John Deere]

"Again a good experience with the Laevo, today I have tried the new straps and it works very well. As stated earlier the Laevo is ideal for loading byclicles. I hope that management decides to buy them (at least mine!!!)"

Mr. J. Popma [Logistician at Portena]

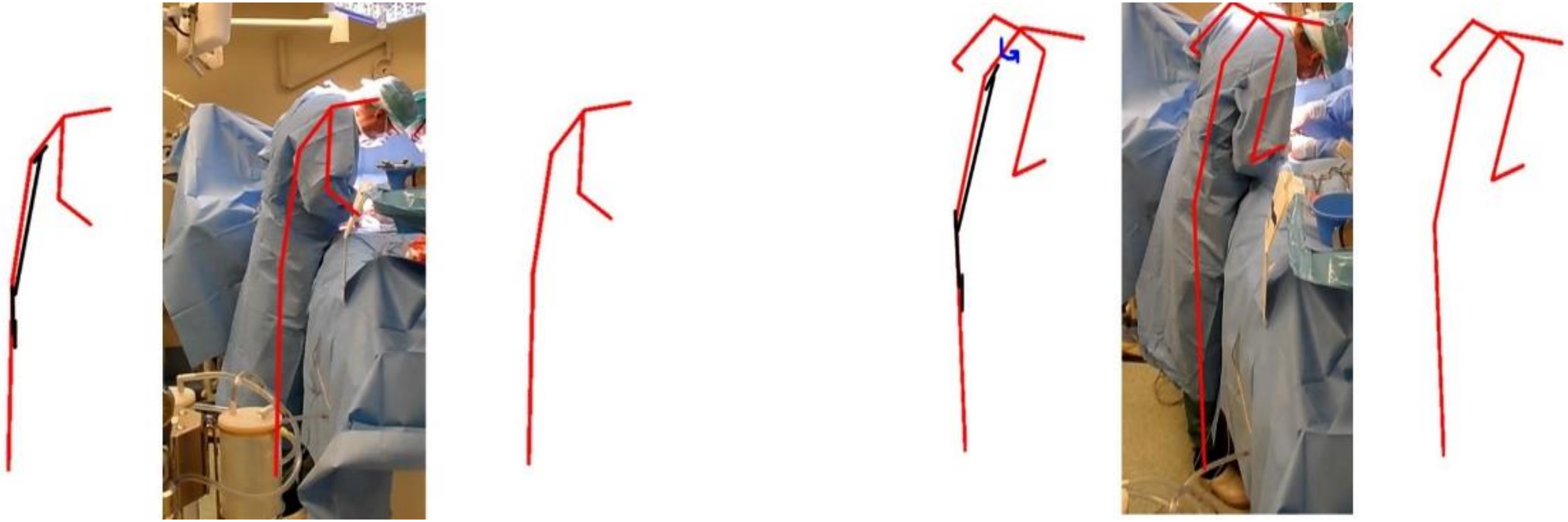
"I notice that it (the Laevo) helps me with the lifting of the radiators"
"I notice that I am less tired at the end of the week"
"… my wife has noticed that too …"

Mr. M. Koot [Logistician at RENSA]

Surgeon Laevo

During testing:

The position the surgeons are operating in is both static forward and rotated (slightly) askew.



Results:

The surgeons were pleased with the Laevo as a structure, but desired more support whilst standing over a patient during surgery. Some additional suggestions were made for more comfort and practical problems when facing an operation.

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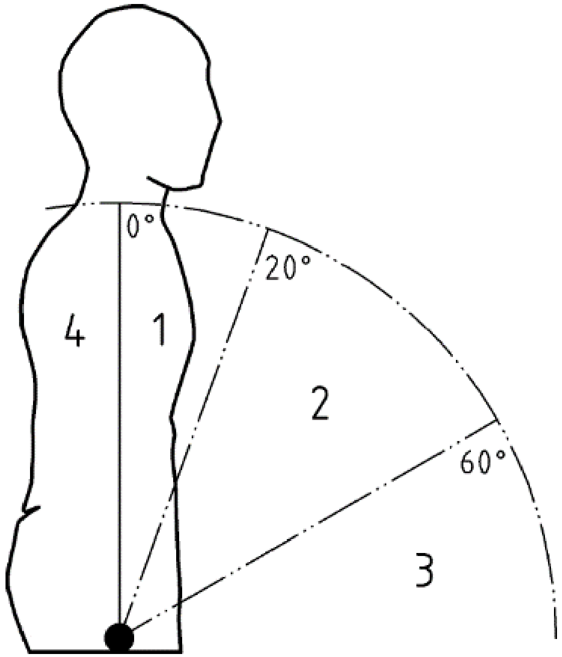
First suggestion:

On average surgeons would like to receive maximum support when slightly bend over a patient.
In the first 0˚ to 20˚, therefor we will develop a new structure which will do that.



Zone 1. Maximum support in the first twenty degrees as desired by surgeons and other operators in a slight forward bended work position.
Zone 2. Maximum support between 20˚ and 60˚, typically desired by order-pickers, welders, grinders etc.
Zone 3. Maximum support between 60˚ and little over 90˚, typically desired by people working in small spaces or extreme forward bended position.
Zone 4. No support, only reminding the user of the correct posture.

Second suggestion:

Surgeons would like to be able to adjust the angle of support during surgery, but they are unable to alter anything using their hands.

Therefor we will develop a possibility to:

•Adjust the initial angle (of support), and Adjustment (of angle of support) to be made with the wrist of the hand (above the hip-line

Option 1

Option 2

laevo

Third suggestion:

More support through the chest pad, due to the fact that surgeons sometimes must stand in a slight forward bended position for a long time, the suggestion has been made that a larger chest pad would be more comfortable instead of a small one. The same amount of pressure over a larger surface would be experienced as being more comfortable.

Any questions?

And if we have time I have a small bonus

Laevo persona's

*

4 maten voor MAN
- Small-Large (lengte)
- Narrow-Wide (breedte)

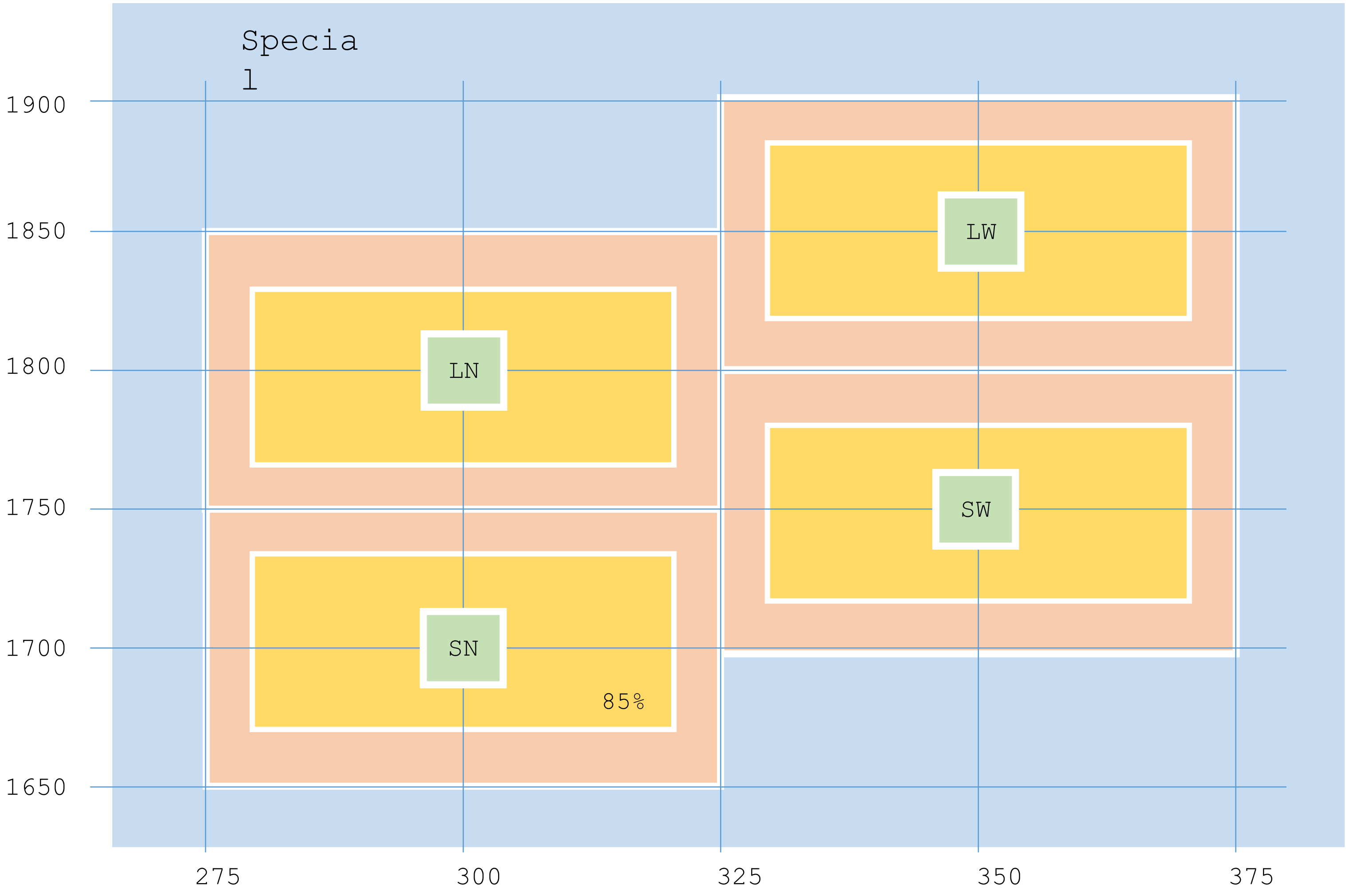
interval dat **dagelijks gebruikt** kan worden [mm]:
- Breedte: -20 + 20
- Lengte: -30 + 30

**

interval **dekkende maten voor proberen** [mm]:
- Breedte: -25 + 25
- Lengte: -50 + 50

**

Specials (op maat)



* / ** volgende slide

To do's

Opmerkingen:

* Beenpads, en met name de initiele hoek, etc. kunnen ook nog varieren in praktijk.

** Allemaal aannames, moet nog getest worden. Belangrijk is dat we zelf deze intervallen vertrouwen!

- Alles boven 90% is een special
- Huur op maat wordt: SN, etc is jouw maat!

Opties:

- In elkaar schuiven tot het betrouwbare interval raken, nu vallen er mensen tussen
- Uitbreiden naar kleiner voor JP, FR, dames.
- Uitbreiden naar breder voor USA.

Visie naar V3 en tussenstap V2.x

Uitgangspunt: Ontgrendeling hoger effect op comfort dan meer passing. Nog te testen, geldt bij beroepen waar bewegingsruimte is.

- **Zoveel mogelijk standaard**
  - Borstpad V-shape voor ieder -- dames en heren gelijk
  - Smartjoint met vrijloop en instellinghoek -- duurder maar geen ihoek-instelling meer nodig.
  - Beenpads altijd small -- moet redelijk zijn voor ieder, te testen aanname
  - Rugband naar 1 maat.

- **Structuren** blijft meest variabele onderdeel. Maar betaalbaar.
  - 9x (?) standaard voor mannen.

Bedankt