ATHLON

RE-IMAGINING SPORTS INJURY REHABILITATION

PRODUCT REPORT

MSc04-ID13 - May 2017
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ATHLON

THE FIRST PERFORMANCE ENHANCING ANKLE REHABILITATION PRODUCT

ABSTRACT

This master thesis deals with the design and development of a combined sports performance and ankle rehabilitation product for athletes sustaining ankle sprains. An ankle sprain is the most common sports injury accounting for 20-40% of all sports injuries. Additionally, it is found that up to 80% of athletes who have sprained their ankle will re-sprain the same ankle at least once more, often due to inadequate rehabilitation. Currently there is a variety of ankle sprain rehabilitation equipment on the market, however, athletes are found to differ from other people in the way that they are motivated and the functional level that they need to be rehabilitated to.

Athlon is a smart and adaptive ankle rehabilitation product system enabling everyday athletes to return to their active life and prior physical performance level following an ankle sprain. Building on the well-known rehabilitation benefits of traditional balance boards, Athlon takes sports injury rehabilitation to the next level; supporting the home training throughout the rehabilitation phases and exceeding the physical challenge level of other rehabilitation products in order to accommodate for the specific rehabilitation needs of athletes.

A central focus of the project is facilitation of correct and efficient home rehabilitation, targeting and promotion of the intrinsic nature of athletes' training motivation as well as incorporation of elements of identity, lifestyle and performance enhancement found to be valued within the sports context.


"...SO, I'M SUBSTITUTING THIS WITH THAT?"

ATHLON

PROFESSIONAL REHABILITATION AT HOME

Athlon is a premium ankle rehabilitation product designed for the modern sports enthusiast, consisting of the Athlon Trainer and supported by the Athlon App.

Inspired by the methods used by the world's top athletes and their therapists, Athlon adapts the rehabilitation program to the specific injury. The athlete is guided safely and efficiently back to prior athletic performance through a mixture of rehab and fitness exercises that are constantly challenging due to ongoing adaption to the user's current physical capabilities.

Athlon provides an interactive and motivating training experience with real time feedback on training performance as well as insight into overall training data. Through visualisation training data, the user is able to see progress, set sub-goals and experience small wins.

Athlon acts as a personal trainer; assisting the return to the active life and sport while becoming a part of athlete's daily workout routine, helping to prevent further injuries.

ATHLON APP

- Gives exercise instructions and optimises training outcome
- Shows live feedback and corrections based on exercise performance
- Visualises training data and progression patterns
- Provides insights into rehabilitation process to avoid common pitfalls and set realistic and motivational goals
- Helps to manage exercise time through push messages; learning the user's habits to fit in training throughout the day

ATHLON TRAINER

- Tracks movement and generates accurate training data
- Adapts to the athlete's training abilities through adjustment of difficulty levels
- Enables integration of resistance band exercises
- Nudges the athlete by showing progress in daily workout program
- Has a sporty aesthetic - borrowing elements from high performance sports products

FROM INJURY TO RETURN

MIXING REHAB WITH FITNESS

When recovering from an ankle injury, the motor skills, ligaments, nerve sensors and muscle groups in the injured area all need to be rehabilitated. Athlon guides the user through a customised rehabilitation journey with steps that are each responsible for regaining a lost skillset.

When starting the recovery, the athlete initially uses Athlon to perform ankle rehabilitation exercises. As the athlete improves, the training intensifies, while more and more fitness exercises are introduced, gradually replacing the rehab exercises through challenging movements that put increasing demands on the ankle.
When the ankle is recovered, dynamic fitness exercises are introduced, gradually replacing the balance training, strength and stability elements from the rehabilitation exercises. These exercises simulate situations known from sport and prepares the athlete to safely return to the sport.

The training on Athlon thereby becomes an intense workout that activates the entire body and improves balance, coordination and body awareness while preventing further injuries.

ATHLON EXERCISE BASICS

REHABILITATION EXERCISES

Front to back flexion
Side to side flexion
Proprioception
Around the world

FITNESS EXERCISES

Push-ups
Abdominal crunches
Planks
Side planks
Calf raises
Lunges
Squats

DYNAMIC FITNESS EXERCISES

Single & double leg jumps
Jumping lunges
Jump squat
Step backs


INJURED
REHABILITATION EXERCISES
INJURED
FITNESS EXERCISES
DYNAMIC FITNESS EXERCISES
PREVENTION
BACK TO SPORT

TRAINING JOURNEY

EXERCISE EXAMPLES

FRONT TO BACK FLEXION

At the early phases of ankle rehabilitation, the athlete can slowly begin mobilising the injured ligaments and tissue through front to black flexion. By setting a high resistance level on Athlon, extreme positions are avoided and the exercises can be performed in a controlled and safe manner.

PROPRIOCEPTION

When ready, the athlete can begin proprioceptive exercises such as trying to keep the board at a horisontal level. The proprioceptive exercises are central in regaining lost body coordination and serves as a supplement to the flexion exercises.

SIDE TO SIDE FLEXION

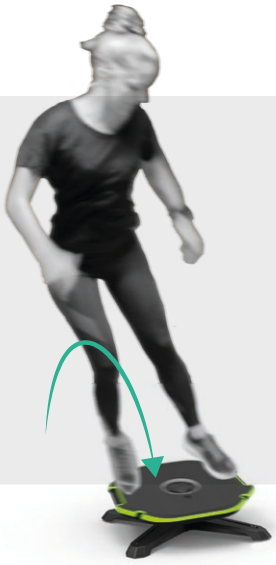
Side to side flexion aids in recovering the outer ligaments, which are important in regaining lost stability in the ankle joint. The exercise strengthens the pronation and supination movements of the joint, improving the rapid joint corrections that are needed when the athlete is back at the sport and lands on uneven surfaces.

AROUND THE WORLD

Around the world ties together the movements trained in front to back and side to side flexion exercises and thereby trains the collaboration between plantarflexion/dorsiflexion and pronation/supination.

SQUATS

Training exercises such as squats gradually replace the balance training, strength and stability elements that were earlier trained through rehab exercises. The workout becomes more intense and serves as a great alternative to traditional training exercises due to the unpredictable movements of Athlon's unstable platform, allowing the athlete to improve both balance and gain muscle strength



JUMPS

Dynamic training exercises such as jumping put additional pressure on the ankle. These exercises simulate situations known from sport and prepares the athlete to safely return while also improving strength and function of the body's core muscles.

THE EVERYDAY ATHLETE

MOTIVATED BY A DETERMINATION TO IMPROVE

Athlon is a product for the everyday athlete, a still growing segment of the modern society. This group of sports enthusiasts varies in many ways, but all sharing a common mindset driven by performance, persistence and a determination to improve. This determination motivates these athletes to set ambitious goals, train dedicatedly and push the limits to achieve them, which brings a great sense of accomplishment and well being in their daily lives.

When training, even the small margins of their performance matter, which is why this target group invests in equipment that helps them perform better, such as wearables and other devices that underlines the saying 'what can be measured can be improved'. These technologies and the data they provide have seen an explosion in the recent years, moving from the arena of the professional sportsmen, into the homes of the everyday athletes, serving as tools for performance improvement, while increasing motivation and the commitment the athletes have to their sport.

Besides their risk of spraining or re-spraining their ankles, the target group is defined by the mindset they share, and not a specific sport or competitive level. Athlon does not target professional athletes who already have access to supervised treatment, but instead takes inspiration from this context and the elements and triggers that are proven to work in supervised rehabilitation.

THE EVERYDAY ATHLETE

THE RECREATIONAL ATHLETE

THE AMBITIOUS ATHLETE

THE ASPIRING ATHLETE

CORRECTIONS ON EXERCISE EXECUTION

COACHING AS MOTIVATIONAL FORCE

EXPERT KNOWLEDGE ON INJURY

CUSTOMISED TRAINING PROGRAM

CONTINUOUS ADAPTION OF EXERCISES

RELATIVE TO PROGRESSION OF REHAB

SUPERVISED TREATMENT

- THE SECRET BEHING PROFESSIONAL ATHLETE'S QUICK & EFFIFIENT RECOVERY

"THE MORE DATA, THE BETTER! MEASURING MY PERFERMANCE PUSHES ME TO DO EVEN BETTER ON MY NEXT RUN"

"I AM PHYSICALLY ACTIVE BECAUSE I LOVE BEING CHALLENGED. THE INTENSITY AND UNPREDICTABILITY OF THE GAME IS WHAT MOTIVATES ME"

"MY COACH KEEPS TRACK OF MY PERFORMANCE AND STRUCTURES MY TRAINING, MEANING THAT I CAN FOCUS ON PLAYING MY ABSOLUTE BEST"

THE IDEAL REHABILITATION

THE ROUTE TO RECOVERY

An ideal rehabilitation program as structured by physical therapist goes through the following 7 phases, which all must be completed before returning to the sport to avoid fall-backs. Each phase adds new elements to the training, and a complete and successful recovery is dependent on going through the phases in the correct order and tempo. Adapting the program so to constantly challenge the injured athlete without risking additional damage will result in a quick and thorough recovery.

In the following illustration, the 7 phases and the common pitfalls everyday athletes fall into are described along with the methods Athlon utilises to avoid them.

By turning the dial, the stability level of the platform is changed, making exercises adaptable to any rehabilitation and fitness level. Athlon thereby offers the opportunity for a challenging workout but also supports the user when needed.

Regaining mobility

Regaining stability and neuromuscular control

Prevent further injuries

COMMON PITFALLS

'Waiting out' the injury instead of starting rehab programme

Pushing ankle to extreme positions before fully mobilised, thereby making matters worse

Stopping with rehab exercises as symptoms disappear

Ends rehab and returns to soon to sports training

Increasing intensity in sports training too fast

Not focusing on preventing future injuries

ATHLON

HOW ATHLON ASSISTS IN AVODING PITFALLS

Communicates the recovery plan in small fractions at a time, and slowly easens the user into rehabiliation

Regularly tests the limits of the ankle's ligaments while tracking pain levels and adjusts training programme to avoid extreme positions

Communicates that the rehab is entering a new stage and gradually increases difficulty level demonstrating that full strength is not yet achieved

Gradually replaces rehab exercises with fitness exercises that challenge the athlete in new ways

Adaps to the level at which the user should be pushing the ankle based on the mobility, stability and neuromuscular control of it.

Becomes a part of the daily workout routine in training the entire body and preventing future injuries.

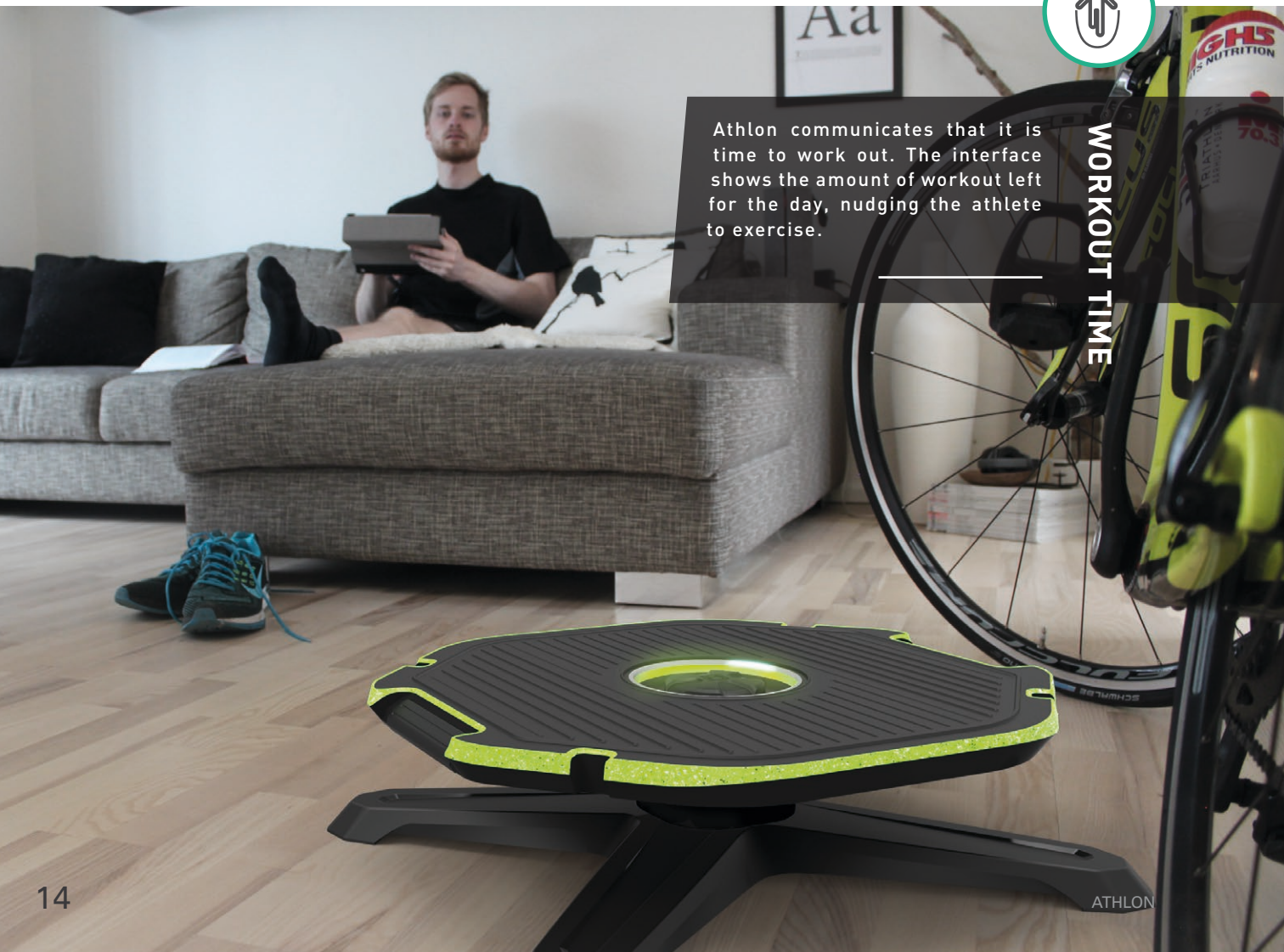
THE ATHLON EXPERIENCE

AN INTERACTIVE WORKOUT

As the athlete progresses in the rehab, Athlon adapts, so the training program, instructions and user experience fit the current capabilities of the athlete. The exercises vary in order to put demands on physiology, gradually adding new exercises and requiring higher tempo and precision to always keep the user challenged in both rehab and fitness exercises. The following scenario presents an example of a experience representative of a typical training session with Athlon.

In this scenario, the athlete is three weeks into the training program, and still performs a large amount of rehab exercises. Different fitness exercises are now mixed into the training program, allowing the user to combine the ankle rehabilitation with an intense workout that put demands on balance and the body's core muscles.

ATHLETE IS AT HOME



WORKOUT OVERVIEW

The user checks the exercise program. New exercise instructions are demonstrated with videos.

ACCEPTS THE WORKOUT REQUEST

PUTS ON APPROPRIATE CLOTHING, SETS UP THE ATHLON TRAINER AND GETS READY

STARTS THE WORKOUT PROGRAMME

REHAB EXERCISE

The athlete follows the exercise instructions and gets live feedback on performance through an interactive experience.

ADJUSTING SUPPORT

Between exercises, the dial is adjusted to set the resistance level. The suggested level is communicated through the app based on previous workouts.

SIDE TO SIDE EXERCISE

SQUATS

AROUND THE WORLD

FITNESS EXERCISE

Push-ups are performed on the board while trying to keep the board steady and horisontal.

PROPRIOCEPTION

LUNGES

PLANK

PAIN TRACKING

At the end of the training the athlete is asked to log his current pain areas and severity in the app.

SCREENING REQUEST

SCREENING

Routinely, the user is informed that it is time for a screening, testing the progress in the ankle's mobility.

POST WORK OUT PAIN TRACKING

An hour after the workout has finished, the athlete is asked to again log the ankle's pain areas and severity, enabling Athlon to adjust difficulty level.

FINISH UP AND PACK AWAY

SETS NEW GOALS

DATA CHECK

Statistics, achievements and track record can be viewed to evaluate progression relative to the program and compare to other athletes in the same category.

PHASE ADAPTION

A PERSONAL REHABILTATION

Adapting the training to fit the athlete's specific injury and skill level is a corner stone of the Athlon training experience. This adaption makes sure that the user is either challenged or supported when needed, ensuring the seven phases of an ideal rehabilitation is followed and pitfalls are avoided.
By combining and analysing a multitude of datasets, the Athlon system is able to accurately estimate at what stage of the rehabilitation process the athletes are, how they need to progress, and adapt the specific training program accordingly.

LOGGING PAIN LEVEL

The ankle pain level is logged after each training session and compared to the specific program the user has performed, to determine if it was too challenging. A low or medium amount of pain after a training session is a sign that the program was challenging enough, but this pain must be gone after an hour. Therefor the user gets a notification reminder to log pain level again an hour later, and the difficulty level is adjusted accordingly.

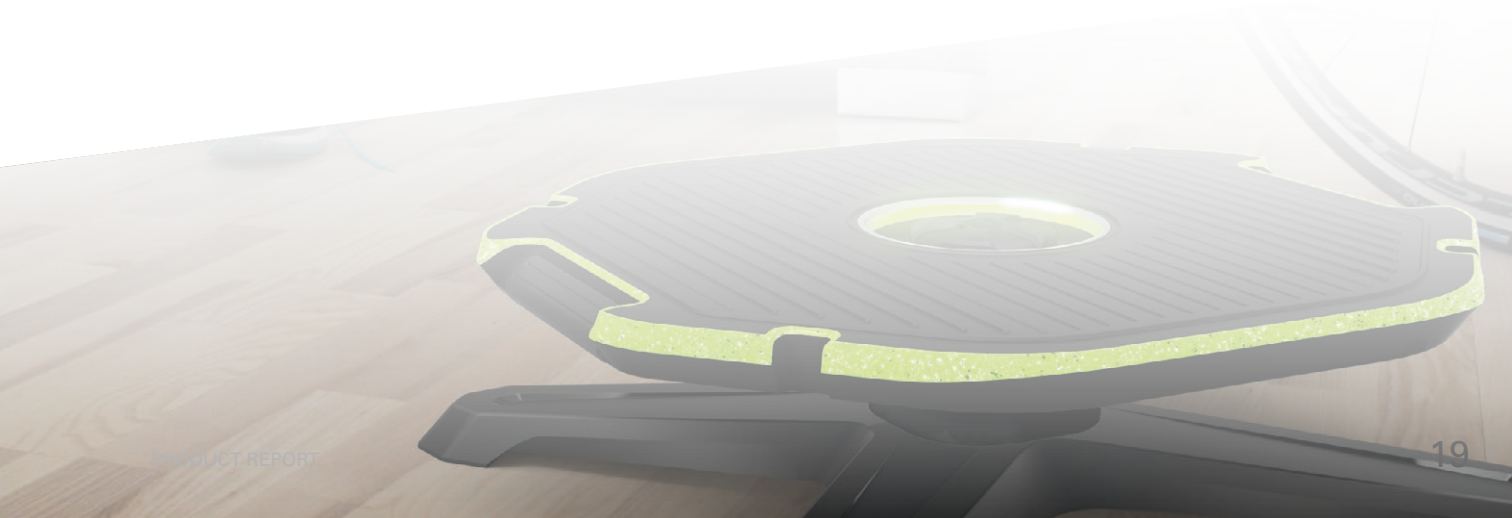
After the symptoms of the injury is over, and pain no longer is tracked, the difficulty level will be adjusted according to how well the athlete perform during exercises, combined with the data acquired from the ongoing screening tests.

SCREENING TESTS

Routinely the user will preform a screening test, where relevant phase specific parameters is measured to determine whether the user can progress to the next rehab phase, or if more time is needed in order to obtain the necessary skill level/ mobility/strength to safely progress. This test is a separate and contorted exercise aiming at providing more precise and reliable data than what is collected through the normal training program.

BIG DATA ANALYTICS

The collection and comparing of training data from all Athlon users enables further customisation of Athlon's recommendations about fitting exercises and difficulty level. By comparing the training data of athletes who have matching injuries and progression patterns, realistic future goals can be estimated - a key to delivering a personalised rehabilitation program. As the volume of Athlon users increase, the predictions of the customization become more precise and reliable.



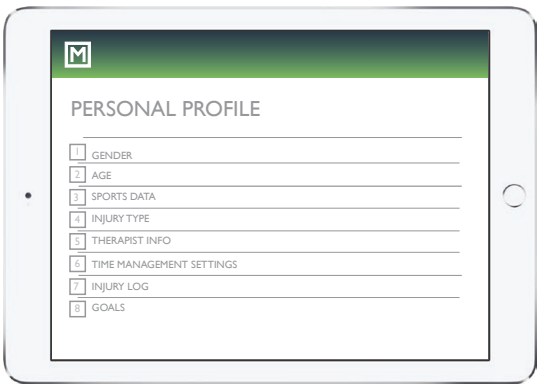
USER INTERFACE

BEFORE AND AFTER EXERCISE

A large part of the Athlon interaction is experienced through the app based user interface which communicates training data and facilitates motivational aspects such as goal setting, progression visualisations, nudging and time management.

PERSONAL PROFILE

Creating a personal profile is the first step when downloading the app, and it allows the training program to be adapted to the atlhete's specific condition, skill level and preferences, and allows them to compare their training data and rehabilitation program with others in the same category.

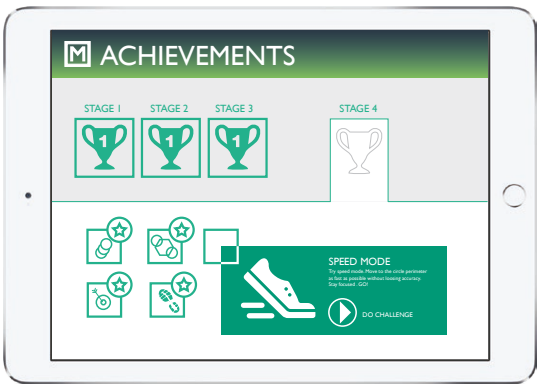


DATA VISUALISATION

Progression and key numbers from training sessions can be accessed and compared to the projected training path set for the athlete. This enables the assessment of actual performance vs. expected performance and aids in instructing the athlete in changed difficulty levels.

ACHIEVEMENTS & PHASE UNLOCK

When going through rehabilitation, athletes unlock new stages that put additional requirements to their abilities. The stages communicate progress, serving as a way to benchmark realistic goals that the user can reach. This adds small wins and a feeling of accomplishment during the rehabilitation, motivating the athlete to keep improving.

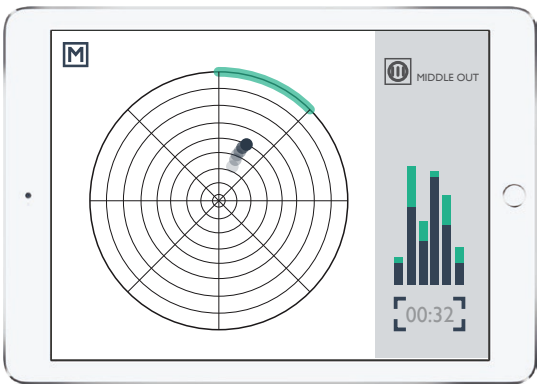


DURING EXERCISE

When exercising on the Athlon Trainer, the app communicates the training program, instructs in the individual exercises and provides live feedback. Athlon provides a large variety of exercises - common for them is that they are based on the two following primary instruction modes that are varied in difficulty and intensity throughout rehabilitation.

STABILITY MODE

This mode visualises the stability of the athlete compared to an instructed threshold. Stability mode is used during proprioception exercises for rehablitation and during all fitness exercises.



PRECISION MODE

In precision mode, the athlete's live position and movement accuracy is visualised relative to a direction given on the app. This mode is used in multiple rehab exercises including 'front to back' and 'side to side.'

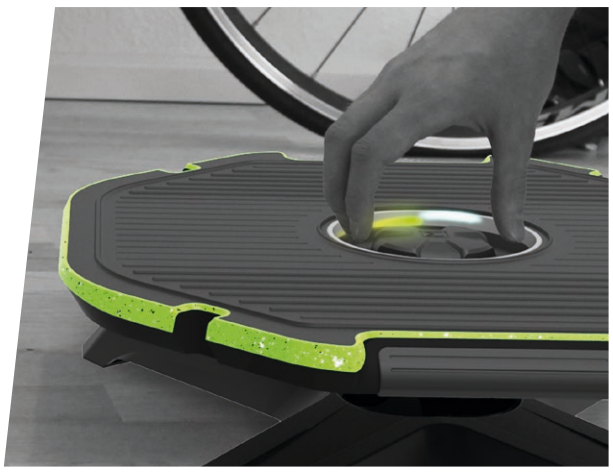
ATHLON TRAINER - INTERFACE

RESISTANCE ADJUSTMENT

When adjusting resistance level, the LED ring will communicate the turning direction and when the resistance is set at the desired level.

TIME MANAGEMENT AND NUDGING

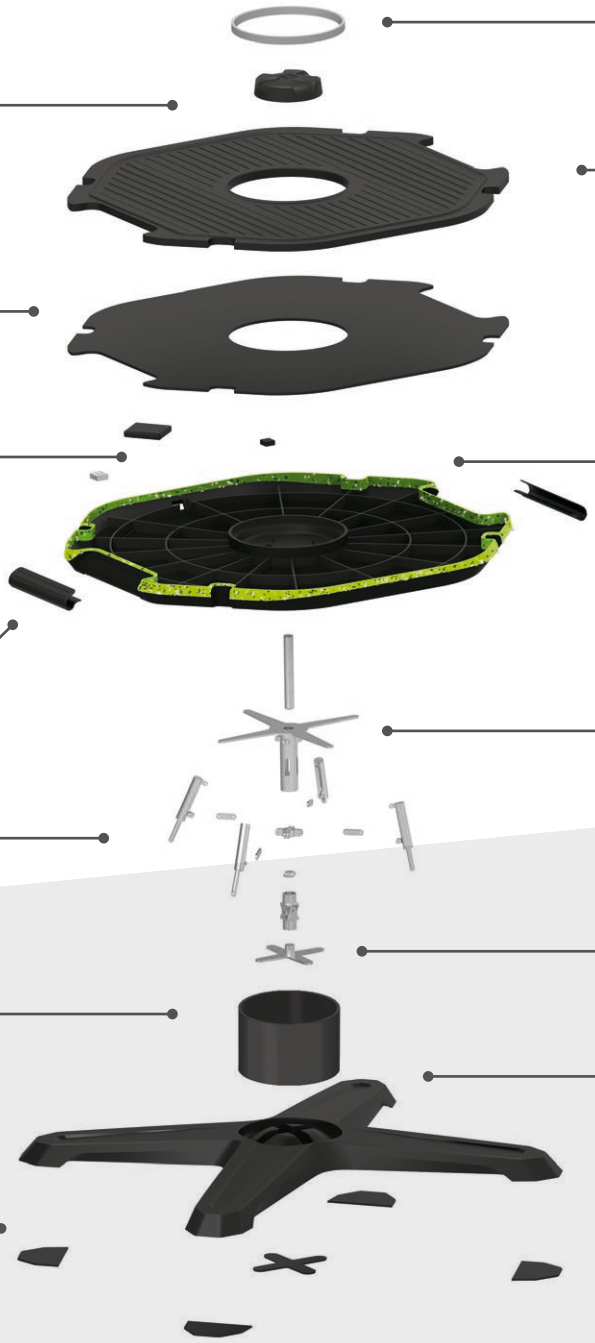
During an exercise, the bottom LED ring shows time left of the ongoing exercise, while the top LED ring shows progress in the ongoing training program. This is also communicated when the athlete needs to perform his daily exercises, serving as a nudging element.



COMPONENTS

EXPLODED VIEW

The Athlon Trainer consists of multiple parts that are designed to withstand the demands of repeated and heavy use through a solid and stable construction.



LED RING
POLYCARBONATE SHEET

DIAL
COMPRESSION MOLDED, POLYPROPYLENE

NON SLIP SURFACE
COMPRESSION MOLDED, POLYURETHANE RUBBER

STIFNESS PLATE
THERMOPLASTIC SHEET

BATTERY, SENSORS, PCB, USB PORT (CHARGING)

TOP SURFACE
INJECTION MOLDED, POLYPROPYLENE

GRIP PADS
COMPRESSION MOLDED, POLYURETHANE RUBBER

FASTENING PLATE
SHEET METAL

RESISTANCE SYSTEM
COMBINATION OF STANDARD AND CUSTOMISED METAL COMPONENTS

FASTENING PLATE
SHEET METAL

CONCEALER
POLYESTER FABRIC

BASE
INJECTION MOLDED, POLYPROPYLENE

RUBBER PADS
POLYURETHANE RUBBER SHEET

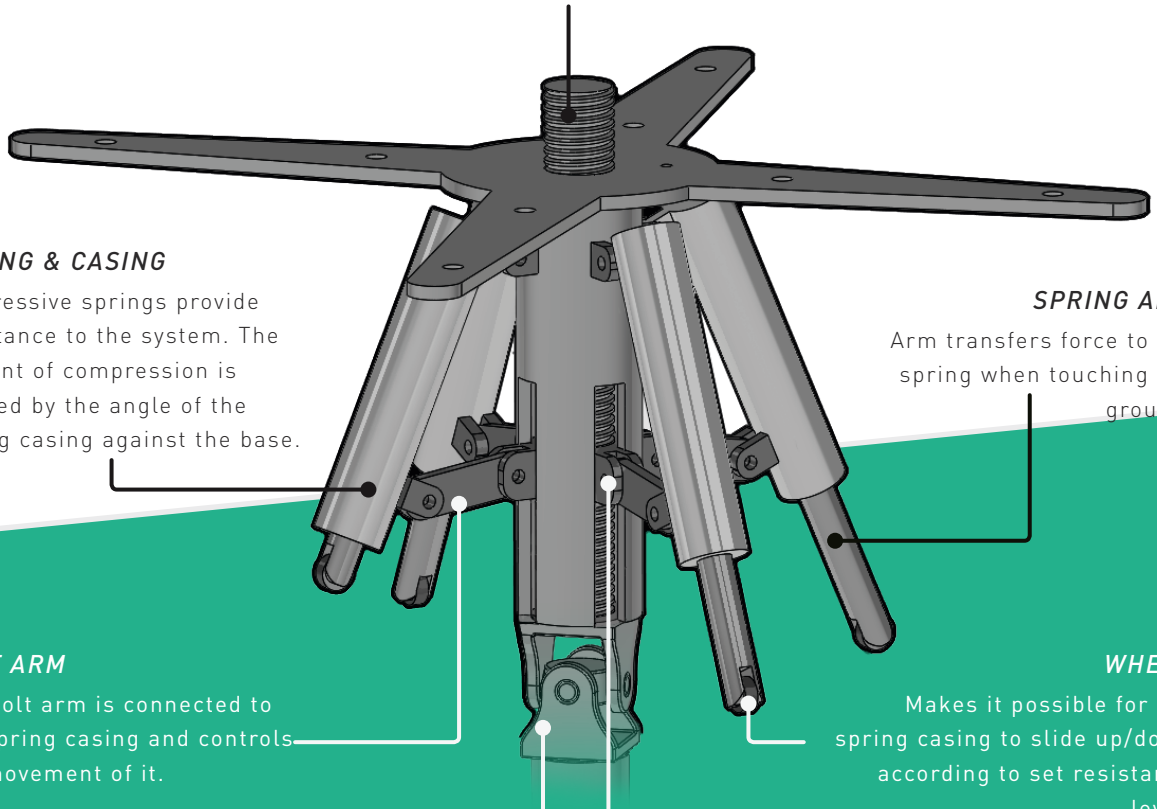
RESISTANCE SYSTEM

THE CORE OF DIFFICULTY LEVEL ADJUSTMENT

The resistance system makes it possible to adjust the level of resistance experienced when exercising on the Athlon trainer. When adjusting the dial, four progressive springs are compressed, providing the desired resistance.

THREADED ROD

The rod transfers the rotation of the dial to moving the bolt.



SPRING & CASING

Progressive springs provide resistance to the system. The amount of compression is defined by the angle of the spring casing against the base.

SPRING ARM

Arm transfers force to the spring when touching the ground.

BOLT ARM

The bolt arm is connected to the spring casing and controls the movement of it.

WHEEL

Makes it possible for the spring casing to slide up/down according to set resistance level.

UNIVERSAL JOINT

Ensures a fixed center of rotation for the top surface, simplifying the system and minimising tear.

BOLT

Moving up and down the rod, the bolt adjusted the position of the spring casing.

PRODUCT INQUIRY

HOW TO GET ATHLON

The decision of what rehabilitation equipment to buy is highly influenced by two segments, the physical therapist, and the sports community of the athlete. By utilising both sales channels, Athlon is easily available regardless of who is influencing the decision.

ATHLON SALES PRICE:

1.599 DKK

PHYSICAL THERAPIST CLINIC SALES

As most everyday athletes visit a physical therapist clinic in the beginning of their rehabilitation, this is an important sales channel to create awareness of and endorse the product. Athlon will be displayed and available for purchase at the physical therapy clinics that retail products.

PROFIT PER UNIT **308 DKK**

ONLINE SALES

Athlon will also be available online, where the user can understand the full scope of the product before placing an order. It will be possible to set up the personal profile and download the app, so the rehabilitation can start as soon as Athlon arrives.

PROFIT PER UNIT **787 DKK**

FITNESS EXERCISES ON ATHLON CONDITIONS THE ENTIRE BODY WHILE IMPROVING BALANCE, COORDINATION AND CORE STRENGTH

BUSINESS STRATEGY

TRENDS AND BUSINESS OPPORTUNITIES

The evolving societal trends are the foundation on which Athlon is designed and gains it validity. The ongoing trend of sports and fitness, the growing number of injuries sustained, the high level of non compliance to ankle rehabilitation when using existing products, and the technical and digital influence in home health care and the lives of everyday athletes are all pointing towards the solution Athlon delivers.

20-40%

OF ALL SPORTS INJURIES ARE ANKLE SPRAINS.

20-40% of all injuries sustained by the target group are ankle sprains, making it the most common sports injury. Additionally, it is found that up to 80% of people who have sprained their ankle will re-sprain the same ankle due to poor rehabilitation.

65%

SHOWS LOW COMPLIANCE TO REHAB EXERCISES

65% of everyday athletes with an ankle sprain will show some degree of non compliance to the active therapy provided to them by the physical therapist. This makes a point to why physical therapists should recommend Athlon when advising a patient on which equipment to buy.

$34B

IS THE ESTIMATED HOME HEALTH CARE MARKET SIZE IN 2021

$34 B is the estimated size of the home health care market in 2021. This market has been growing steadily for years, but is predicted to increase dramatically due to technical advancement and the growing acceptance and desire for technology integration into everyday life, which is in line with what Athlon stands for.

KEY BUSINESS NUMBERS

The Momentum team will begin its journey in Denmark, selling the Athlon system to both physical therapist clinics and consumers. The first year will be spent on development, launch and marketing of the product.

It is expected that by year three, approximately 60.000 units will have been sold in Western Europe, resulting in a contribution of 33 M DKK.

DENMARK

10.000 potential new customers every year
Accumulated market potential of 50.000 units

WESTERN EUROPE

530.000 potential new customers every year
Accumulated market potential of 2.5 M units

ESTIMATED BUDGET

amounts in DKK

	Year 1	Year 2	Year 3
Units sold	1000	20.000	40.000
Turnover	911.430	20.147.400	44.132.400
Variable costs	1.090.333	10.586.667	20.393.333
Contribution-margin	-178.903	9.560.733	23.739.067

BREAK EVEN POINT

3296 UNITS

(1ST QUARTER YEAR 2)

RETURN ON INVESTMENT

20.5%

INVESTMENT NEEDED

To further develop the product and its software, market the product, pay for tooling and send promotional models to physical therapists, Momentum is seeking an investment of 1,5 M DKK.

- DEVELOPMENT COSTS: 980.000 DKK
- MARKETING COSTS: 30.000 DKK
- PROMOTIONAL MODELS: 82.400 DKK
- TOOLING COSTS: 380.000 DKK

MOMENTUM ATHLON

PROFESSIONAL REHABILTATION AT HOME

Athlon delivers a unique, interactive ankle sprain rehabilitation experience specially tailored towards the everyday athlete.

Through inspiration from the sports and fitness world with its elements and triggers known to motivate and engage the athletes, as well as inspiration from the supervised treatment of professional athletes, Athlon guides the user through a motivating and efficient rehabilitation and aids a safe return to the sport.

When following the interactive instructions on the Athlon app through a mixture of rehabilitation and fitness exercises, the user is challenged without being put at risk. By routinely monitoring the progression of the ankle and the pain level, the training program is customized to fit the circumstances of the individual athlete, providing a personal rehabilitation experience only paralleled through supervised treatment in the professional sports world.

With the look of a top performance product, a constantly challenging program, and the insight of a personal physical therapist, Athlon provides a exceptional rehabilitation experience in the home of the athlete, enabling a quick and efficient return to the sport, not only recovered, but stronger than before and more resilient to future injuries.

ATHLON DELIVERS CHALLENGING & VERSATILE WORKOUTS THAT MAKES OTHERWISE REPETITIVE EXERCISE ROUTINES FUN AND MOTIVATING

MO
MEN
TUM

RE-IMAGINING PHYSICAL THERAPY
FOR SPORTS INJURIES...

ATHLON

RE-IMAGINING SPORTS INJURY REHABILITATION

PROCESS REPORT

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TITLE PAGE

TITLE
ATHLON

PROJECT MODULE
MASTER THESIS IN INDUSTRIAL DESIGN

PROJECT PERIOD
FEBUARY 1ST - MAY 18TH - 2017

PROJECT TEAM
GROUP 13 - MOMENTUM

MAIN SUPERVISOR
LOUISE MØLLER HAASE

TECHNICAL SUPERVISOR
JØRGEN ASBØLL KEPLER

PAGES
58 STANDARD PAGES*
(138.746 CHARACTERS INCL. SPACES)

EDITIONS
7

ABSTRACT

This master thesis deals with the design and development of a combined sports performance and ankle rehabilitation product for athletes sustaining ankle sprains. An ankle sprain is the most common sports injury accounting for 20-40% of all sports injuries. Additionally, it is found that up to 80% of athletes who have sprained their ankle will re-sprain the same ankle at least once more, often due to inadequate rehabilitation. Currently there is a variety of ankle sprain rehabilitation equipment on the market, however, athletes are found to differ from other people in the way that they are motivated and the functional level that they need to be rehabilitated to.

Athlon is a smart and adaptive ankle rehabilitation product system enabling everyday athletes to return to their active life and prior physical performance level following an ankle sprain. Building on the well-known rehabilitation benefits of traditional balance boards, Athlon takes sports injury rehabilitation to the next level; supporting the home training throughout the rehabilitation phases and exceeding the physical challenge level of other rehabilitation products in order to accommodate for the specific rehabilitation needs of athletes.

A central focus of the project is facilitation of correct and efficient home rehabilitation, targeting and promotion of the intrinsic nature of athletes' training motivation as well as incorporation of elements of identity, lifestyle and performance enhancement found to be valued within the sports context.

MO MEN TUM **DESIGN TEAM**

MICHAEL PLANCK

NIELS BACH

HENRIETTE NØRGAARD LAURIDSEN

**Excluding formalities, appendix & illustrations*

PREFACE

The following project is a master thesis in industrial design engineering at Aalborg University, Denmark. The project has been running for 15 weeks at the point of submission, supported by milestone presentations and feedback from supervisors, fellow students and external experts within relevant fields.

A thank you to the supervisors, Louise Møller Haase and Jørgen Asbøll Kepler, for feedback and guidance throughout the project, and to field experts Lars Henrik Larsen (MSc. Physiotherapy, Ph.d., responsible for the Movement Laboratory, UCN), Claus Asmussen Hou (physiotherapist, Fysio Danmark) and Martin Grønbech Jørgensen (Ph.d sports science and clinical biomechanics, AUH).

This master thesis deals with the development of a combined sports performance and ankle rehabilitation product for athletes sustaining ankle sprains.
The chosen topic enables meeting the general project criteria of the semester as well as meeting a broad field of interests within the team. Creating a product within the combined category of sports injury rehabilitation and sports performance is found to be a great opportunity to integrate human, technology and business parameters in order to create value based on matching people's needs with what is technologically feasible in combination with a viable business strategy (ill. 8.01).
Additionally, it meets a collective interest within the team; working with and attaining more knowledge about smart and connected products and how these can create value in the world of design. Lastly, the sports injury context is found to be appealing as it entails working with an interesting user group with high demands to both function and aesthetics.

READING GUIDE

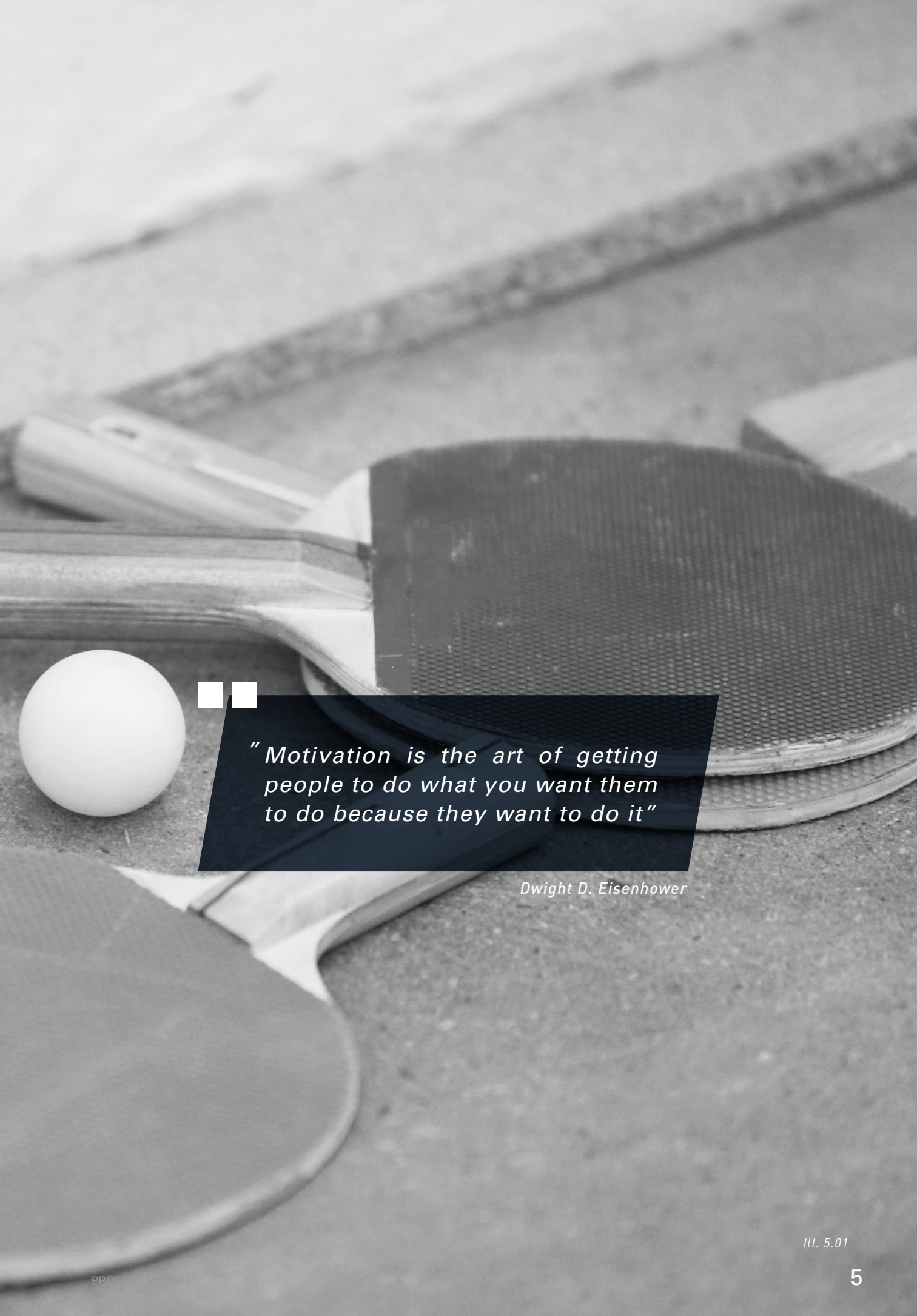
The master thesis project is documented in two main parts; a ***process report*** giving insight into a simplified exposition of the industrial design and development process and a ***product report*** presenting the final product system proposal, *Athlon*.

Appendices and ***worksheets*** can be found on the ***enclosed USB device*** which also contains the ***technical documentation*** as well as digital versions of both reports.

References are listed using the Harvard Method and found throughout the process report as (author, year.) Additional reference information can be found within the reference list on page 116. Illustrations are named according to page number, e.g. Ill. 14.1 is the first illustration on page 14, and refers to the illustration list on page 116.

Appendices are listed within the text as [AP xx], Worksheets are listed as [WS xx]. Both can be found on the enclosed USB. A list of the appendix and worksheet content can be found on page 117.

The process report is divided into 7 main chapters (p. 10), each starting with a chapter introduction as well as key activities carried out within the phase. Green boxes within each phase indicate either findings (pre-phase, understand) or preliminary conclusions found to be central for the following process. Danish quotes are translated to English.



"Motivation is the art of getting people to do what you want them to do because they want to do it"

Dwight D. Eisenhower

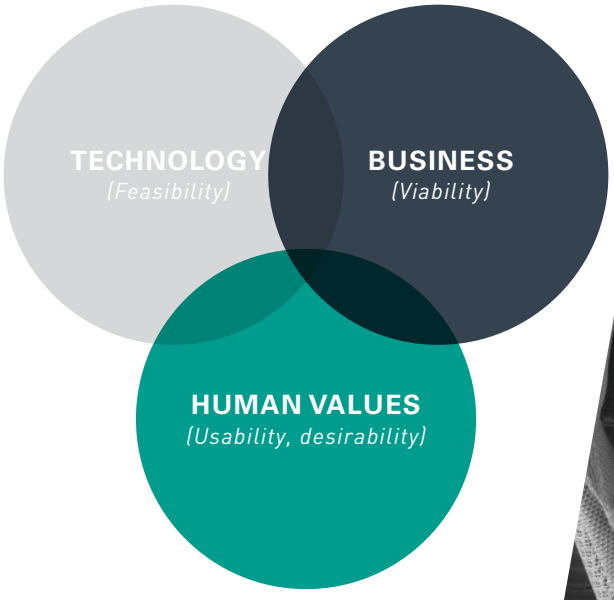
Ill. 5.01

TABLE OF CONTENTS

APPROACH

Opportunity based start-up

The master thesis is approached as being a start-up company possibility; utilising the broad skillset of three industrial designers to start an opportunity based business venture. The approach of the imagined start-up is based on the principles of Design Thinking; a holistic approach integrating human, technology and business parameters with the goal of creating innovation through design (Ill 8.01). The project builds on inspiration and opportunities found within all three parameters in order to build a strong foundation for value creation. The design thinking approach is further integrated through a great focus on what is found to be desired and valued by the targeted user group. This knowledge is extracted not just by listening to the users but essentially seeing what they are not telling directly - latent needs and desires expressed through their behaviour. Another aspect of the design thinking approach which has been central to the process is experimental investigation through iterative cycles of rapid prototyping, testing, and refinement, making it possible to quickly generate useful feedback and evolve ideas or refine concepts and details. (Brown, 2008), (Brown & Wyatt, 2010)



Ill. 8.01: Venn diagram, integrated parameters of the Design Thinking approach

TEAM IDENTITY - *MOMENTUM*

To strengthen the team feeling and facilitate the experience of a common project goal, the imagined start-up company is given a name. The name and appertaining visual identity is created on the basis of the chosen target audience and the expected product category. With the intention of creating a start-up designing and developing sports performance and rehabilitation equipment for athletes, the company name Momentum is chosen. The term, momentum, can be defined as *"the strength or force that allows something to continue or to grow stronger or faster as time passes"* (merriam-webster.com), thereby making a strong reference to the desired goal of both sports as well as sports injury rehabilitation.

"the strength or force that allows something to continue or to grow stronger or faster as time passes"

(merriam-webster.com)

Ill. 8.02: Team identity - Momentum

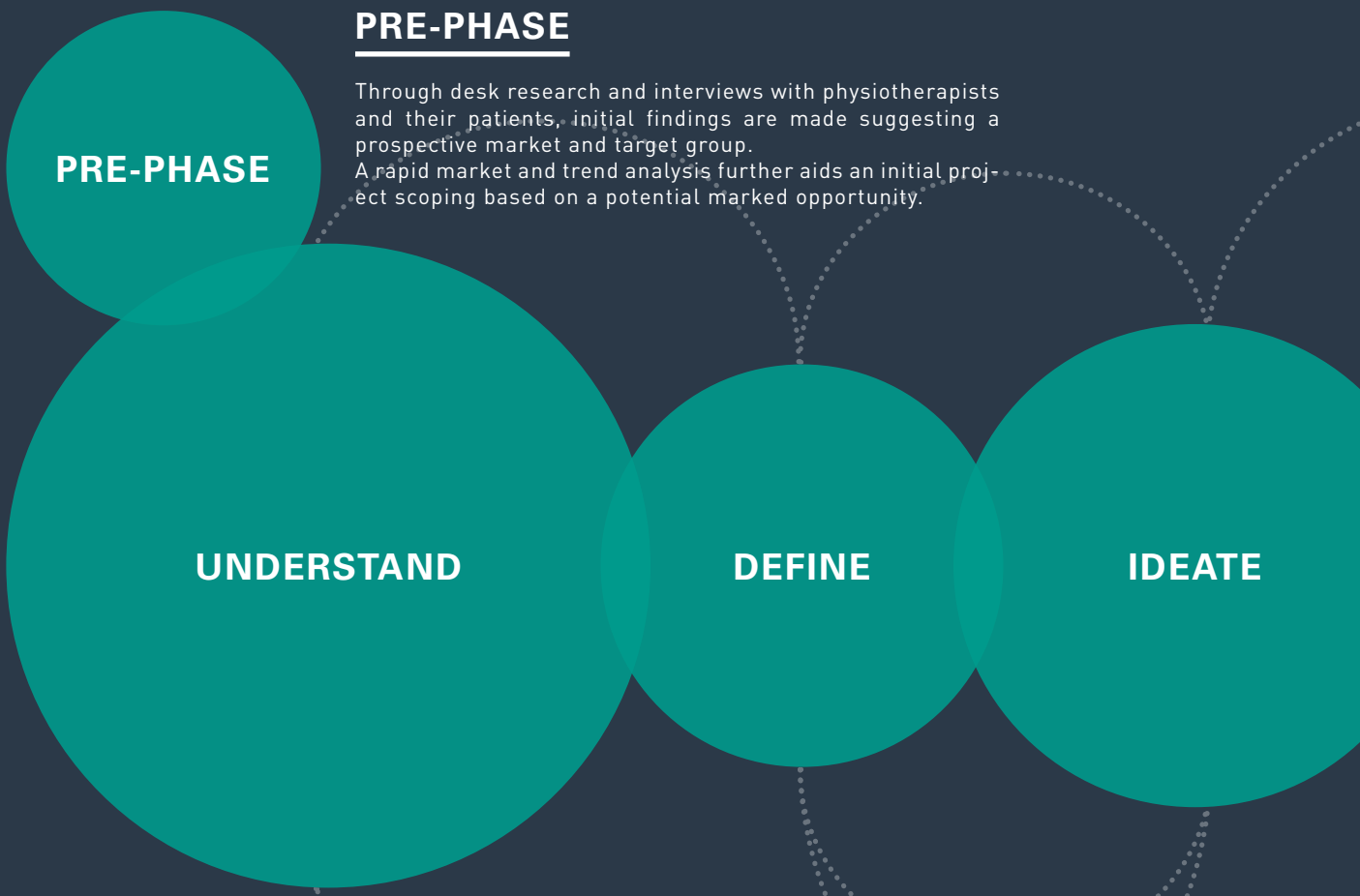
This master thesis focuses on the development of a combined sports performance and ankle rehabilitation product for athletes sustaining ankle sprains. An ankle sprains is the most common sports injury accounting for 20-40% of all sports injuries. Additionally, it is found that up to 80% of athletes who have sprained their ankle will re-sprain the same ankle at least once more, often due to inadequate rehabilitation. Currently there is a variety of ankle sprain rehabilitation equipment on the market, however, athletes are found to differ from other people in the way that they are motivated and the functional level that they need to be rehabilitated to...

... why are they rehabilitating using the same products as everybody else?

Ill. 9.01

PHASE OVERVIEW

An iterative progression



0.00

PRE-PHASE

Through desk research and interviews with physiotherapists and their patients, initial findings are made suggesting a prospective market and target group.
A rapid market and trend analysis further aids an initial project scoping based on a potential marked opportunity.

1.00

UNDERSTAND

Through additional desk research and expert interviews in the field, the opportunity area is further uncovered and analysed.
Additional findings guide the process, leading to normative curiosities and two guiding paradoxes giving direction to the subsequent steps.

2.00

DEFINE

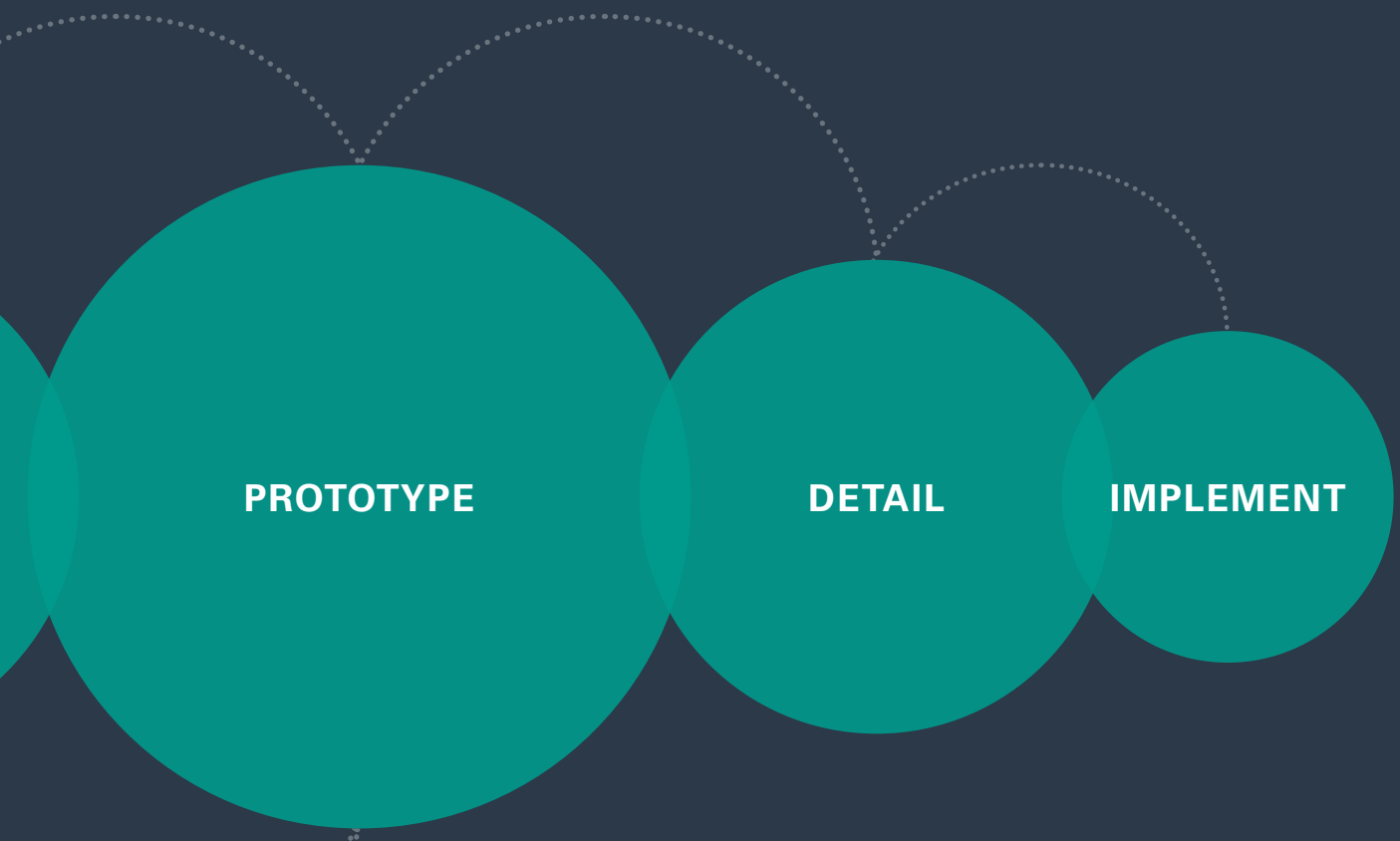
Based on previous phases, the project scope is defined through specification of target group, injury focus, value mission and project vision. Insights are transformed into aspired values with the purpose of acting as initial guidelines for the following concept ideation.

3.00

IDEATE

Based on the discovered findings and derived aspired values and curiosities the possible solution space is explored through multiple iterations of explorative sketching, rapid prototyping and testing.
The project focus is further specified, general concept criteria are created and a concept direction is chosen.

The phase overview shows a simplification of the design process; the different phases and how they relate. The size of the circles compare the approximate relative duration of each phase and the dotted lines indicate the iterative nature of the process. Overall the process has developed through an understand phase, encompassing pre-phase, understand and define, an explore phase consisting of ideation and prototyping and finally a materialise phase in which detailing and implementation has been in focus.



4.00

PROTOTYPE

The chosen concept direction is developed further through iterations of prototyping, testing and evaluation, exploring different solution principles and specifying the product requirements needed for the following detailing.

5.00

DETAIL

The developed concept is detailed through a combination of sketching, physical modeling and CAD modeling. Components, dimensions and materials are defined.

6.00

IMPLEMENT

In continuation of the detailing phase, the developed product system is specified in relation to business and marketing strategy and a timeline outlining the future work is created.


SELECT
casall
HOOLA HOOP
casall
Exercise
Ball

KEY ACTIVITES

DESK RESEARCH

- Sports injuries, ankle sprain
- Rehabilitation & compliance
- Macro trends, technology
- Rehabilitation products

FIELD RESEARCH

- Sports injury products & rehabilitation equipment

INTERVIEWS

- Physiotherapist, Lise Skjødt Birkeland
- Physiotherapist, Rikke Jepsen
- Physiotherapist patients

■ 0.00

PRE-PHASE

Through desk research and interviews with physiotherapists and patients, initial findings are made suggesting a prospective market and target group.
A rapid market and trend analysis further aids an initial project scoping based on a potential market opportunity.

0.01

INTRO

In Denmark and the Western world in general, the number of people exercising regularly is growing - meaning a growing number of athletes ranging from the recreational athlete to the professional athlete. Being physically active is inherently linked to the risk of getting a sports injury. Danish numbers show that 90% of athletes, independent of their sporting level, will at some point in their active life experience getting at least one injury, making sports injuries a reality for almost everyone with an active lifestyle.

Ideally, the athlete makes an effort to prevent injuries through preventive training, however, if an injury is sustained it is central to get the correct treatment in order to fully return to the active lifestyle.

[WS 20], (Neergaard, C., Andersen, B., 2010)

0.02

SPORTS INJURIES

A sports injury is an injury that occurs in athletic activity or during exercising. A sports injury can be many things; injuries in different areas of the body and of different types. Generally, sports injuries are divided into acute injuries and overuse injuries. As the name indicates, acute injuries occur suddenly, followed by intense pain and decreased function. Overuse injuries develop over time, typically with a gradual worsening of the symptoms.

Acute injuries account for the majority of sports injuries, especially in contact sports. Research shows that one of the most common injuries sustained by athletes are ankle sprains, accounting for approximately 20-40% of all athletic injuries (Dubin, J. et al., 2011). Additionally, it is found that up to 80% of people who have sprained their ankle will re-sprain the same ankle at least once more, often due to inadequate rehabilitation (bodyrhythmphysio.com).

The amount of sports injuries is increasing

FINDING #1

Up to 20-40% of all sports injuries are ankle sprains

FINDING #2

Up to 80% of ankle sprains are recurring injuries, often due to inadequate rehabilitation

FINDING #3

Ill. 15.01

0.03

TREATMENT JOURNEY

What happens when you get a sports injury?

When sustaining an acute sports injury there are multiple possible courses of treatment, depending on the type and severity of the injury as well as own treatment preferences. Some people chose to ignore the injury and wait it out or seek treatment advice from friends, family, personal trainers or on the Internet, while others seek professional treatment. An accurate diagnosis followed by prompt and well-planned treatment can decrease the time away from sport for the athlete as well as lowering the risk of re-injury, both in general and in relation to ankle sprains, for which reason it is advised to contact relevant healthcare professionals (Neergaard, C., Andersen, B., 2010), (Dubin, J. et al., 2011)

Whether seeking treatment at the hospital, from a general practitioner, a physiotherapist or similar, so called active therapy - treatment through an exercise program - will most often be part of the rehabilitation of the sports injury at some point. This is also the case with sprained ankles, where it is found that most sprains can be successfully treated using a non-surgical approach. (Dubin, J. et al., 2011)

EXPERT INTERVIEWS

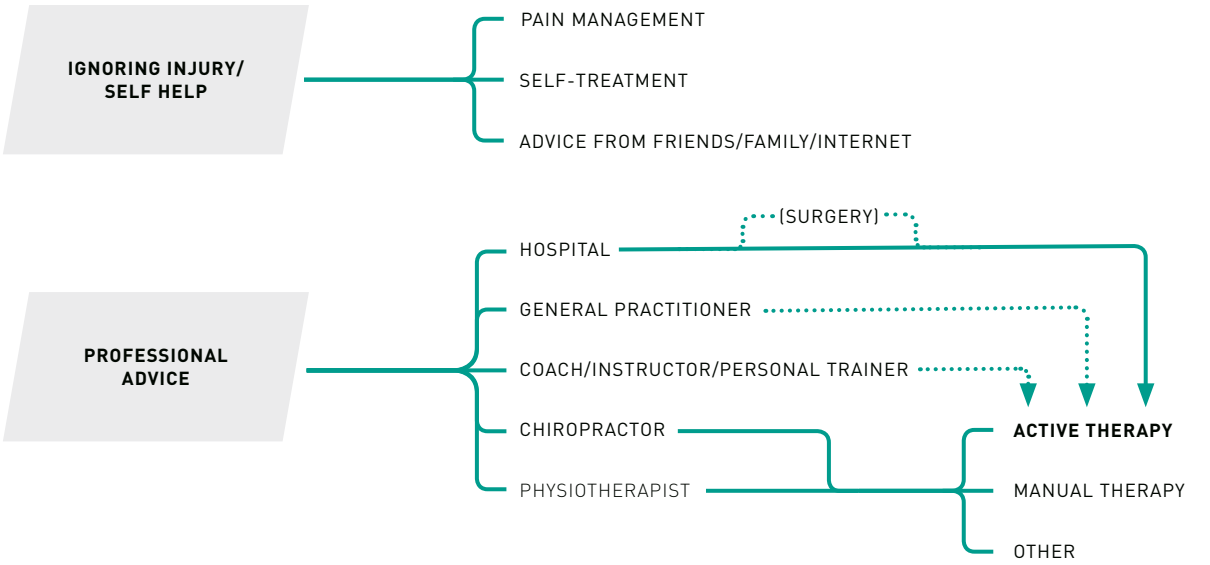
ABOUT PROFESSIONAL TREATMENT

> *"Things have changed in relation to how Physical Therapy is carried out. As it is now, there is a lot of focus on active therapy."*

Rikke Jepsen, Physiotherapist

> *"Almost 100% of the patients get some form of exercises for home treatment."*

Lise Skjødt Birkeland, Physiotherapist



Ill. 16.01: Treatment journey based on desk research (Neergaard, C., Andersen, B., 2010) and patient interviews

Active therapy will most often be part of the rehabilitation of sports injuries

FINDING #4

0.04

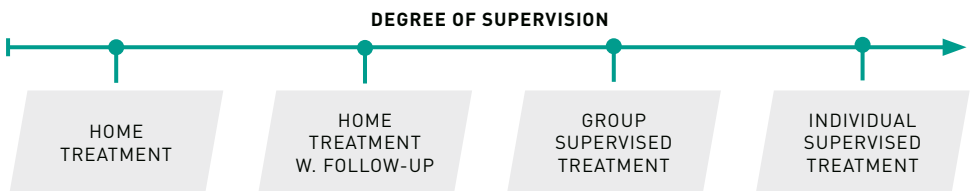
ACTIVE THERAPY

Supervised treatment - the rehabilitation potential

Active therapy is the part of physiotherapy concerning execution of physical exercises in order to rehabilitate or improve the physical level of function. In relation to acute sports injuries, the goal is to restore normal mobility followed by restoring normal stability and neuromuscular control. As described by physiotherapists Rikke and Lise [WS 1, 2], active therapy is a core activity carried out by physiotherapists, who communicate patient-adapted treatment plans based on assessment of the injury. Treatment plans can also be communicated by other professional healthcare personnel like chiropractors, hospital staff or general practitioners as well as coaches or personal trainers (ill. 16.01), however, the degree of patient- or injury-adaptation may vary depending on the specialisation level of the prescribing person. In recent years there has been an increase in active therapy within the field of rehabilitation, due to research confirming the effect and potential of exercise programmes. Recent studies comparing surgery to supervised active therapy further underline the potential of this rehabilitation form, e.g. in relation to knee injuries, where intensive exercise treatment programmes are found to outmatch surgery both in the short and the long run (politiken.dk).

Depending on the type and severity of the injury, the patient will carry out the planned rehabilitation based on just one combined diagnosis and treatment plan consultation or return for status follow-ups throughout the rehabilitation process, ensuring progress and adaption of the treatment plan according to the current level of function (Ill. 17.01). In some cases, patients attend rehabilitation exercise groups, where a physical therapist supervises the treatment. However, this type of treatment is mostly target elderly or patients with severe or chronic illnesses like stroke or Parkinson's patients. In some instances where the patient has specific rehabilitation needs, so called individual supervised treatment is provided. This type of treatment is mostly offered to people at hospital facilities recovering from traumatic injuries or as intensive rehabilitation stays for people suffering from chronic illnesses like severe arthritis or back pain. A different patient group often getting individual supervised treatment by specialised healthcare professionals are elite athletes, for whom it is important to recover fast and regain full physical functionality while preventing future injuries.

Regardless the patient type, some of the core benefits of supervised treatment is an increased exercise compliance by the addition of an externally driven motivational force, insurance of correct and optimal execution of exercises as well as continuous adaption of the exercise programme based on the current level of function [WS 6]. Supervised treatment is expensive and not necessary for everyone, for which reason it is mostly limited to be an option for people for whom external stakeholders benefit from this choice.



Ill. 17.01: Degree of professional supervision in relation to active therapy type

Supervised treatment improves compliance through external motivation FINDING #7

The majority of active therapy is carried out as home treatment FINDING #5

Supervised treatment ensures correct execution of exercises FINDING #8

The rehabilitation goal is to restore normal mobility followed by restoring normal stability and neuromuscular control FINDING #6

Supervised treatment ensures continuous adaption of the exercise programme based on the current level of function FINDING #9

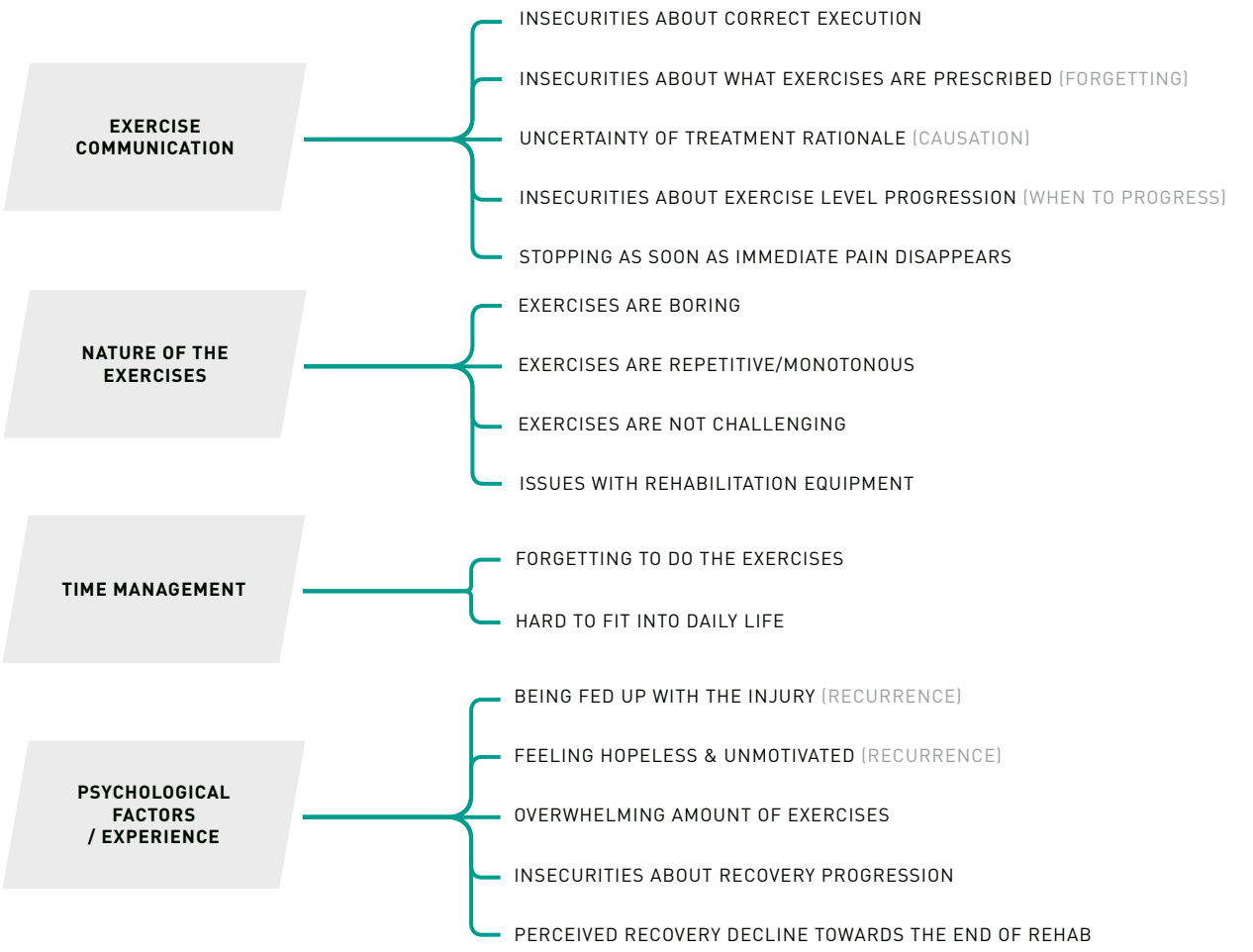
0.05

NON-COMPLIANCE

Why aren't home exercise programmes successful?

Despite the well-documented benefits and potential of active therapy, far from everyone who get prescribed rehabilitation programmes from trained professionals obtain the full effect of the therapy. One of the central reasons is non-compliance. Even when looking isolated at athletes, research shows that around 65% of patients will demonstrate some degree of non-compliance to their prescribed home exercises (Marshall, et al., 2012). Through reviews of current academic research on the topic, interviews with physiotherapy patients as well as physiotherapists, a range of reasons for non-compliance reasons are found. The listed reasons are connected to a variety of sources, encompassing athletes of varying types and levels with different sports injuries. More specific non-compliance reasons can be linked to specific injuries and related equipment (Dean, et al., 2009), [WS 3].

DISCOVERED REASONS FOR DECREASED REHABILITATION PROGRAMME EFFECT



Ill. 18.01: Found causes to non-compliance among athletes, grouped into general topics and underlaying causes

Athletes' compliance problems are rooted in issues with exercise communication, the nature of the exercises, time management and the experience

FINDING #10

INTERVIEW STATEMENTS

The following statements further describe some of the reasons for non compliance, found through interviews with previously injured athletes paired with data from journals.

UNCERTAINTY OF TREATMENT RATIONALE

I don't really think I got a full rationale, in terms of saying if you do this, this will work on improving certain muscle areas... didn't really get that kind of explanation at all"

(Marshall, et al., 2012)

STOPPING AS SOON AS IMMEDIATE PAIN DISAPPEARS

"After a while my ankle felt fine again - so why should I keep doing the exercises? "

Lotte, recreational runner

INSECURITIES ABOUT RECOVERY PROGRESSION

"I didn't really feel like I was getting any better. Only when I went to the physiotherapist who would help me see my improvements and praise my effort"

Maria, Multi athlete

FORGETTING TO DO THE EXERCISES

"It's more of a case of remembering rather than finding the time"

(Marshall, et al., 2012)

0.06

OPPORTUNITY SPACE

Defining a project focus

MACRO TRENDS - TECHNOLOGY

An aspect often affecting opportunities in new product development is emerging technology trends. Desk research [WS 4, 20] as well as general insight and observations in relation to what is trending in the world of technology uncovers an array of trends that are applicable and inspirational in the context of sports injury rehabilitation. In regards to sports and health in general, one of the major trends is monitoring and tracking of every possible data point. Athletes are now tracking everything from pulse and heart rate to macronutrient intake and specific muscle activity. Additionally monitoring and tracking functionalities are migrating from watches and phones into other products like headphones and even clothes. It is predicted that the home health technology market will expand rapidly within the coming years; becoming a $34 billion market in 2020 (forbes.com). This is a development enabled by the decreasing size and price of sensors, which also plays a part in the increasing amount of smart and connected products that surrounds us in our everyday lives. Lastly, technology enabling sports performance improvement is transitioning from the world of professional athletes to that of the ambitious and aspiring athlete.

Ill. 20.01: Technology trends, collage

SPORTS INJURY REHABILITATION

As previously described, an ankle sprain is the most common sports injury and up to 80% will re-sprain their ankle due to inadequate rehabilitation. Furthermore, it has been found that patients do not reach the full potential of rehabilitation due to compliance problems and lack of supervision. Additionally, a quick screening of the current products used for rehabilitation of ankle injuries show that they are in general non-responsive and both functionally and aesthetically un-sporty compared to the general products targeted athletes.

INSPIRATIONAL SAYING

"What gets measured gets improved"

Saying known from the sports and managing context

Ill. 21.01: Sports injury rehabilitation findings, collage

*...WHY NOT TAKE ADVANTAGE OF THE **EMERGING TECHNOLOGY** AND **TRENDS** TO GET THE **QUALITY** AND **EXPERIENCE** OF SPORTS INJURY REHABILITATION **CLOSER TO** THAT OF **SUPERVISED TREATMENT**?*


MONARK

KEY ACTIVITES

DESK RESEARCH

- Sports injuries, ankle sprain
- Rehabilitation & compliance
- The athlete and sports context
- Rehabilitation products
- Motivation

FIELD RESEARCH

- Movement lab, UCN Aalborg
- Physiotherapist, FysioDanmark

INTERVIEWS

- Physiotherapist, Claus
- MSc. Physiotherapy & Ph.d. student, Lars Henrik Larsen
- Physiotherapist goers
- Survey (injured athletes)
- Athletes, in person & post-survey emails

1.00

UNDERSTAND

Through additional desk research and interviews with experts in the field, the opportunity area is further uncovered and analysed. Additional findings guide the process, leading to normative curiosities and two guiding paradoxes giving direction to the subsequent steps.

1.01

THE ATHLETE

Who gets an ankle injury?

Everyone can get an ankle injury but athletes are especially at risk. An athlete is defined as *a person who is trained in or good at sports, games, or exercises that require physical skill and strength* (merriam-webster.com-2). Athletes range from being on a recreational level, mainly exercising to improve physical as well as mental health and well-being, to the professional athlete for whom sports is their whole life and even career.

Whether you are a recreational athlete or an athlete on a professional level you are in risk of the same injuries, as described in sports injury literature (Neergaard, C., Andersen, B., 2010). The football player meeting up with his friends for a recreational Sunday match can be just as unlucky to sprain his ankle as the professional player during an important match.

Some types of sports have higher injury risk than others. In general, contact sports like football, handball and alike are more prone to causing acute injuries. The prevalence of different injury types is also highly connected to the type of sport. In relation to ankle sprains, these *"are common among athletes who participate in sports that involve running on changing terrains, repetitive jumping, or frequent changes in direction, such as basketball, volleyball, soccer, football, and cross-country"* (Dubin, J. et al., 2011).

Ill. 24.01: Examples of sports with high risk of ankle sprains; cross-country running, volleyball, football, handball

1.02

ANKLE SPRAINS

Cause, consequence & rehabilitation

As described earlier, ankle injuries are common in sports. Most types of sports encompass stress and strain on the lower leg and ankle, as this is the connection point with the surface; having to provide support for the entire body weight during running, jumping and quick direction changes or when met with unforeseen and sudden obstacles. This calls for high demands in relation to strength and adaptability of the lower extremities in order to avoid injuries (Neergaard, C., Andersen, B., 2010)

An ankle sprain is a stretching or tearing of the ligaments in the ankle. The ankle joint has ligaments both on the outer and inner side of the joint to ensure stability. Most often it is one of the three outer ligaments that gets stretched or torn when an athlete sprains an ankle. The severity of the injury is determined by which and how many ligaments are torn and to which extent. Depending on the severity the sprain is categorised as being grade 1, 2, or 3 (ill. 25.01). The severity of the injury affects factors like pain, joint instability, risk of long term pain and damage, as well as the timespan for healing.

GRADE 1 MILD	GRADE 2 MODERATE	GRADE 3 SEVERE
STRETCHING, SMALL TEARS	PARTIAL TEARING	COMPLETE TEAR
2-4 WEEKS	4-8 WEEKS	8-12 WEEKS

Ill. 25.01: Grade and characteristics of sprain based on degree of ligament damage & approximate healing time

Overall the rehabilitation goal is the same for all severities; to restore normal mobility followed by restoring normal stability and neuromuscular control. The stability and neuromuscular control is created through rehabilitation of the muscles controlling the ankle joint in combination with regaining so-called joint proprioception. Proprioception is defined as *"one's ability to integrate the sensory signals from various mechanoreceptors to thereby determine body position and movements in space"* (1).
When sustaining an ankle injury the proprioceptive receptors are damaged and thereby affecting the person's ability to sense the exact position of the ankle, affecting both short term functional stability and balance, as well as increasing the risk of re-sprains or even the risk of sustaining other injuries. A well-functioning ankle proprioception is central for athletes, as it ensures correct foot positioning before landing during running and jumping as well as facilitating rapid joint corrections when presented with unforeseen surface irregularities (e.g. an opponent's foot) or external forces affecting predicted post-jump landing (e.g. the defense pushing an attacking handball player).

Proprioceptive training on balance boards have been found to reduce the risk of ligament injuries in the ankle for both athletes with previous ankle sprain injuries as well as athletes with undamaged ankles. The benefits of a strong and responsive ankle joint are not just connected to injury prevention but can in fact improve the athlete's sports performance in relation to e.g. speed and agility, which in a football match can mean that you will be the first person on the ball after a heading duel. (Neergaard, C., Andersen, B., 2010), (Han, J. et al. 2015).

Rehabilitation of the ankle joint encompasses rehabilitation of the muscles controlling the ankle joint
FINDING #11

Rehabilitation of the ankle joint encompasses rehabilitation of joint proprioception
FINDING #12

Proprioceptive training on balance boards have been found to reduce the risk of both ligament injuries and re-injuries
FINDING #13

A strong and responsive ankle joint can improve an athlete's sports performance
FINDING #14

1.03

PERSONAS

Target group archetypes

To get a greater understanding of the potential target group, athletes from a variety of sports and of different level and age are contacted. Interviews are conducted at fitness centres, at the university premises as well as via email; contacting athletes who have participated in a survey created by the team with the purpose of attaining knowledge about the athletes, their injuries and rehabilitation as well as establishing contacts to persons within the target group that can be sparred with throughout the development process.

In the following archetypes, the statements from the interviews, as quoted in the following, are paired with general observations as well as written depictions of different athlete types found in sports injury literature. The personas are used to synthesise and align target group information within the team and to exemplify this to other stakeholders involved in the design process. Creating personifications of the user group aids the design process in relation to ideation and decision-making by making reference points in relation to different polarities of user characteristics and behavioural profiles. [WS 3, 9, 11]

THE RECREATIONAL ATHLETE

ANDERS - 32 YEARS OLD - RUNNER

Anders has been a regular runner for many years and has established a running club with his friends, who he runs with 1-2 times a week. Besides this, he will go for a run or to the gym 2-3 times by himself. Anders does his best to live a healthy lifestyle, exercising regularly in order to stay fit. The friendly competition among his running mates helps in motivating him to improve, not wanting to be the one to fall behind or look weak in the eyes of his friends. By using running watches he keeps track of time, heartbeat and speed, both for himself to keep track and set goals, but also to compare results and progression among the members of the club.
Anders recently resprained his ankle, only a few months after recovering. He is frustrated as he knows that once again it will not only put his training on hold, but set him way back. When his ankle sprained the first time, he went to the physiotherapist who subscribed home exercises. Since the pain disappeared a few weeks into the programme, he didn't see the value in continuing the rehabilitation, and was relieved that he could put an end to what he felt was meaningless exercises and return to his running club.

" When I sprained my ankle, I got frustrated and annoyed. Rehab as I have experienced it can in no way be a stand in for sport."

Anders, Runner

Ill. 26.01: Persona

THE AMBITIOUS ATHLETE

JOHN - 38 YEARS OLD - TRIATHLETE

John is a dedicated triathlete. Training for a triathlon is a huge challenge and requires commitment, patience and self-motivation. The feeling of accomplishment when completing such an extreme challenge, and doing it better each time, is what drives John. Sport is his lifestyle - he practices either running, cycling or swimming all days of the week, while complementing with fitness exercises at home. He closely follows the recent developments in sports technology and gladly pays for products that can give him just a marginal advantage in competitions. He keeps track of as many aspects of his training as possible, making sure that nothing goes unchecked.
He has no ambitions to become a professional, yet he was training for his first Ironman when he last got injured. John was devastated as he was finally feeling ready to take on the challenge. Even though the physiotherapist told him to not rush his recovery, he did not want to miss out on the race that he had been looking forward to, and tried to push through by quickly moving into challenging exercises.
A few weeks before the competition, he relapsed.

" I was in the best shape of my life when I got injured, and have never returned to the same level as a result of the many frustrations that has caused me to lose motivation.

John, triathlete

Ill. 27.01: Persona

THE ASPIRING ATHLETE

LOUISE - 21 YEARS OLD - HANDBALL PLAYER

Louise plays handball with her team 5 times a week - 4 times practicing and one match. Playing handball is her great passion, and she aspires to become a professional one day. Being part of a team and not letting them, herself or her coach down keeps her motivated. Having her coach keep track of her progression and advise her on how to improve, allows her to focus on just performing at her best level. Since high school, handball has been a major part of her life and identity. The physical contact sport is rough on her joints and Louise has sprained her ankle many times. She knows that she needs to do the exercises on the balance board subscribed by the physiotherapist, but when she is just at home on her own, she finds it difficult to motivate herself. She finds the exercises boring and does not fully understand how it helps her, seeing no connection between standing on the board and the intensity and team spirit she experiences on the pitch. After initially feeling committed and buying the equipment that the physiotherapist suggested, she slowly stopped performing the full program, leaving out the exercises that she thought was too repetitive.

" I absolutely dreaded being injured as handball was and still is a huge part of my life. Missing out on the training was a burden for me mentally, and I would watch my teammates play, feeling frustrated that I couldn't be there for the club.

Louise, handball player

Ill. 27.02: Persona

1.04

EXISTING MARKET

What products are currently on the market?

To get an overview of the current market for ankle rehabilitation products desk research is conducted, supported by interviews with physiotherapists and people who have been through ankle rehabilitation. The selection of products below are the products that are most often used and recommended for ankle sprain rehabilitation; both for home exercise programmes and when rehabilitating with the physiotherapist at the clinic. The product found to be recommended most often by the physiotherapist in relation to home use is the balance board, often complimented by a resistance band. The products are used in different stages of the rehabilitation; starting with products creating a slightly uneven surface (e.g. 4 & 6), transitioning into wobble cushions and balance boards (2, 3 & 5) and ending with products that can support exercises closer to the normal sports situation like the BOSU ball (7). However, the actual difficulty depends on the specific products as it might vary within each category. As the function of the injured ankle gets increasingly restored through the rehabilitation, the athlete needs to acquire multiple products for an ideal treatment that supports the entire rehabilitation period, but this is seldom prioritised by patients. Instead, cheap pseudo solutions are used to mimic the same effect, like using a towel to create an uneven surface in the beginning [WS 5].

3

2

1

DESCRIPTION & PRICE

1. ***Balance pods*** can be used individually but are most often used to make balance trails with different sensory challenges.

   Price 80-199kr per piece

2. ***Standard balance board.*** Used to train ankle mobility and proprioception. Has a fixed difficulty level depending on height and dome shape.
   Price 69-299kr

3. ***Adjustable balance board.*** Used in the same way as the standard balance board, but with the possibility of changing the difficulty level by changing the dome shape or height.
   Price 100-399kr

4. ***Surface structures*** with different surface profiles are used to challenge the ankle through different uneven standing surfaces in the early phases.
   Price 600-900kr

6

4

7

5

8

29.01. Examples of used and recommended ankle sprain rehabilitation equipment

5 ***Wobble cushion.*** Used to create an instable and challenging surface. Available in different difficulties and in some cases adaptable by increase or decrease of air level.
Price 180-350kr

6 ***Balance pad***. Used to create a slightly instable and challenging surface in the early faces. Available in different sizes and thicknesses.
Price 350-700kr

7 ***BOSU ball.*** The BOSU ball can be used later in the rehabilitation for functional exercises and injury prevention.

Price: 1299-1999kr

8 ***Resistance bands*** are used for exercises in the first parts of the rehabilitation; training different ankle movements and strengthening muscles.
Price: 50-60kr

1.05

FIELD RESEARCH

Clinic visit and physiotherapist interview

To get a deeper understanding of sports injury rehabilitation, ankle sprain rehabilitation and the athlete as target group, a physiotherapy clinic is visited. This additionally provides insight into rehabilitation equipment used at the clinic as well and current methods used by the physiotherapist to measure and track rehabilitation progress of patients. The following describes key parts of the interview and observations grouped into different areas of interest with associated insights [WS 6].

ELITE ATHLETES AND SUPERVISED TREATMENT

Elite athletes typically do individual supervised active therapy two or three times a week when rehabilitating a sports injury additionally supplemented with strength training to stay fit while injured.

REHABILITATION PITFALLS OF THE ATHLETE

Compared to the average person, everyday athletes are described to be prone to a range of rehabilitation pitfalls. If the physiotherapist does not control the rehabilitation it is often experienced that the athlete will skip stages of the rehabilitation, either due to external pressure from a coach or an important match, or due to the athlete's own determination to get back as quickly as possible. In general, the athletes are described to be over-doers also resulting in excessive execution of the prescribed exercises, thinking that it would make the rehabilitation faster. Contrarily, the phase skipping or overdoing will make the recovery slower or even result in re-injury or attaining a different and sometimes even worse injury. A similar issue seen both in relation to athletes and the average person, is stopping the rehabilitation programme as soon as the immediate pain disappears, likewise often resulting in re-injury or additional injuries. In general, the pitfalls are described to affect the athlete's end functional level, which will not reach the pre-injury level without proper rehabilitation.

DIFFERENCE IN REHABILITATION NEEDS

Compared to the average person, the athletes need to be rehabilitated to a higher functional level, as their sport is way more demanding than the everyday life of a non-athlete. For the average person the goal of the rehabilitation might just be to be pain free during everyday life - not to be able to play high intensity handball or run a marathon, which requires a higher level and quality of the rehabilitation.

Ill. 30.01: Selection of rehabilitation equipment found at the physiotherapist clinic

Elite athletes supplement rehabilitation with strength training to stay fit while injured
FINDING #15

Athletes are prone to skipping rehab phases
FINDING #16

Athletes are prone to overdoing the number and intensity of exercises
FINDING #17

Rehabilitation is often stopped too early due to experienced pain relief
FINDING #18

Inadequate rehabilitation will decrease the athlete's performance level
FINDING #19

Inadequate rehabilitation will increase risk of re-injury or attaining different injuries
FINDING #20

The rehabilitation of an athlete needs to be of a higher level and quality than that of the average person
FINDING #21

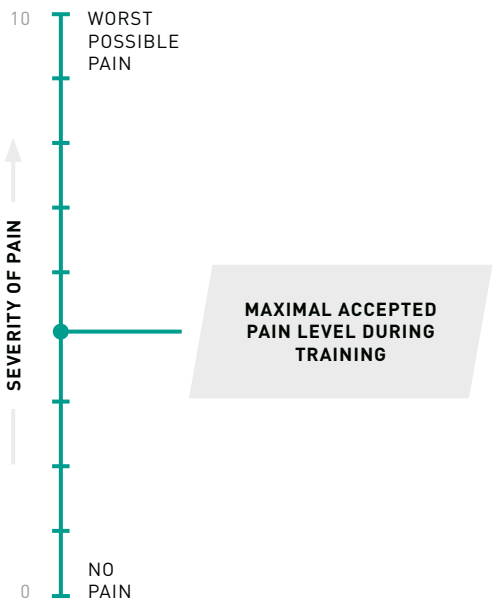
TESTS, PROGRESSION & ADAPTION

In all kinds of rehabilitation, it is important to do a start test and re-tests multiple times throughout the rehabilitation as it makes it possible to see progression, which is both valuable for the patient and helps guide the physiotherapist in structuring and adapting the programme. In relation to sports injuries the physiotherapist additionally does a so-called return-to-play test before letting the athlete return to their sport. The test is adapted to the specific injury as well as type and level of sport. It is designed to simulate the athlete's sports situation; requiring physical demands similar to challenges in the actual sport.

Progression in relation to mobility is possible to measure quantitatively, by comparing the athlete's maximum joint mobility in the different movement axis of the ankle week by week. Joint stability is more difficult to measure. This is most often done qualitatively by the physiotherapist who observes the atlete perform certain exercises and, based on experience, decides if progress has been made and if the athlete is ready for more difficult exercises or equipment. Without the help of the physiotherapist it can be difficult to figure out when to progress to the next rehabilitation steps. The interviewed physiotherapist describes how he has multiple times experienced patients advancing too fast, resulting in setbacks. A way to keep track of when to progress is tracking pain levels. When rehabilitating injuries, it is not possible to be totally pain free. Pain is evaluated based on the VAS scale, subjectively rating the pain level between 0 and 10 (Ill. 31.01). During the exercises the pain should not exceed three or four. Half an hour to one hour after exercising, the pain should be gone - otherwise the exercise level has been too high. Training at the correct intensity and level is central for the optimal rehabilitation. That is why supervised treatment is so effective. The physiotherapist is always making sure that it is neither going too fast or too slow.

ANKLE REHABILITATION EQUIPMENT

There is a lot of different equipment available. It is not necessarily better to use a combination of everything, but it is a good way to create variation to ensure that the training does not get boring when you have to repeat the same exercise for a long time. The balance board is described to be a prehistoric piece of rehabilitation equipment, but it is still being used because the effect of it is good and it is found to deliver a high quality rehabilitation. It enables axial movement challenges which is known to be beneficial and challenging - but it is not very exciting unless you have a physical therapist who can facilitate that part.



31.01: VAS pain scale

Joint mobility and stability is tested throughout the rehabilitation to ensure the correct progression and motivate the patient FINDING #22

Training at the correct intensity and level is central for the optimal rehabilitation FINDING #23

Pain is used as an indicator for training at the correct intensity and level. It is evaluated subjectively using the VAS scale FINDING #24

Use of different rehabilitation products creates variation to prevent boredom FINDING #25

1.06

PRE-SCOPING

Normative curiosities

Insights discovered through the pre-phase and understand phase give rise to normative curiosities within the project focus. These curiosities are used to unfold possible parameters to target in order to create value for the target group.

How is the rehabilitation supposed to progress? ... and how can correct training be facilitated at home? p. 34-35

TRAINING RIGHT

As discovered when interviewing both physiotherapists and athletes who have been through the rehabilitation process, ankle sprain rehabilitation and sports injury rehabilitation in general encompasses a range of pitfalls that are typical for the athlete. Some of the central pitfalls concern skipping rehabilitation phases, overdoing number and intensity of exercises and stopping when the immediate pain disappears. During supervised treatment the physical therapist is managing the execution and progression as well as making sure that intensity and level is constantly adapted to the functional level.

MOTIVATION

For the average person, lack of motivation to do the rehabilitation exercises is found to be a central reason for non-compliance. Contrarily, the athletes are motivated to recover, as the injury keeps them from being active. Additionally, they are more aware of the importance of rehabilitation as a medium to recover fast and fully. Still, there are issues in relation to the equipment and the experience of using this that keep them from completing the rehabilitation and reaching its potential. During supervised treatment the physical therapist is found to be the motivating factor creating variation and meaning for the athlete and thereby appealing to the athlete's motivational triggers.

What is motivation? ... and what are the motivational triggers of an athlete? p. 36-39

What characterises the products in the athlete's context? ... and how can the equipment appeal more to athletes functionally and aesthetically?

p. 40-41

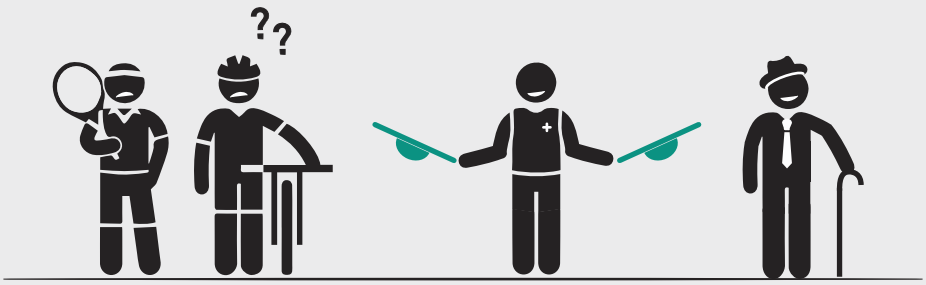
EXPRESSION & EXPERIENCE

As briefly touched upon in the pre-phase, ankle rehabilitation products are found to be generally non-responsive and both functionally and aesthetically unsporty compared to the general products targeting athletes - a view found to be shared by the interviewed physiotherapy patients, who all had given up on their balance board after a short while.

Discovered paradoxes

THE REHABILITATION PARADOX

(PHYSIOLOGICAL)

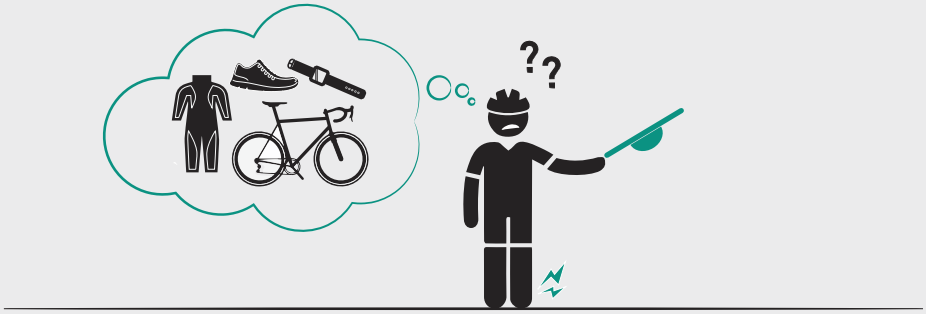


Athletes differ from other people in the way that they are motivated and the functional level that they need to be rehabilitated to.

Why are they rehabilitating using the same products as everybody else?

THE PERSONAL PARADOX

(PSYCHOLOGICAL)



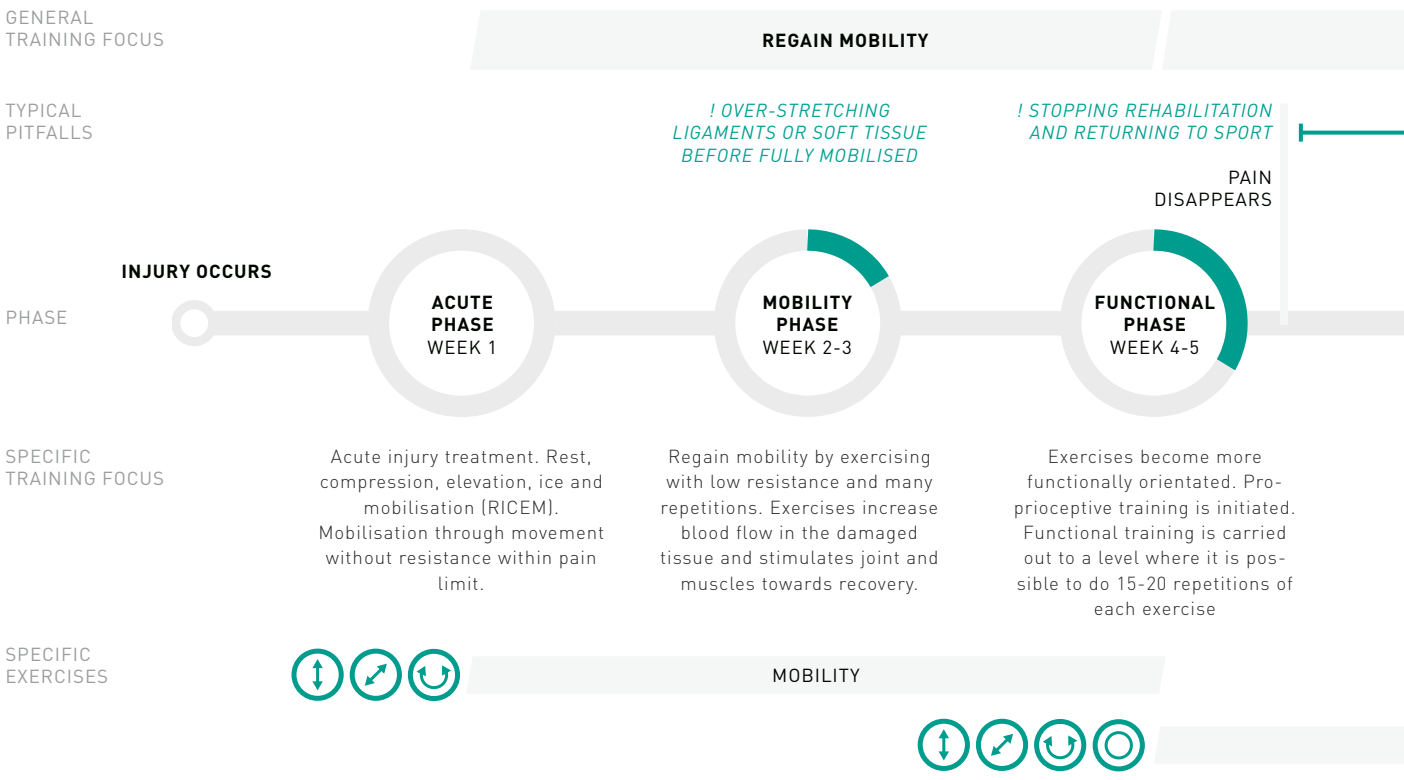
When an athlete sprains an ankle they exchange their active lifestyle and personal sports performance equipment with a generic balance board and a resistance band.
Why is there such a big contrast between the rehabilitation context and the sports context when both have to do with training?

1.07

REHABILITATION PHASES

Desired progression and possible pitfalls

Every rehabilitation process is different depending on the type and severity of the ankle sprain, the pre-state of the joint and tissue, the injured person in question and so on. However, the process can be simplified to consist of seven phases; acute, mobility, functional, training, sports-specific, back-to-sport and prevention [WS 7, 8], (Neergaard, C., Andersen, B., 2010). The following mapping gives an overview of what is found to be central in each phase as well as which exercises are typically done. Additionally, the mapping is used to create an overview and synthesise insights and other data collected through the interviews with physiotherapists as well as the previously mentioned survey [WS 9], in order to add the knowledge about what is central when dealing with the specific target group. The duration of the described rehabilitation is an approximation based on a grade 3 ankle sprain which takes approximately 8-12 weeks to rehabilitate.



ANKLE JOINT & MOVEMENTS

Ill. 34.01: Ankle rehabilitation movements

PLANTAR FLEXION & DORSIFLEXION

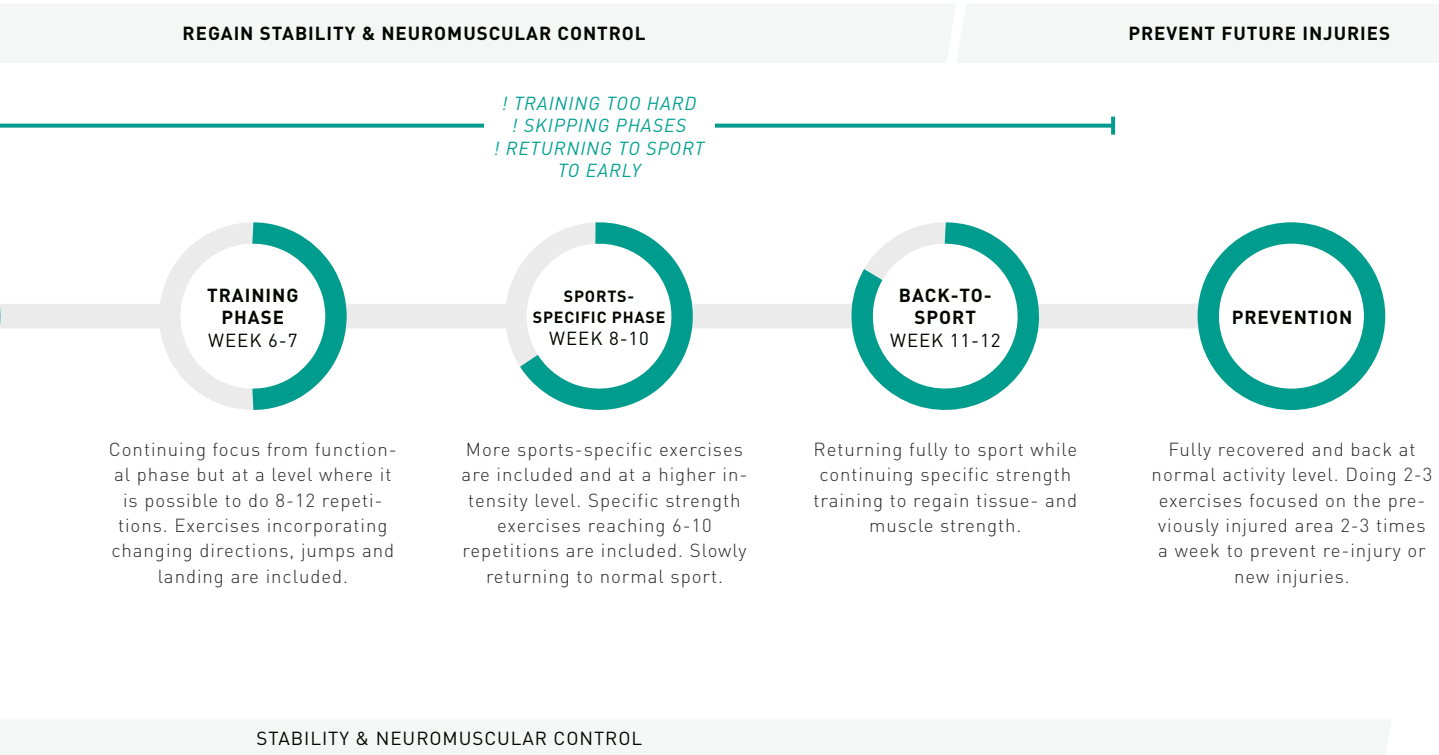
INVERSION & EVERSION

PRONATION & SUPINATION

PROPRIOCEPTION

The same basic exercises are carried out over a long period of time with little or no variation

FINDING #26



Foot movements are made possible by two major joints; the ankle joint making up- and downwards movements possible and the subtaler joint allowing the foot to rock from side to side. Ligaments, the tissue that is damaged when you sprain your ankle, connects bones to bones. Tendons are soft tissue structures that attach muscles to bones. In the case of the ankle it is the lower leg muscles that enable movements of the two earlier mentioned joints.

When spraining your ankle you rehabilitate by regaining mobility followed by regaining joint stability and neuromuscular control. Simplified there are four types of exercises which are gradually introduced and afterwards get more difficult along the way, for example by adding resistance to regain muscle strength and joint stability. The first exercise that is introduced is plantar flexion and dorsiflexion, which is the earlier mentionen upwards and downwards movement. This is followed by pronation and supination which is the sideways motion as well as inversion and eversion which is a diagonal pulling up and outwards motion. Lastly proprioception is trained through balance exercises to rehabilitate the neuromuscular receptors [WS 7], (Youtube.com-1), (Youtube.com-2).

1.08

MOTIVATION

What is motivation and how can it be facilitated?

In order to be able to appeal to the athlete's motivational triggers, it is necessary to firstly understand the nature of motivation - both in general and in relation to the desired target group. Motivation is found to be a key aspect of sports performance. It can be defined as being *"the hypothetical construct used to describe the internal and/or external forces that produce the initiation, direction, intensity and persistence of behaviour"* (believeperform.com-1). In relation to motivation this distinction between internal and external forces is referred to as intrinsic and extrinsic motivation, respectively. Intrinsic motivation comes from within, is fully self-determined and refers to doing an activity for the satisfaction of the activity itself. Contrarily, extrinsic motivation relies on external factors like demands, expectations or even rewards. In relation to sports, athletes are in their nature intrinsically motivated, as neither demands or rewards are enough to persistently train without deep personal interest and enjoyment. (believeperform.com-1), (believeperform.com-2), (Ryan, R., Deci, E., 2000).

SELF-DETERMINATION THEORY (SDT)

There are a variety of different theories dealing with how to understand motivation. One of the most recognised and used approaches is the self-determination theory, formulated by Deci and Ryan in 1987. Self-determination theory (SDT) is based on the idea that different types of motivation can be described by placing them in a self-determination continuum based on to which extent behaviour is chosen and self-initiated (Ill. 37.01). SDT argues, that intrinsic motivation is not the only type of self-determined motivation. Instead, it is proposed that extrinsic motivation can vary in its relative autonomy - splitting the construct of extrinsic motivation into four sub-categories; external regulation (classic understanding of extrinsic motivation), introjected regulation, identified regulation and integrated regulation.

In combination with previously collected data about various physiotherapist goers, SDT can be used to understand the difference in rehabilitation motivation between the average person and the athlete, as well as giving pointers in relation to how the rehabilitation motivation of athletes can be further improved through target group specific new product development (Ill. 37.02).

Externally regulated motivated tasks are characterised by being performed to satisfy an external demand. Similarly, the type of extrinsic motivation known as introjected regulation is characterised by behaviour being carried out to avoid guilt or to attain ego enhancements. For many people, rehabilitation is carried out due to an external demand; to satisfy a demand made by an authority and to avoid guilt when meeting this person at the next consultation. Identified regulation is a more autonomous and self-determined form of extrinsic motivation, where the individual understands the value or values the outcome of actions or behaviour despite not enjoying it. Integrated regulation share many qualities of intrinsic motivation. Behaviour is initiated out of choice because the known outcome is of high value to the individual despite not being viewed as enjoyable in itself. For athletes, rehabilitation will often be connected to the two latter forms of motivation in a similar way that parts of the sports training often is (ill. 37.02).

The understanding of outcome value and the actual outcome value in relation to a central aspect of the athlete's life - sports performance - means that rehabilitation motivation is in general not a problem for the target group. However, non-responsive rehabilitation equipment might conflict with the value perception and thereby decrease the rehabilitation motivation (ill. 37.02). An opportunity is found in targeting motivational triggers found within the athlete's sporting context in order to move the rehabilitation experience closer to that of sports (believeperform.com-1), (believeperform.com-2), (Ryan, R., Deci, E., 2000).

Athletes are in general intrinsically motivated in relation to their sport

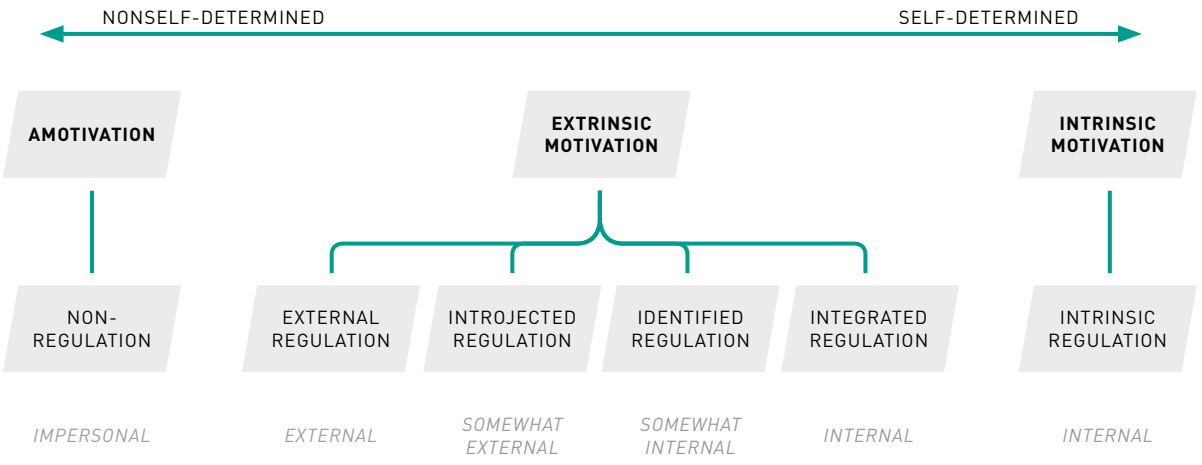
FINDING #27

Understanding the value or valuing the outcome of actions or behaviour makes motivation more self-determined for athletes

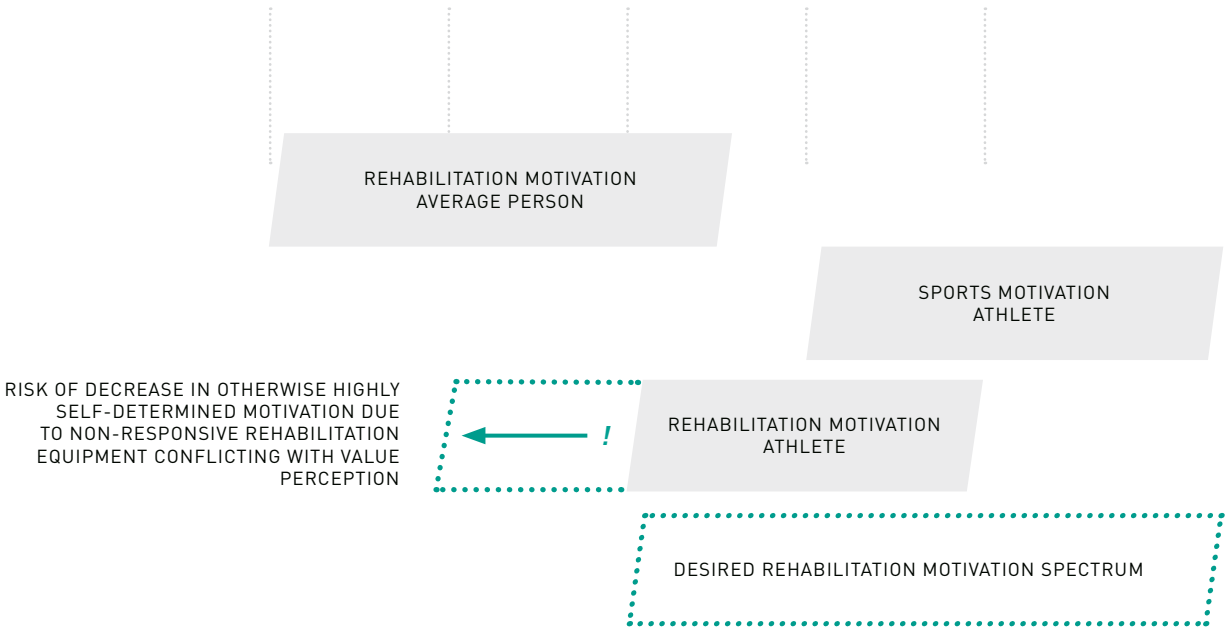
FINDING #28

SELF-DETERMINATION THEORY CONTINUUM

The following shows the self-determination model as made by Deci & Ryan (Ill. 37.01) along with understanding of current rehabilitation motivation, sports motivation, risks and opportunities based on the collected data (Ill. 37.02).



Ill. 37.01: Self-determination continuum, showing types of motivation with their regulatory styles and source of causality. (Ryan, R., Deci, E., 2000)

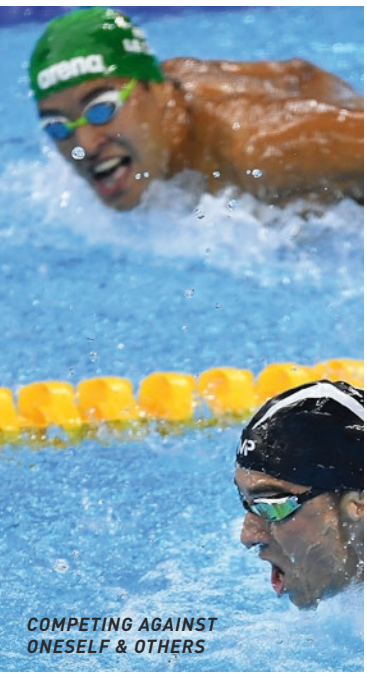


Ill. 37.02:. Understanding of current rehabilitation motivation, sports motivation, risks and opportunities based on collected data

MOTIVATION IN SPORTS

In addition to supporting the process of understanding the difference in rehabilitation motivation between the average person and the athlete, SDT also gives pointers in relation to different factors that can potentially affect the athlete's intrinsic motivation positively and thereby support new product development within the desired motivation spectrum (Ill. 37.02).
Research shows that external events like feedback and communication can facilitate a feeling of competence during an action and thereby enhance the intrinsic motivation for that action (Ryan, R., Deci, E., 2000). It is also found, that a perfect match between the perceived demands and an athlete's perceived abilities in relation to an activity will increase intrinsic motivation. If a challenge is unrealistic it can cause excess anxiety whereas a non-challenging activity will result in boredom for the athlete. A central way to create motivation is therefore *"to stretch athletes just a touch further than they have been stretched before"* (believeperform.com-1), which goes well together with the knowledge attained in relation to rehabilitation. In addition to this is, the approach of creating short term goals as a motivational driver in the process of reaching a bigger long term goal is found to facilitate improvement in performance (believeperform.com-1).

In addition to the theoretical knowledge foundation in relation to possible motivational elements, an array of motivational principles are derived through a mixture of interviews and desk research on different sports forums. The desired target group is found to stay motivated by tracking progress over time, seeing or feeling the progress, getting small wins by setting intermediate goals as well at including competitive elements both in the sense of beating own records as well as beating other athletes.



Ill. 38.01: Motivational principals found within the sports world

Feedback and communication can facilitate a feeling of competence during an action

FINDING #29

Match between the perceived demands and perceived abilities can increase intrinsic motivation

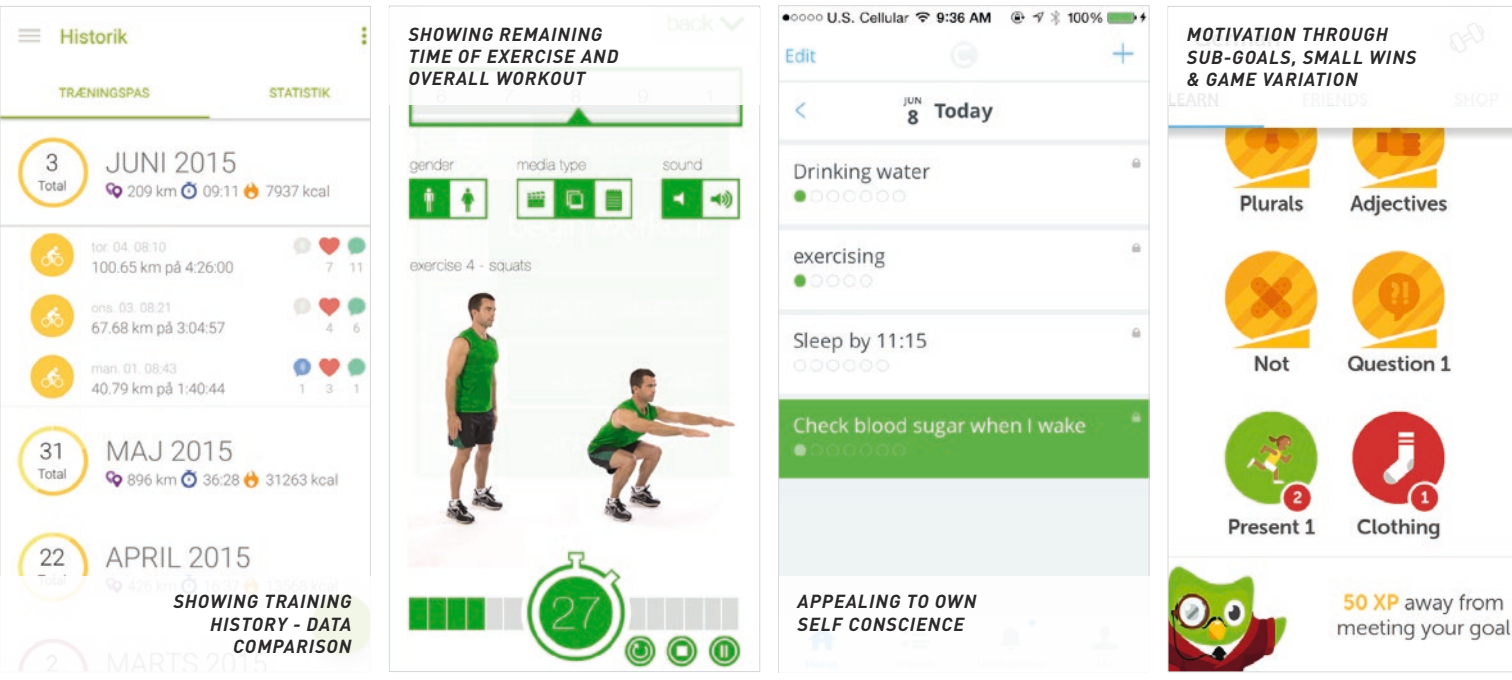
FINDING #30

DIGITAL MOTIVATION

Besides the motivational principles found within the sports context, the earlier described emerging technologies and trends open up for the opportunity to incorporate some of the motivational principles currently popular in the digital world. Applications tracking sports data in similar ways to running watches have been around for a while and continue to be popular. Apps like 'Endomondo' lets you track various workout data, enabling data comparison as well as giving you the possibility to let an automated voice coach tell you e.g. your km pace while working out, to let you know how you are doing through live feedback. Another popular fitness app is '7 minute workout', a circle training-like workout app making it easy for you to squeeze in a workout in your busy life, helping you with reminders and guiding you through the workout by either video, illustration or text descriptions, depending on preference. Additionally, the app shows you the remaining time of the specific exercise as well as the overall workout.

Another motivational app type that has become increasingly popular, is habit facilitating apps, like 'Coach.me'. 'Coach.me' lets you set specific habit goals and helps you maintain these through notifications and visual calendar systems appealing to your own conscience - keeping promises to yourself. It is also possible to seek support from other users or even "hiring a coach".

A final app type trying to maintain users' motivation, is skill learning apps like the language app 'Duolingo'. Like the habit facilitating apps, 'Duolingo' tries to get you to keep the promise you have made to yourself by tracking the days you have reached your learning goal. Additionally it compiles these to an ongoing streak, which, when reaching a certain amount is experienced to be very motivating for the users, of which some have been seen to seek help on the app forum when losing a 100+ day streak due to forgetfulness on a busy day. 'Duolingo' also helps maintaining motivation by dividing that overall goal into sub-goals, providing small wins through intermediate tests as well as creating variation though different learning or game modes.



Ill 39.01 Motivational principals found within the digital world

1.09

SPORTS CONTEXT

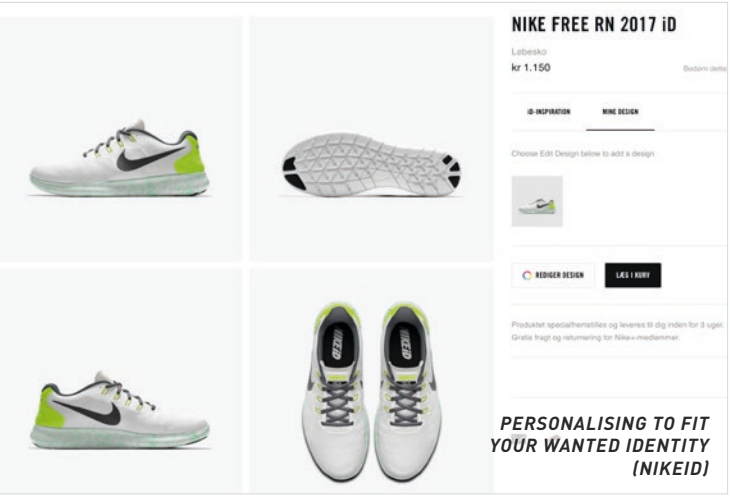
Sports identity, lifestyle & performance enhancement

To make a future product appeal to the desired target group and in general fit into the athlete's context, it is necessary to understand what characterises this context, both at the present time, but also the developments within the product context that will direct future solutions.

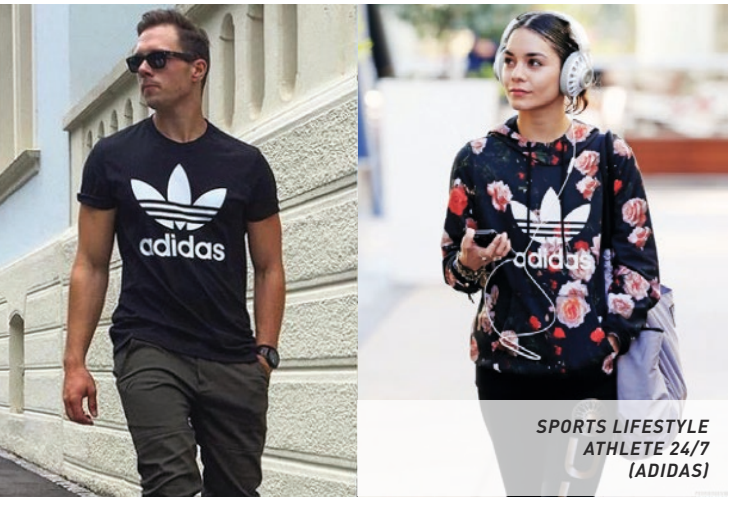
Products most often provide more value to people than the mere functional value. Research within the field of consumer behaviour suggests that we use possessions to contribute to and reflect our identities, as described by e.g. Belk in his work regarding possessions and 'the extended self' (Belk, 1988). Belk argues that our possessions are often regarded as being parts of ourselves or even extensions - either symbolically as identity depictions or literally as when a product allows a person to do things that they would otherwise be incapable of (Belk, 1988). Sports equipment is not an exception - quite the contrary.

Looking into the world of sports apparel and equipment it is quite apparent that the value of reflecting one's identity in combination with achieving some kind of self-actualisation is central.
When people buy sports equipment they buy a specific identity and lifestyle as well as the opportunity to improve their sports performance. This also explains why people are willing to spend a lot of money on exactly this product category - you do not want to be let down by your gear.

IDENTITY & LIFESTYLE



PERSONALISING TO FIT YOUR WANTED IDENTITY (NIKEID)



SPORTS LIFESTYLE ATHLETE 24/7 (ADIDAS)

CUSTOMISED

CUSTOMISED EQUIPMENT FOR OPTIMAL PERFORMANCE (PERSONAL SHOE INLAYS)

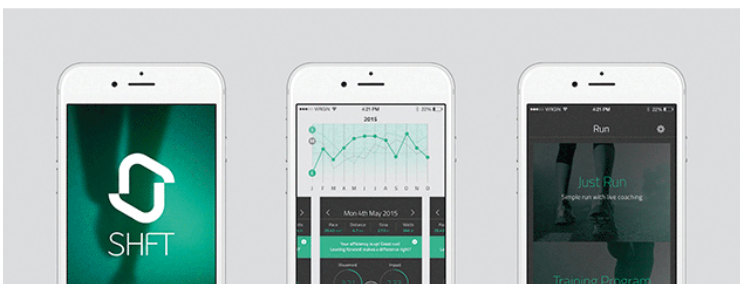
CUSTOMISED EQUIPMENT FOR OPTIMAL PERFORMANCE (BIKE FITTING)

The identity and lifestyle aspect is central. Athletes are often athletes 24/7, both in mindset and their exhibited identity. Sports apparel is a big part of their wardrobe in order to show their sports identity. Training does not stop when they are done at the sports club but is taken home in order to keep improving or is used as a social event. Sports equipment is personalised both functionally and aesthetically; running shoes and racing bikes are personally fitted to ensure the best possible performance, and colours and overall expression is matched throughout all equipment and apparel. New equipment is meticulously picked out; nothing is left to chance. If possible, inspiration is found in sporting idols. Buying products used by the professional athletes can only improve your chances of performing like a pro.

Athletes at all levels are adopting sports technology formerly only used by the pros, in order to improve their sporting performance. Running watches have tracked and helped improve runners' performance for multiple years. An example of the current technology progression in relation to sports performance technology is products enabling responsive live running analysis, made possible by smaller and cheaper sensors as well as possibilities for big data accumulation and smart algorithm generation.
Summing up, sporting equipment is very much about a specific identity and lifestyle, performance enhancement as well as responsive and smart technology *- everything ankle rehabilitation equipment is not.*

PROFESSIONAL AT HOME

PERFORMANCE ENHANCING TECHNOLOGY



Ill. 41.01: Elements and characteristics found within the sports context


INSIGHTS

KEY ACTIVITES

ACTIVITIES

- Target audience definition
- Mission & vision specification
- Aspired value generation
- Project development focus

2.00

DEFINE

Based on previous phases, the project scope is defined through specification of target group, injury focus, value mission and project vision.

Insights are transformed into aspired values with the purpose of acting as initial guidelines for the following concept ideation.

2.01

TARGET AUDIENCE

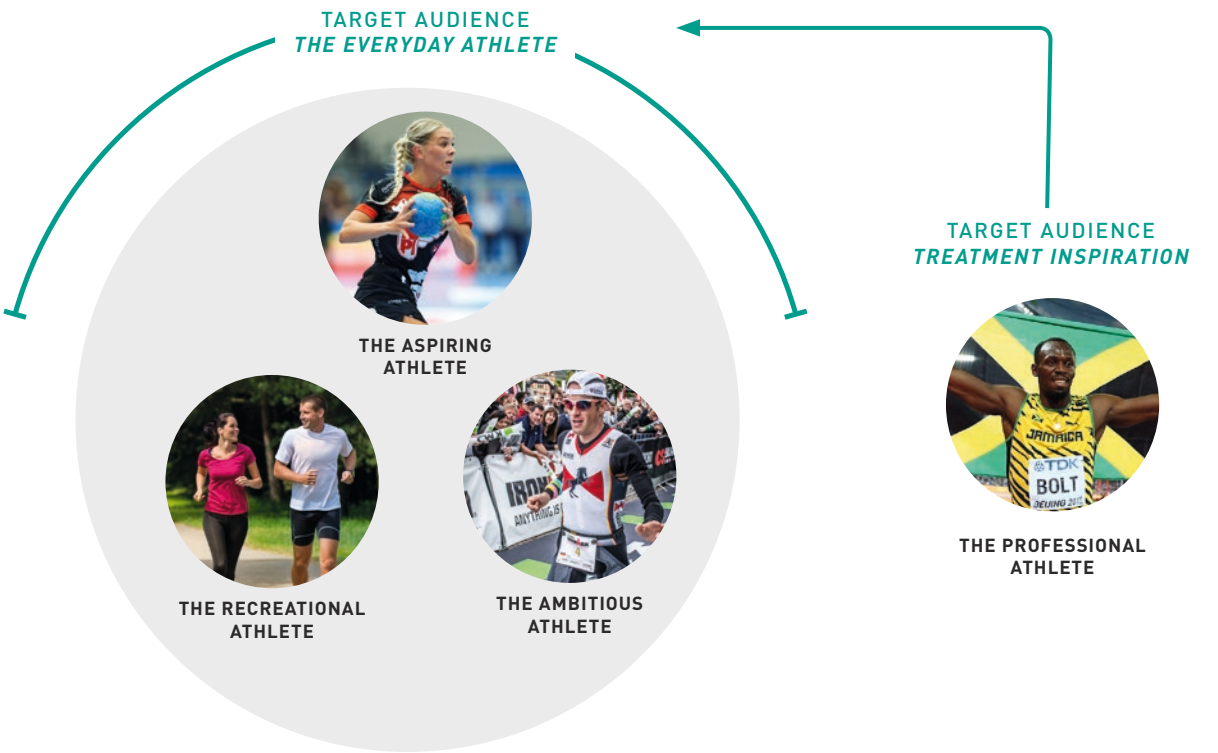
For whom are we creating value?

The term athlete has earlier been defined as a person who is trained in or good at sports, games, or exercises that require physical skill and strength (p. 24). Athletes vary in relation to a range of parameters, like the type of sport they do, their level of fitness, the number of training hours and so on. Common for the athletes is their specific mindset; the intrinsic nature of their training motivation, the value that the active life brings to them and the constant strive for improvement.

As described earlier, athletes at all levels are in risk of spraining an ankle. It is found, that athletes need to be rehabilitated to a higher functional level than the average person, as their active life and sport is more demanding than the everyday life of a non-athlete. Whether being an athlete at a recreational level or at a professional level, the needed level of function in the ankle is higher than that of a non-athlete, although it naturally varies. However, a big difference lies in the current treatment the different athletes receive and the degree to which this is successful. This rehabilitation difference is a guiding factor for both the specification of target audience as well as the following solution propositions.

The professional athlete, defined as a person for whom the sport is their main occupation partly or fully earning their living, is found to get the ideal treatment, making them a target audience inspiration in relation to the desired rehabilitation value and content. The target audience, *the everyday athlete*, is broadly defined as the remaining athletes (Ill. 44.01), further defined based on the described sports mindset. As mentioned earlier, athletes vary in relation to a range of parameters, meaning that the target group includes both recreational athletes, mainly exercising for physical and mental well-being, ambitious athletes for whom the competitive level and sports performance plays a big role and even the aspiring athletes striving to reach a professional level. The target audience depiction (ill. 44.01) should not be seen as spectrum ranging athletes in relation e.g. the time they spend training or the specific level they are competing on, but rather as examples of potential users as explored through the user group archetypes (p. 26).

Shortly put, the target audience can be described as *the everyday athletes who are in the risk of spraining or re-spraining their ankles and who do not currently have the opportunity or to receive supervised treatment.*



Ill 44.01: Target audience examples and the professional athlete as target audience treatment inspiration.

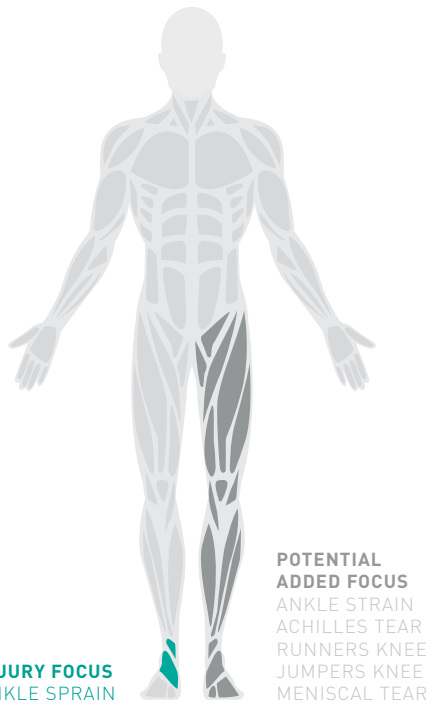
2.02

INJURY FOCUS

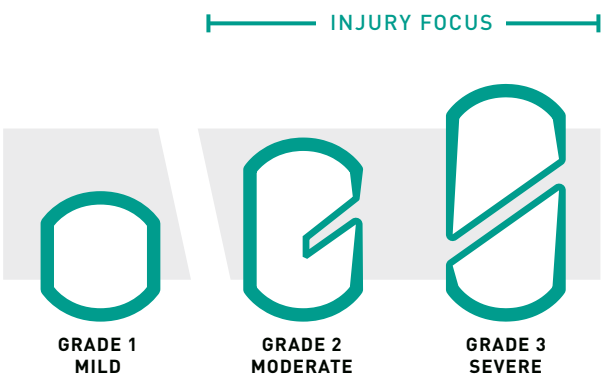
Which injuries are targeted?

The focus on ankle sprains is earlier chosen as this is found to be a very common injury which is often poorly rehabilitated resulting in a high amount of re-sprains. The limitation to a primary injury focus is chosen strategically in order to simplify and thereby drive the design process. However, it is kept in mind that a lot of injuries in the lower extremities could potentially benefit from the same product system solution as a lot of rehabilitation exercises and equipment currently overlap, meaning that other ankle injuries, a variety of knee injuries and so forth could be seen as a potential secondary focus. A different approach could be to strategically develop a leveragable product system, making it possible to reach additional target audiences with few product changes.

Referring to the previously defined sprain severities, it is chosen to mainly focus on sprains that are either grade 2 or 3, as the considerable severity results in a longer and more demanding rehabilitation process. Grade 1 sprains are generally not seen as a viable target, as the healing time is only 2-4 weeks as well as functionally impacting the injured person very little, meaning a immensely decreased buying incentive.



Ill. 45.01: Injury focus and examples of potential secondary injury types possible to target



Ill. 45.02 Injury focus based on severity of the sprain.

2.03

VALUE MISSION

THE EVERYDAY ATHLETE

It is the mission to enable everyday athletes to return to their active life and prior physical performance level following an ankle sprain, while decreasing the risk of re-sprains or secondary injuries by making the home rehabilitation fitting for the specific rehabilitation needs of an athlete.

2.04

PROBLEM STATEMENT

How can we create an ankle sprain rehabilitation product for the everyday athlete that...

- *... facilitates correct and efficient home rehabilitation?*
- *... targets and promotes the intrinsic nature of their training motivation?*
- *... is in line with the central elements of identity, lifestyle and performance enhancement valued within the sports context?*

2.05

VISION

THE VISION IS TO

ADD THE QUALITY AND EXPERIENCE OF THIS... *... TO THIS.*

Ill. 47.01 Vision

The vision is to provide the everyday athletes with a sports specific rehabilitation product for ankle sprain rehabilitation, that brings the quality and experience of home exercise programmes closer to that known from supervised treatment of professional athletes.

2.06

ASPIRED VALUES

Explorative value statements

The value mission, problem statements and project vision create an initial project scoping, but are kept on an abstract level as a specific project direction is not yet defined. The targeted problem is strategically viewed as being a so-called 'wicked problem', understood as being a problem that is indeterminate and ill-defined as well as being characterized by being incomplete, changing, contradicting and having interdependent information (Laursen et. al., 2014), (Buchanan, 1992). The discovered findings give information about the problem context as well as inspiration to possible solution directions. The said wickedness of the problem suggests that there is not one immediate and definite solution to the approached problem. Instead the solution space holds an array of solutions bringing different value to the user.

To explore the possible solution space, a value-focused approach is applied. Keeping the project at an abstract level when heading into the ideation phase will make it possible to additionally open up the solution space and thereby increase the opportunity to bypass the limitations of the current solution context and open up a new field of alternatives within a strategic context (Keeney, 1996.)
This is found to be interesting for the project as the targeted users have different needs and desired values than what is currently provided to the broad user spectrum in the category of ankle sprain rehabilitation products. Meaning that a strategic and value-focused approach could be seen as an opportunity to re-imagine sports injury rehabilitation for athletes.

Instead of formulating product requirements at this point, the value-focused approach is applied by transforming the different insights into aspired values as explorative question statements (Ill. 48.01), which in that way act as a guiding framework for the following ideation phase. Each aspired value and question is labeled with the number(#) of the finding(s) that it is derived from.

Ill. 48.01: Transformation of findings into aspired values

ASPIRED VALUES - EXPLORATIVE VALUE STATEMENTS

1 HOW CAN CORRECT EXECUTION OF EXERCISES BE FACILITATED?

(Finding#8, #10, #17)

2 HOW CAN EXERCISES BE IMPLEMENTED INTO DAILY LIFE?

(Finding #10)

3 HOW CAN PROGRESSION BE MADE VISIBLE OR TANGIBLE?

(Finding #10, #22)

4 HOW CAN THE EXPERIENCED EXERCISE TIME SPENT BE REDUCED?

(Finding #10)

5 HOW CAN THE MEMORY RESPONSIBILITY BE REMOVED?

(Finding #10)

6 HOW CAN A FEELING OF COMPETENCE BE ENDORSED?

(Finding #29)

7 HOW CAN CONTINUOUS EXERCISE ADAPTION ACCORDING TO SKILL & PROGRESS BE CREATED?

(Finding #9, #16, #17, #18, #23)

8 HOW CAN THE HIGH REHABILITATION DEMAND OF THE ATHLETE BE MET?

(Finding #21)

9 HOW CAN THE VALUE OF THE REHABILITATION BE COMMUNICATED?

(Finding #28)

10 HOW CAN THE ATHLETE'S SPORTS PERFORMANCE BE IMPROVED WHILE REHABILITATING?

(Finding #10, #18))

11 HOW CAN EXPERIENCED EXERCISE VARIATION BE CREATED?

(Finding #10, #25, #26)

12 HOW CAN THE REHABILITATION APPEAL TO THE ATHLETE'S MOTIVATIONAL TRIGGERS?

(Finding #7, #27, #28, #29, #30)

13 HOW CAN THE EXERCISE EXPERIENCE BE BROUGHT CLOSER TO THAT OF THE NORMAL SPORT?

(Finding #27)

14 HOW CAN EXERCISE COMPLIANCE BE FACILITATED AFTER PAIN RELIEF?

(Finding #14)

15 HOW CAN PERCEIVED DEMANDS BE MATCHED WITH PERCEIVED ABILITIES?

(Finding #30)

2.07

PROJECT FOCUS

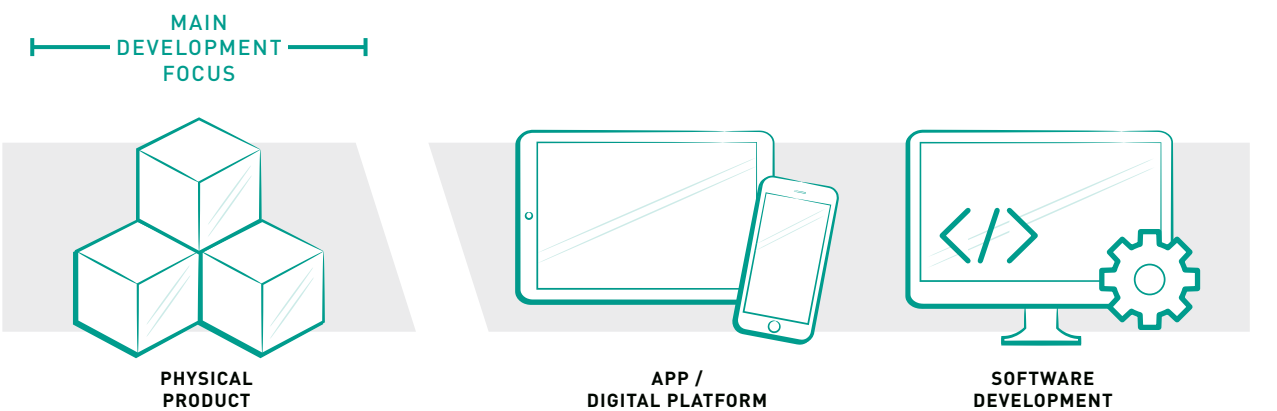
Development focus and delimitation

Despite not knowing much about the product-to-be at this early stage of the process, the desire to utilise sensor technology to create a form of connected smart product suggests that the final concept will most likely be part of a product system including a digital platform of some sort.

The main focus and resources of this master thesis concerns the development of the physical part of the product system as this best matches the profile of the industrial designer, enabling the fulfillment of both personal and official learning goals. In the situation of an actual start-up development, this part would likewise be handed over to an internal or external specialist within this field.

This means a general delimitation from app and/or software development which will only be dealt with on a conceptual level. This is however central to develop in parallel tracks to the possible extent to ensure a coherent system, for which reason it should be conceptually developed consecutively although not reaching a functional state within the time frame of the master thesis.

Technical focus points will be specified later in the process, depending on the concept direction.



Ill. 50.01. Development focus of prospected product service system

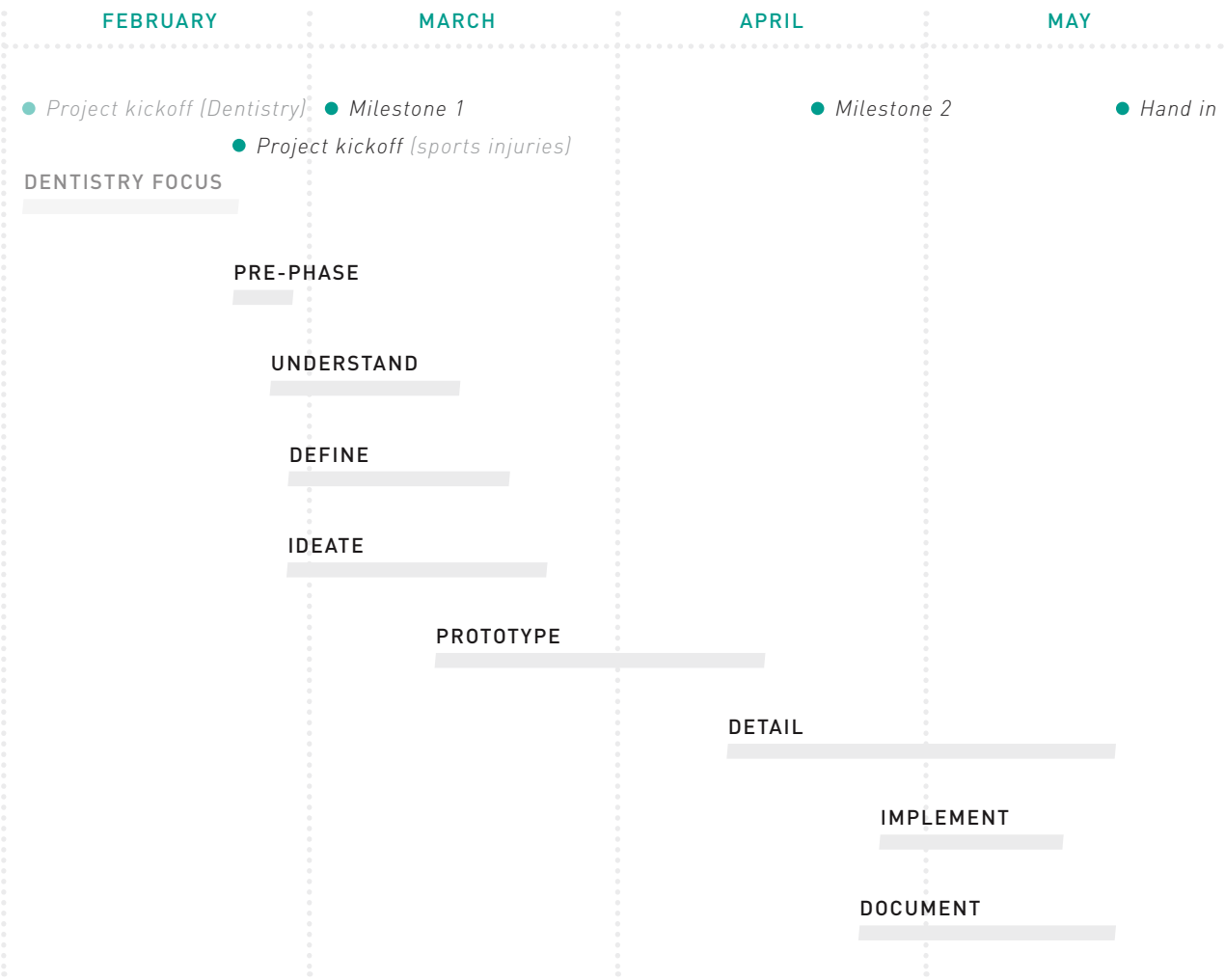
2.08

TIME PLANNING

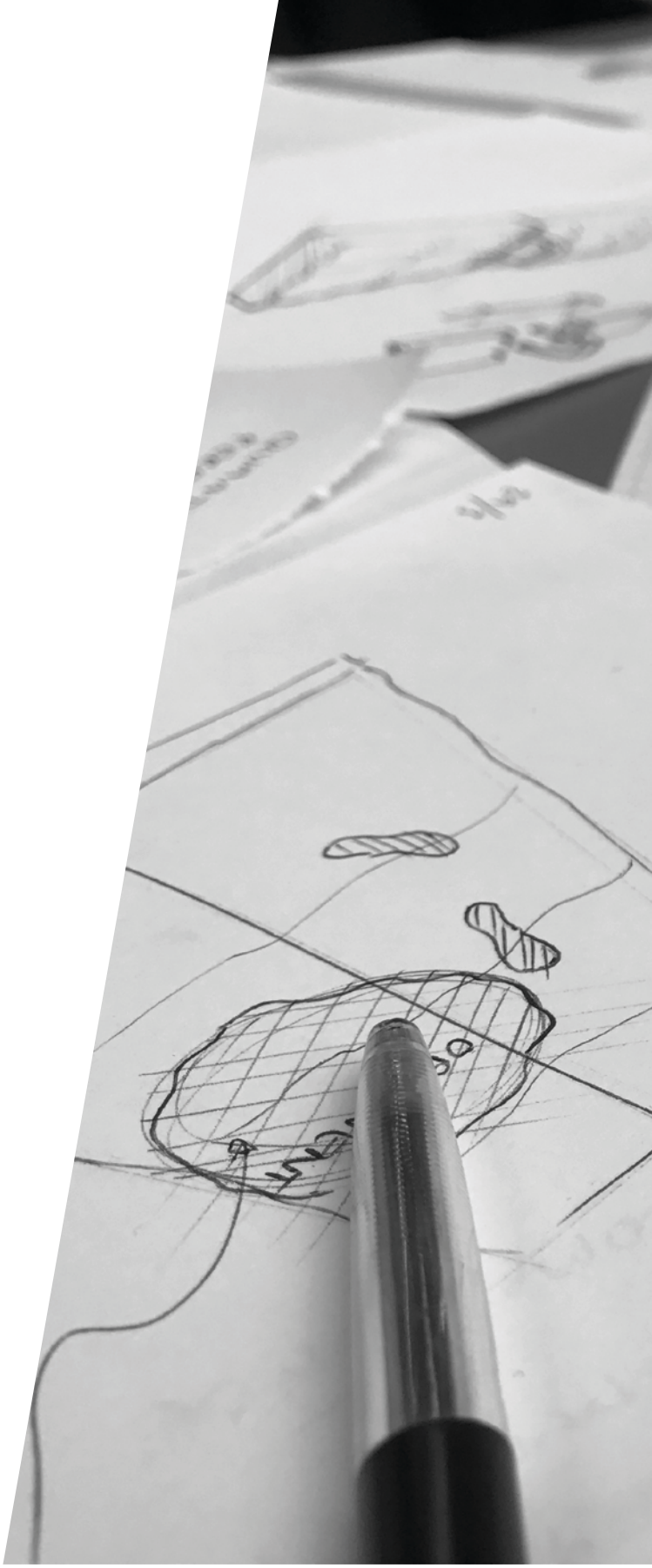
Project milestones, deadlines and phases

The time planning overview shows a simplified mapping of the project phases, milestones and deadlines. The project period is roughly planned out at the beginning of the project in order to create an overview of the general desired progression [AP 1]. Phase duration and content is roughly estimated based on experience from previous projects. The overview is used within the team as basis for weekly and daily goal planning, where tasks are further specified and broken down.

Besides the general project overview a daily logbook is kept in order to keep track of the performed daily activities as well as important decision milestones throughout the project.
As indicated by the overview, the initial weeks of the master thesis have been spent working on a different topic, until the project focus was reframed to the opportunity based project presented in the submitted material.



Ill. 51.01: Project time line, simplified version [AP 1]



KEY ACTIVITES

ACTIVITIES
- Brainstorming
- Explorative sketching
- Rapid prototyping & testing
- Acting out / Bodystorming
- Criteria specification
- Concept evaluation

MODELING
- Sketching
- 2D modeling
- Physical modeling

3.00

IDEATE

Based on the discovered findings and derived aspired values and curiosities the possible solution space is explored through multiple iterations of explorative sketching, rapid prototyping and testing.

The project focus is further specified, general concept criteria are created and a concept direction is chosen.

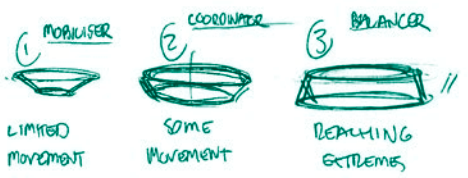
3.01

INITIAL CONCEPTS

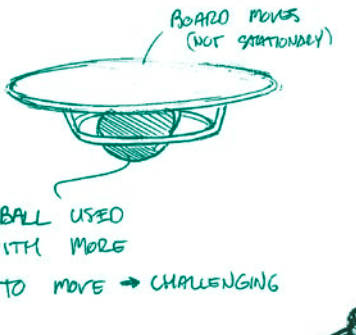
Exploring the possible solution space

As described in the define phase, the project focus is purposely kept on an abstract level in order to enable a value-based exploration of the possible solution space. The solution space exploration facilitates implementation and understanding of earlier discovered insights, as well as aiding the prioritisation of these. Through iterations of sketching, rapid prototyping and testing, different ways of creating value for the user group is investigated. The value and curiosity-based ideation facilitates a deeper user group and project focus understanding, by exemplifying what could be valuable for the user and why, thereby aiding valuable discussions within the team, guiding the process towards the creation of concept criteria and the choice of a product concept.

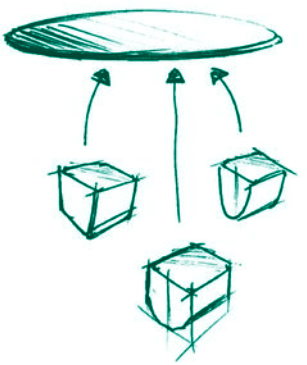
Due to the iterative nature of the process the first parts of the explorative ideation are initiated before a defined mission and vision for the project is created, meaning that some of the sketches are not directly targeted that project understanding. These are, however, still a central part of the solution space exploration aiding the very definition of the mission and vision.
The following shows a selection of initial explorative sketches created on the basis of findings and previously presented aspired values.



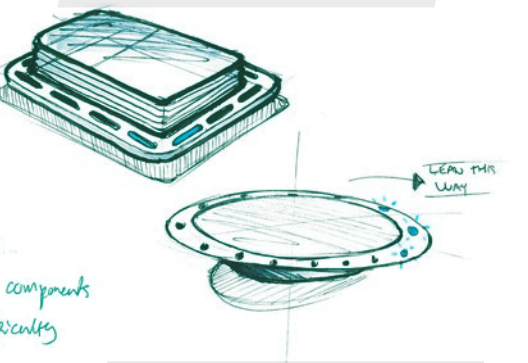
Different levels - similar to phases



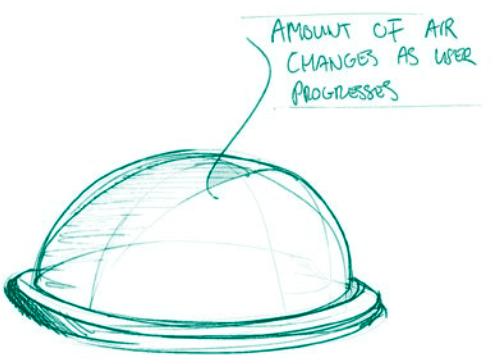
Recieving feed-forward & live feedback

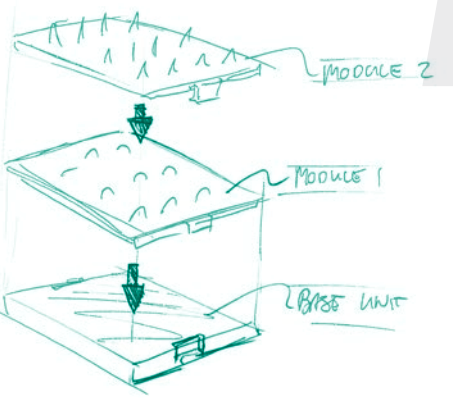


Variation in functional difficulty



Beating own or other's high scores





Ill. 55.01: Initial concept sketches

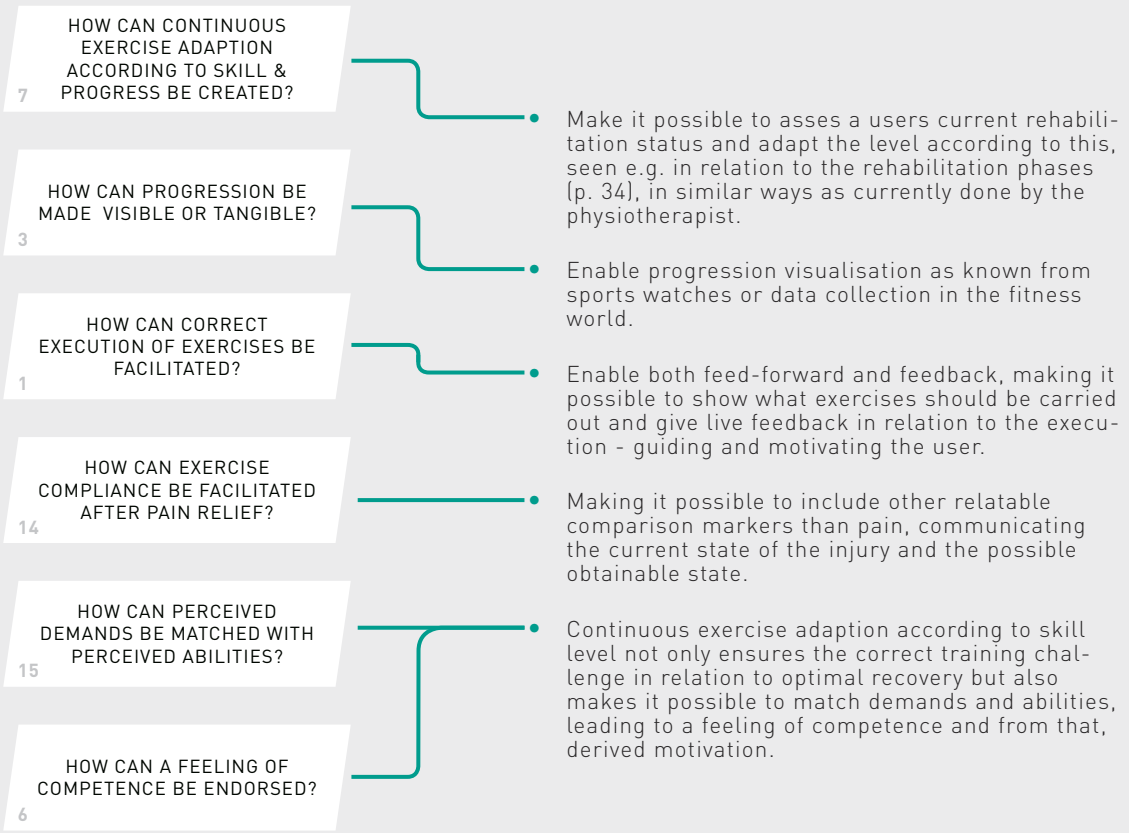
3.02

THREE CONCEPT DIRECTIONS

Based on the initial sketching rounds, three concepts are chosen and developed further through multiple iterations.
The concepts are each driven by different central values and insights, meaning that they are *'solving different problems'* and creating different kinds of value for the user initially based on the stated non-compliance reasons. Some aspired values and working principles are common for all three concepts; derived from the found opportunity of incorporating sensor technology, as it is discovered that *"what gets measured gets improved"* (p. 21).
Each concept is presented through it's driving insights and values as well as concept metaphors and sub-metaphors. The metaphors act as abstract guiding stars; creating the connection between the value and the applied working principles. Additionally, the use of metaphors facilitates possible expression of value-based or tacit understanding of concept elements and thereby helps to ensure alignment of understanding within the design team as well as helping to communicate the desired concept values to others.

THE POTENTIAL OF TRACKING - *QUANTIFYING DATA INPUT*

Common for all the concepts are that they are created based on the opportunity found in relation to quantifying different exercise data. The initial idea sparking this direction is based on the inspirational saying: *"what gets measured gets improved'*, known from the world of sports, health in general as well as the business world. This opportunity was quickly found to solve some of the early discovered issues of sports injury rehabilitation. After more research on the topic, the element of quantifying rehabilitation data is found to:



Ill. 56.01:. Aspired values and their connection to the tracking element

Utilises well-known functional benefits and increases rehab quality and compliance through better exercise experience

CONCEPT 1 - SMART BALANCE BOARD

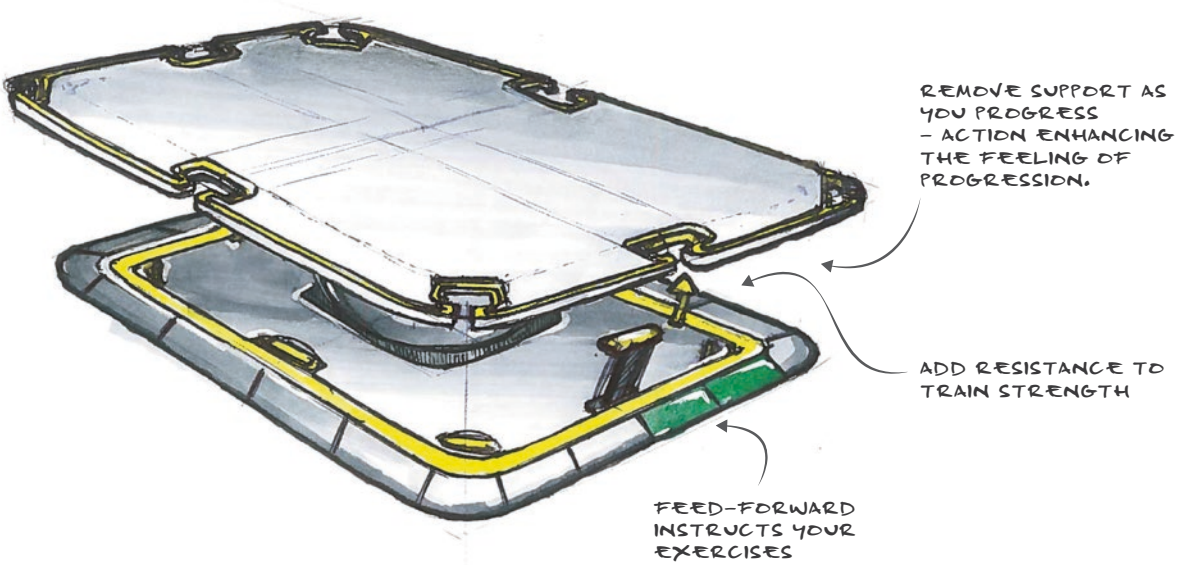
Concept 1, the *Smart Balance Board*, is 'close to home'. It takes advantages of the well-known benefits of the balance board (p. 30) along with incorporating the tracking element to make it responsive through feed-forward and feedback. Exercise variation is created both functionally by making it possible to adapt the level support as well as through the use experience, by communicating different exercises through feed-forward. This makes it possible to use the product from the first rehabilitation stage and all the way to prevention and even performance enhancement. The functional complexity supports the perceived possible recovery impact and distances it from the preconceptions of normal rehabilitation equipment.

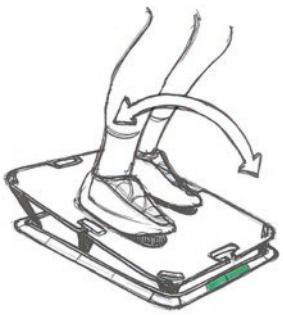
MAIN METAPHOR
'LIKE PROFESSIONAL SPORTS EQUIPMENT'

SUB-METAPHORS
'LIKE MOVING THE PIN AT THE GYM'
(ACTION ENHANCING FEELING OF PROGRESSION)

'LIKE HAVING A PERSONAL TRAINER'
(GUIDANCE, COACHING, LIVE FEEDBACK)

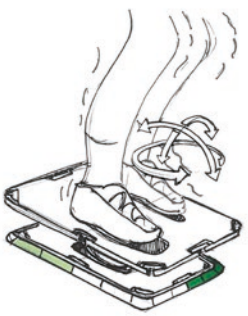
'LIKE FOLLOWING A RUNNING PROGRAM'
(DIFFERENT PHASES, SUB-GOALS, SMALL WINS)





EARLY PHASES

ONE AXIS MOVEMENT WITH FULL SUPPORT



MID PHASES

FULL AXIS MOVEMENTS WITH DECREASED SUPPORT

LATE PHASES

FACILITATING DYNAMIC SPORTS SPECIFIC EXERCISES

Ill. 57.01: Concept 1, Smart Balance Board

Maximizing compliance through convenience and accessibility

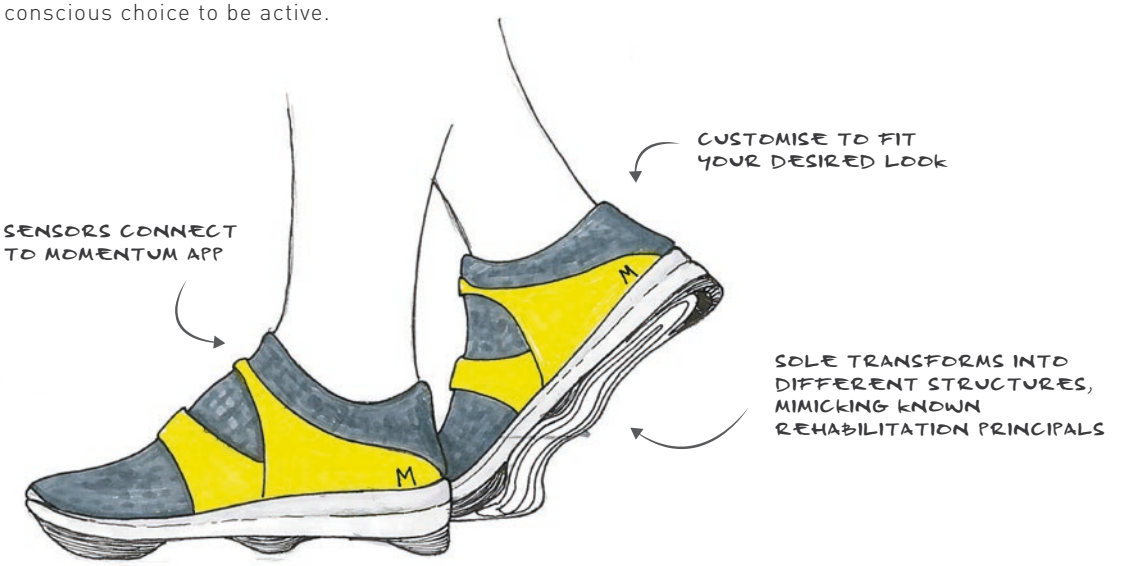
CONCEPT 2 - BALANCE WEARABLE

The balance wearable is a future lifestyle product making joint stability and proprioception training an integrated part of your everyday life. The balance wearable can be used focused for specific exercises or just slightly challenge the athlete throughout the day to build strong and responsive joints and avoid injuries. Late in recovery and after it can even be part of the normal sports training.
The sole can be morphed into different structures, mimicking the uneven surfaces known from wobble cushions and balance boards. In combination with the app, data and recovery progression is tracked, and nudging reminders helps the athlete stay on track. The concept is a personal lifestyle product displaying a conscious choice to be active.

MAIN METAPHOR
'FROM REHABILITATION TO LIFESTYLE CHANGE'
-
'EVERY SECOND IS AN OPPORTUNITY TO TRAIN'

SUB-METAPHOR
'LIKE PLUG'N'PLAY TECHNOLOGY'
(ACCESSIBLE, CONVENIENT AND EFFORTLESS)

'LIKE FIVEFINGER SHOES'
(A CONSCIOUS LIFESTYLE CHOICE)



EARLY PHASES

FOCUSED EXERCISES
REPLACING NORMAL
REHABILITATION EQUIPMENT

MID PHASES

FOCUSED EXERCISES
INTEGRATING DYNAMIC AND
SPORTS LIKE TRAINING

LATE PHASES

INTEGRATED INTO RETURN
TO SPORT - WARM UP AND
PERFORMANCE EXERCISES

Ill. 58.01: Concept 2, Balance wearable

Providing meaningfulness and value through performance enhancement and sports-like experience

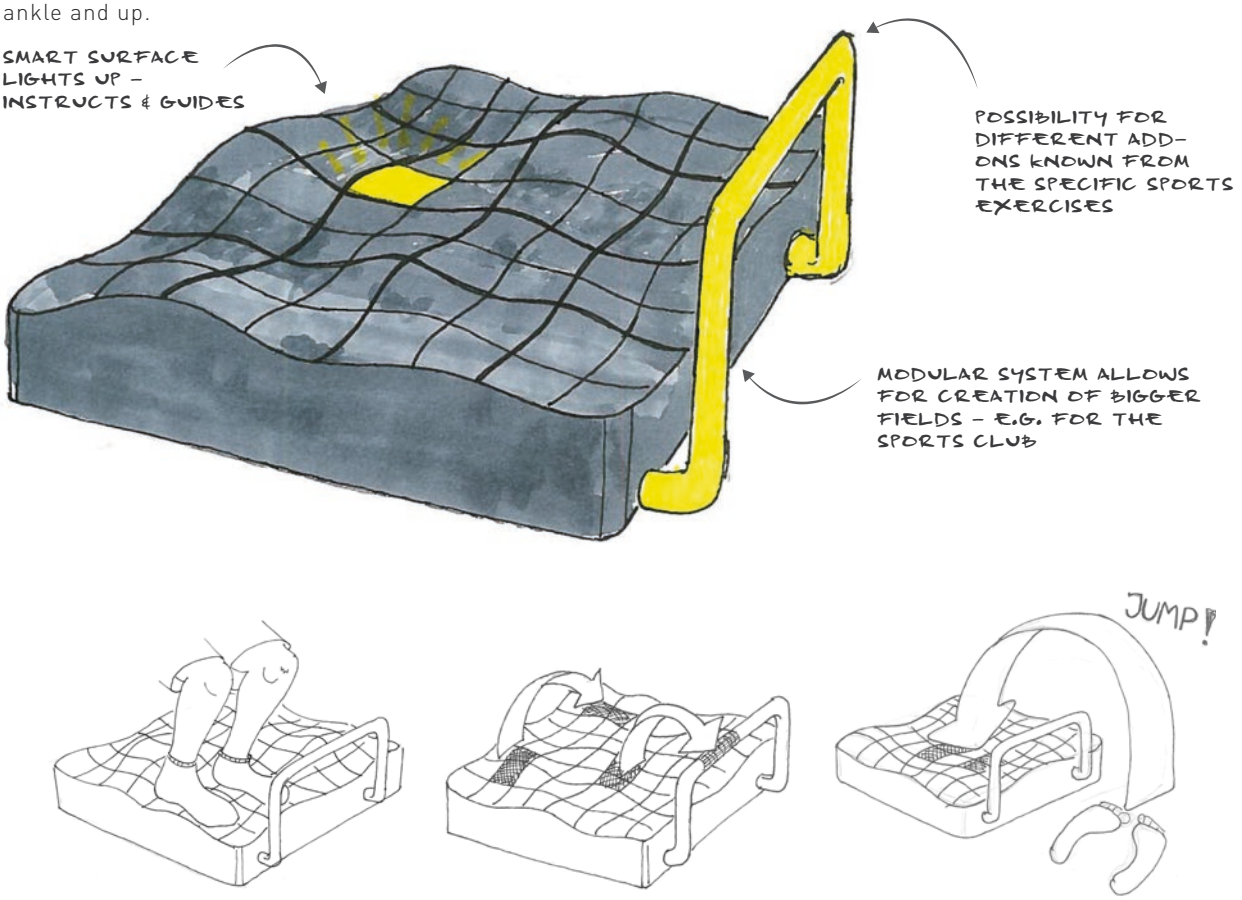
CONCEPT 3 - PERFORMANCE FIELD

Concept 3 is close to sport. It takes its starting point in the later phases of rehabilitation where an athlete's rehabilitation exercises should mimic situations from their sport (p. 34). Including sports-like situations and exercises gives the athlete rehabilitation-meaningfulness; increasing exercise compliance and adding the possibility to increase sports performance through rehabilitation. The balance field is made as an uneven surface structure with integrated smart features. The surface has integrated lights and sensors making it possible to provide feed-forward and feedback; guiding and coaching the athlete through sports-specific exercises known from their sport. The smart surface tracks the athlete's every move - making it possible to compete against oneself, beating own stability and agility records - making one a better athlete from the ankle and up.

MAIN METAPHOR
'FROM REHABILITATION TO SPORTS PERFORMANCE'

SUB-METAPHORS
'LIKE BEING ON THE PITCH'
(FOCUS ON EXPERIENCE, GUIDED BY INTUITION)

'LIKE TRAINING FOR A MATCH'
(ALWAYS IMPROVING - MOTIVATED BY PERFORMANCE)



EARLY PHASES

STAND OR WALK FOR TO IMPROVE MOBILITY

MID PHASES

FUNCTIONAL EXERCISES INCREASING IN DIFFICULTY FASTER & MORE DYNAMIC

LATE PHASES

SPORTS-SPECIFIC EXERCISES - RUN, JUMP, LAND MIMICKING SPORTS SITUATIONS

Ill. 59.01: Concept 3, Performance field

3.03

CONCEPT EVALUATION

Exploring value principles

To quickly evaluate the potential of each concept, rapid prototypes of different functional principles are made. The prototypes make it possible to test specific principles as well as acting out scenarios of the product use experience, thereby uncovering possible strengths and weaknesses [WS 60]. The objective of the testing is not to definitely chose a specific concept as they are not directly comparable. Instead, it is the intention to explore the materialised value principles and how they work in conjunction with the developed concepts.

CONCEPT 1

In relation to concept 1, the two main principles are tested; Getting directions through feed-forward and getting live feedback, as well as having the possibility to get support when needed or create resistance to train strength. The experience of feed-forward and feedback is tested by attaching clothespins to a plate, simulating different axial directions as feed-forward and creating tangible feedback when pressed. Support and resistance is tested by attaching bike tubes to a balance board, allowing for adding of removing the amount of support/resistance.

FEEDFORWARD & FEEDBACK

CONCEPT 2

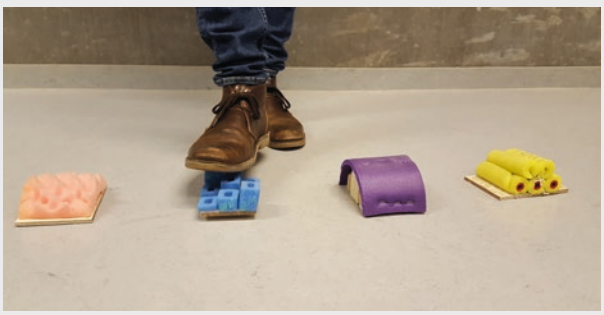
The main functional principle of concept 2 is the creation of instability underneath the foot. This is tested through different shoe attachments (foam, wood blocks etc.) and by testing different fluid viscosities and sole sizes. It is necessary to test if it is plausible to rehabilitate using shoes or shoe attachments. The experience and quality is compared to known rehabilitation products tested at the physiotherapist visit (p. 30) and related to the knowledge about what it physiologically needed in the different rehabilitation phases (p. 34).

WEARABLE INSTABILITY

CONCEPT 3

Concept 3 is tested by trying out standing, moving or landing on changing or unknown surfaces in different situations. Exercises from different phases are tried out with special focus on acting out the sport specific phases - how can different surface structures be used in combination with exercises known from different sports? Additionally, the concept of guided use of the product is tested by appointing different interaction surfaced one by one.

CHANGING / UNKNOWN SURFACE STRUCTURE



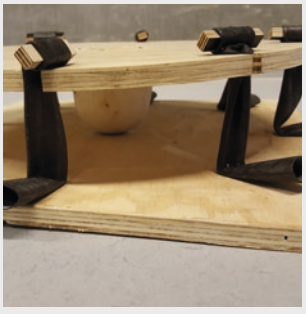
The principles from concept 1 are found to have great potential. The simple clothespin model adds a lot to the experience of using the balance board and the principle of added support and resistance is experienced to enable extension of the use to cover the whole rehabilitation process. Concept 2 and 3 are less successful in the tests, where it is found that the functional principles do not work as intended and especially the possible rehabilitation quality is deemed to be too low. However, the overall value principles of convenience, having a personal lifestyle product and adding sports performance and relatability to the rehab context are still found to be interesting and attractive values. It is chosen to focus on concept 1 while incorporating central values from concept 2 and 3

VALUE PRINCIPLES

Through concept testing and evaluation, the quality of the rehabilitation is found to be central in order to create a product which is valuable for the user. It is determined that this should as a minimum be at the same level as current products, while accommodating for the added quality needs of the target group.

PRODUCT CRITERIA

SUPPORT / RESISTANCE



EVALUATION

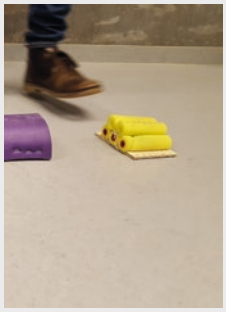
The simple clothespin model is found to add a great deal to the experience of using the balance board. The pins suggest axial direction and adds a point of comparison in relation to precision performance, thereby adding a competitive element. The feedback provides a sense of accomplishment and adds to difficulty variation, as pins can be pressed more or less or even purposely avoided. Added support and resistance is experienced to enable extension of the use to cover the whole rehabilitation process, however, the amount of needed support and resistance should be researched.

DIFFERENT TYPES AND SIZES OF 'SOLES'

EVALUATION

Various issues are discovered when testing the functional principles. Adding an instability attachment to the sole of the shoe can function to exercise early mobility or to add difficulty to normal sports activity in the late phases. However, it does not function in the majority of the phases where more extreme positions are needed. Additionally, a fixed attachment could be a risk factor. The water/air 'bags' are found to be dangerous when too small, as nothing is stopping you from twisting your ankle. It needs to reach a substantial size to have then same experience as a wobble cushion.

DOING STATIC & DYNAMIC EXERCISES



EVALUATION

Concept 3 has some of the same issues as concept 2. The possible obtainable rehabilitation quality is doubtful, especially in the mid phases where a balance board or similar is normally used. The value of being able to do sports-like exercises on the product is found to be interesting, however, the execution of using a small surface structure is problematic in relation to allowing for dynamic exercises and sufficient variation. Additionally, the possibilities in relation to making the exercises directly sports-related are questioned, especially if it is desired to target multiple sports.

3.04

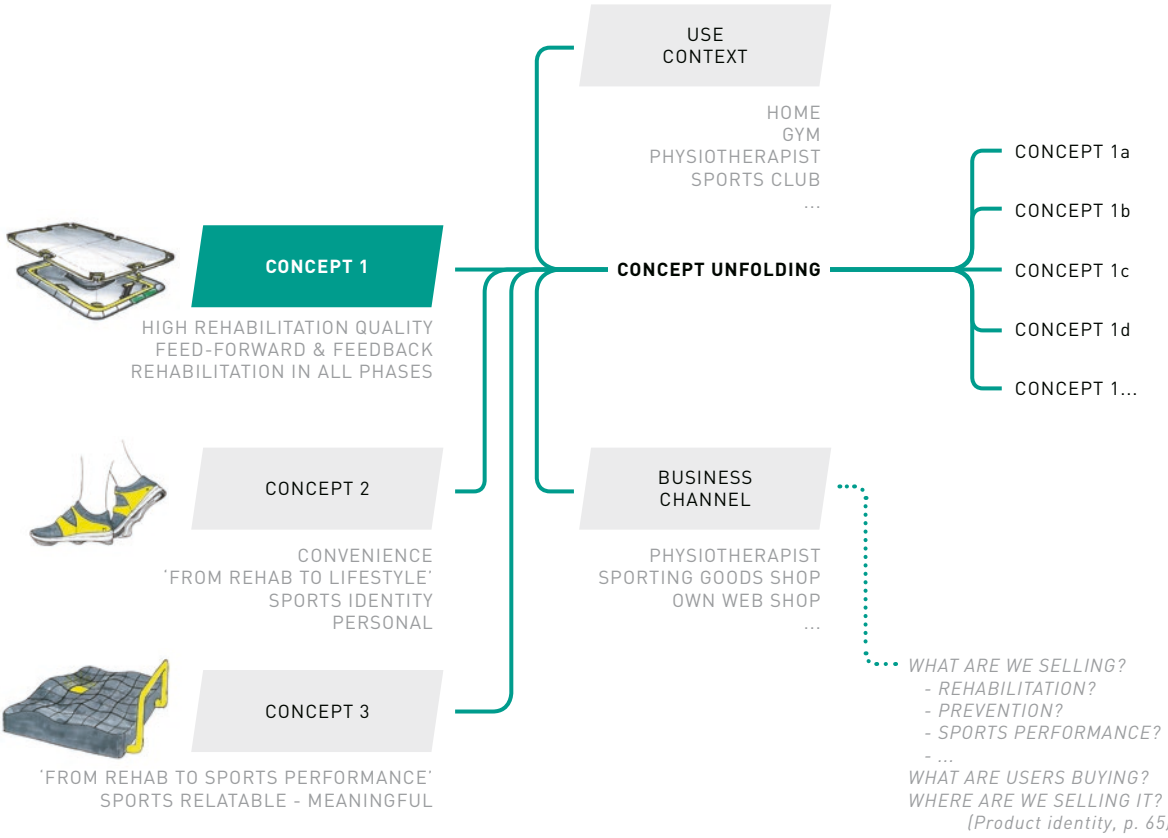
CONCEPT UNFOLDING

Synthesising aspired values

Through concept exploration it is uncovered that the rehabilitation quality needs to be a highly weighted criteria in order for the product to be of value to the target group. This is tied together with the knowledge about the athlete's having more demanding rehabilitation needs than the average person as well as the insights concerning the consequences of e.g. skipping phases or returning to sports too quickly. It is known that the balance board functionally has the potential to facilitate high quality ankle sprain rehabilitation (p. 30), but that is has an array of pitfalls in relation to the use experience hindering the majority of users to ever reach that potential. This is directly stated by one of the interviewed physiotherapist saying: *"If you think about the balance board it is an ancient piece of rehabilitation equipment - but it keeps getting used. That is because the rehabilitation effect is found to be good..., ...but it is not that exciting, unless you have a physiotherapist who can make it exiting for you"* [WS 6].

The concept exploration and testing indicates that it is possible to accommodate for some of the issues of the balance board, by adding elements of feed-forward and feedback making the product more responsive as well as adding a support and resistance system enabling use of the product throughout the entire rehabilitation period. However, there are still issues in relation to ensuring compliance, especially past the pain relief period. Additionally, aspired values linked to sports relatability and sports performance suggest possible accommodation for this along with also enabling perceptual reframing to circumvent the unwanted preconceptions about the value of balance boards.

To accommodate for these challenges, further concept unfolding is carried out. Through multiple iterations of concept generation and sketching it is explored how central values from concept 2 and 3 can be integrated as means to mitigate some of the found issues in relation to the balance board. Additionally the concept is explored in relation to different use contexts and business plans (ill. 63.01).



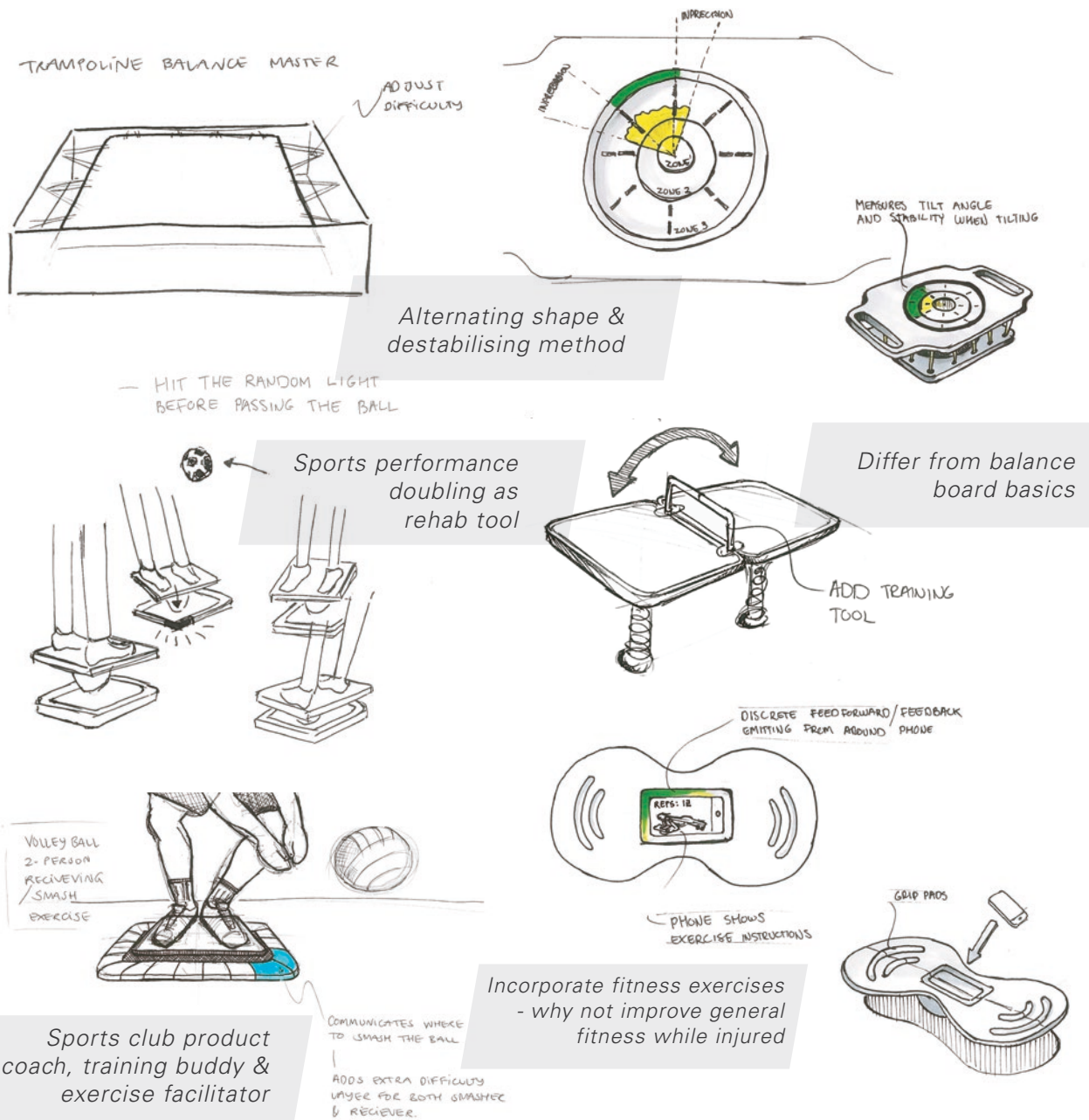
Ill. 62.01: Concept unfolding; adding central values from concept 2 & 3 and unfolding in relation to context and business .

Sketching in relation to the gym and sports context brings out untapped interview knowledge in relation to athlete's secondary training habits. Athletes are found to supplement their primary training with general fitness training to build strength, agility and prevent injuries. This is done by the recreational runner going to the gym as well as the aspiring athlete doing fitness sessions alongside normal training. When an athlete gets injured their whole active lifestyle is put on hold. Why not improve your general fitness level while being injured?

SPORTS PERFORMANCE

Challenging the balance board basics reveals that it is difficult to rethink the basic functionality without compromising the rehabilitation quality. Staying close to the known functionality ensures that the training is of high quality and makes it possible for the physiotherapist to prescribe currently used exercises. The latter additionally strengthens the business potential, as the earlier mentioned survey along with follow-up questions reveal that the physiotherapist is a central player in the rehabilitation as well as the choice of equipment [WS 9, 11]. Deviating from some of the iconic features, like the round shape, simplicity etc. is found to change people's general conception of the product type. It is the goal that the integration of functional complexity will further enhance this as well as adding to the believed rehabilitation potential.

PRODUCT IDENTITY



Ill. 63.01: Selection of sketches from the unfolding iterations

3.05

PRODUCT CRITERIA

Through the concept exploration, it is found that a variation of concept 1 has greatest potential to meet the user's needs desired values. The prioritisation of values is carried out based on the previously attained knowledge, e.g. leading to a high prioritisation of rehabilitation quality (p. 63). In this case, rehabilitation quality is defined on the basis of known desired progression and possible pitfalls; defining quality through both what to do and what not to do (p. 34).
To guide the concept development in the following prototyping phase, general concept criteria are created. The criteria are based on the findings and aspired values (p. 49) which have been investigated and transformed through conceptualisation of the values. Additional criteria have surfaced through the sketching process, including previously unapplied interview knowledge.

The criteria are grouped in categories of functional criteria as well as experience and expression related criteria, with some falling in between the groups. The criteria are tagged with the number of the appertaining aspired values (p. 49) or the page on which the criteria is determined. Criteria are listed randomly, not according to prioritisation.

The criteria are to be further specified through the following prototyping phase; thereby becoming actual product requirements.

FUNCTIONALITY

SAME REHABILITATION QUALITY AS CURRENT SOLUTIONS *(p. 61)*

SAME BASIC PRINCIPLES AS BALANCE BOARD *(p. 63)*

ENABLE GENERAL FITNESS EXERCISES *(10, 11, 13, p. 63)*

ENABLE DATA QUANTIFICATION AND PROGRESS TRACKING *(3, 6, 7, 9, 12, 14, 15)*

EXPERIENCE

EXCEED THE PHYSICAL CHALLENGE LEVEL OF A NORMAL BALANCE BOARD *(8, 10)*

PROVIDE FEED-FORWARD AND LIVE FEEDBACK *(1, 3, 6, 7, 8)*

ENABLE FUNCTIONAL ADAPTION ACCORDING TO SKILL AND PROGRESS *(6, 7, 8, 11, 15)*

SUPPORT TRAINING THROUGHOUT THE REHABILITATION PHASES *(p. 28-29)*

INCORPORATE PHYSICAL ACTION ENHANCING THE FEELING OF PROGRESSION *(3)*

PROVIDE VARIATION THROUGH FEED-FORWARD BASED USE EXPERIENCE *(7, 8, 11, 13)*

FACILITATE TIME MANAGEMENT VIA NUDGING AND NOTIFICATIONS *(2, 4, 5)*

DIVIDE REHABILITATION INTO SUB-GOALS *(6, 12, 15)*

EXPRESSION

AESTHETICALLY REFLECT SPORTS IDENTITY AND PERFORMANCE *(p. 63)*

DIFFER FROM AESTHETIC CHARACTERISTICS OF A BALANCE BOARD *(p. 63)*

INDICATE IMPROVED REHAB QUALITY THROUGH INCREASED COMPLEXITY *(p. 63)*

Ill. 64.01: Concept criteria

3.06

PRODUCT IDENTITY

Rehabilitation or sports performance?

In connection with unfolding the concepts inspired by possible business channels (p. 62), questions about the product identity surfaces. The goal is to make a rehabilitation product for athletes fitting their specific rehabilitation needs, making it fit into the sports context (p. 40) and incorporate elements of performance improvement.
A central way of incorporating these elements, is integration of fitness exercise functionalities, inspired by athletes supplementary workout habits (p. 30) and additionally backed up by post-survey email interviews. In these, the athletes all state that they would very much like to be able to do fitness exercises as part of the rehabilitation [WS 11]. The concept's instability functionality is ideal for increasing the difficulty and athletic benefits of both static and dynamic exercises like push-ups, squats and lunges.

However, this added value and functionality gives rise to an array of questions:
What is the product identity? Is it a sports injury rehabilitation product that transitions into being a sports performance product after rehabilitation? Or is it a sports performance product that doubles as a rehabilitation product when needed?

The product identity influences how the product is marketed and sold as well as where it should be sold. It influences when the product is acquired by the user - pre-injury or post-injury. The product identity and general product rhetoric might influence the user's perception of the product, likewise will the sales channel. As mentioned earlier, it is found that the physiotherapist plays a big role in treating athletes' sports injuries [WS 9,11]. The physiotherapist prescribes the rehabilitation exercises and guides the patient in relation to what equipment is needed. Based on this knowledge, it is deemed that the categorisation as a rehabilitation product is central for building a viable business. This additionally ties well together with the central value of rehabilitation quality.
The challenge thereby lies in creating a product that physiotherapists will vouch for, along with creating a product that fits into the sports context and brings enough sports performance value for the user to view it as such a product, potentially affecting the amount of money they are willing to pay for the product.
When buying products it is often the underlying and perceived value that is the deciding factor, rather than the actual functional value which might be the same for an array of products. Depending of the specific product and buyer, what is bought when buying a wobble board could be ankle rehabilitation, recovery, a healthy physique or self-care. Products within the sports category are very much sold on the potential value; you do not just buy running shoes, a racing bike or swimming goggles - you buy performance improvement, winning and a desired identity. The sold and purchased value of the product-to-be could be viewed differently by the physiotherapist than the athlete, however, it is desired to mix the perceived values found within the two categories. Meaning that you are both buying a rehabilitated ankle as well as buying sports performance through a more stable, stronger and agile ankle as well as a generally improved fitness level which also decreases the risk for additional injuries (ill. 65.01).

Ill. 65.01: Desired percieved identity & appertaining values as a mix of product catefories

It is found that the categorisation as a rehabilitation product is central for building a viable business, but that value elements found within the sports product categories will further improve the business potential. It is desired to design a product that offers high quality ankle rehabilitation along with sports performance through a more stable, stronger and agile ankle as well as a generally improved fitness level which also decreases the risk for additional injuries.

PRODUCT IDENTITY & BUSINESS

3.07

ATHLON

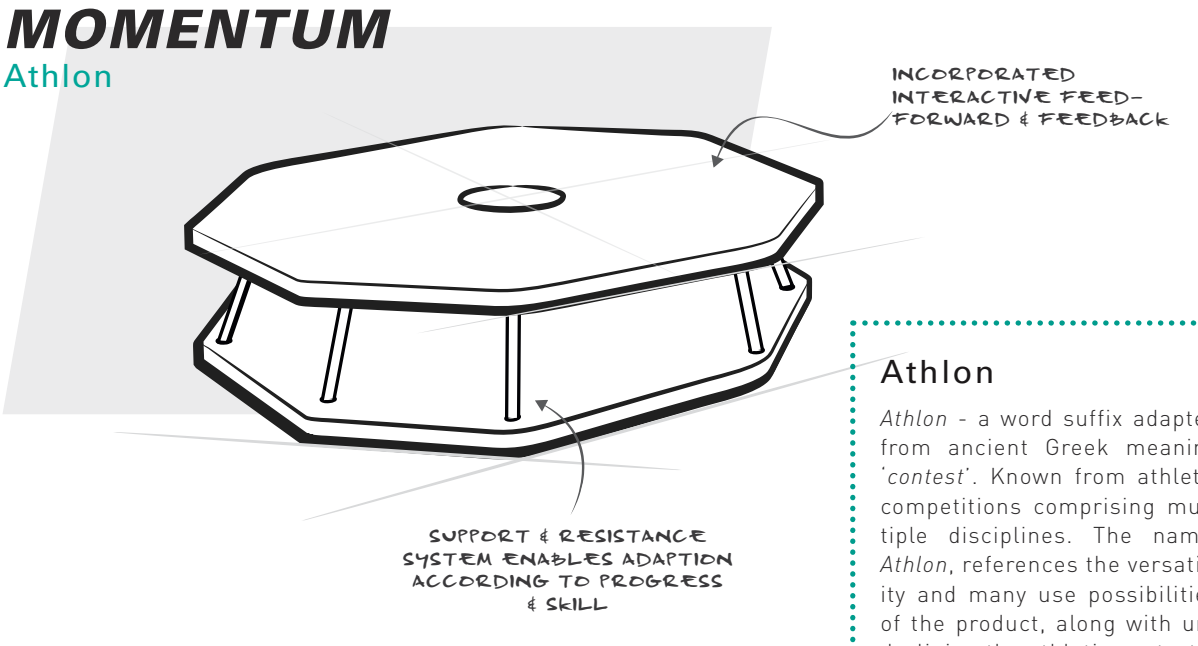
Product system concept

The ideation phase leads to a general product concept which is to be further developed through prototyping in the following phase. The concept is a variation of concept 1 - smart balance board (p. 56) which has been further developed through integration of central values from other concepts and other elements derived from insight integration and concept unfolding.

Athlon is a smart ankle rehabilitation product system enabling the everyday athlete to return to his or her active life and prior physical performance level following an ankle sprain. Building on the well-known rehabilitation benefits of traditional balance boards, Athlon takes sports injury rehabilitation to the next level; supporting the home training throughout the rehabilitation phases and exceeding the physical challenge level of other rehabilitation products in order to accommodate for the specific rehabilitation needs of athletes.

The integrated support and resistance system provides support when needed or makes it possible to do resistance exercises known from training with resistance bands. Support can be used in the early phases where mobility is limited and it is important not to challenge the mobility too much, as this might result in setbacks or further injury. The support and resistance functionality makes it possible to always adapt the product to the specific exercise and level, ensuring that training is never too easy or too hard. The adaptive product features provide an experience of a constantly changing product that 'grows' with the athlete on the way to recovery. Athlon's smart sensor technology adds to the feeling of progression through interactive feed-forward and live feedback elements, adding experience layers to the different exercises to create variety and challenge the athlete further. It enables exercise data quantification, providing the user with progress tracking and systemised level adjustment, ensuring just the right amount of challenge to recover fast and efficient - qualities known from supervised physiotherapy.

In addition to providing high quality ankle rehabilitation, Athlon doubles as a sports performance product. making it possible to stay in shape and improve the general fitness level while injured. The instability adds to the difficulty of known static and dynamic exercises like squats, lunges, push-ups and the plank, making it a useful training product even after recovery.



Athlon

Athlon - a word suffix adapted from ancient Greek meaning *'contest'*. Known from athletic competitions comprising multiple disciplines. The name, *Athlon*, references the versatility and many use possibilities of the product, along with underlining the athletic context.
Athlon should inspire to become a better athlete than you were the day before.
- always improving.

Ill. 66.01:. Athlon, Concept sketch

The Athlon system consists of two things; the trainer and the app (ill. 67.01). The app entails a personal profile, different layers of exercise communication and exercise data enabling progress tracking. The rehabilitation is divided into phases, creating sub-goals for the athlete to complete, endorsing a feeling of competence and motivation while making even longer recovery processes manageable while nudging to continued rehabilitation past the pain relief period. The system operates with a general exercise mode, helping the athlete recover, supported by a test mode, ensuring that the exercise level is neither too easy or too hard (Ill. 67.02). Data regarding the athlete's performance in relation to mobility and stability acts as quantified threshold measurements, guiding the rehabilitation progression, in a similar way to ordinary physiotherapy. Backstage, data from all active users is accumulated and compiled, generating big data to constantly improve data understanding and thereby system quality and experience (ill. 67.01).

FRONT OFFICE
USER INTERACTION
TRAINER + APP

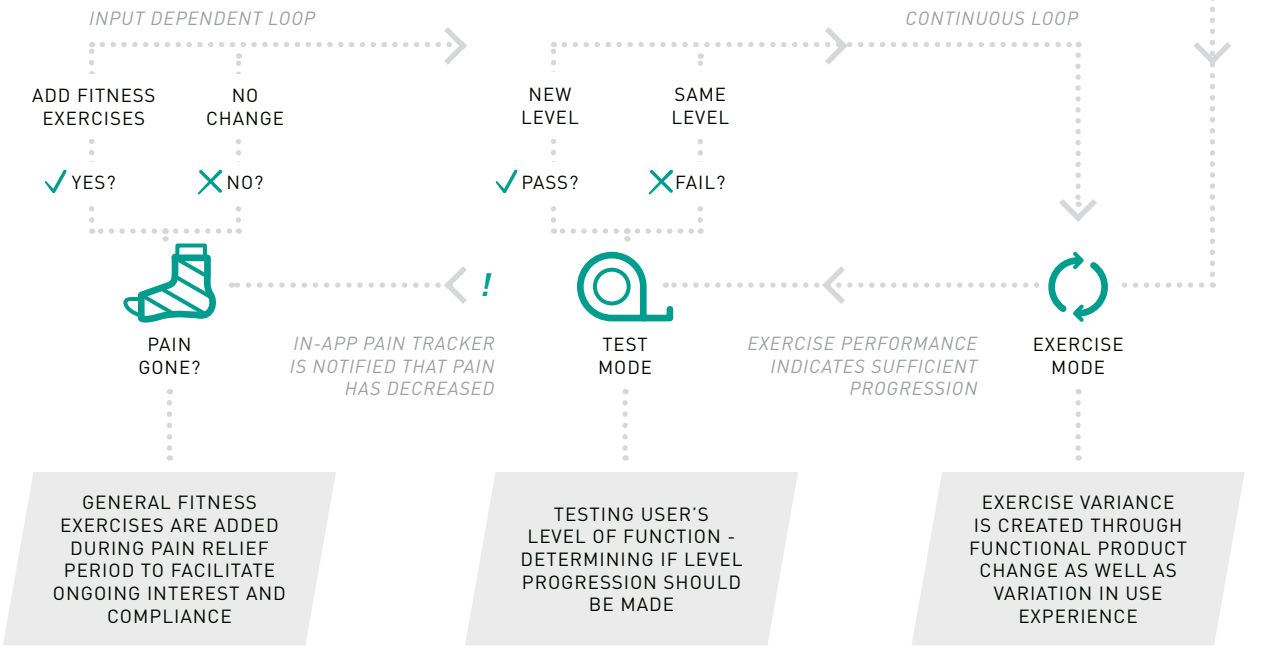
BACK OFFICE
DATA COLLECTION
& OPTIMISATION

Ill. 67.01:. Athlon concept system

PRODUCT USE JOURNEY

ACQUIRING & GETTING STARTED

REHABILITATION AND PERFORMANCE IMPROVEMENT



Ill. 67.02: Simplified product use journey, explaining key features

KEY ACTIVITES

DESK RESEARCH
- Interface technology
- Balance board specifications
- Ankle anatomy
- Suspension mechanisms
- Sensors
- Sports product aesthetics

FIELD RESEARCH
- Rehab research dep., AUH

INTERVIEWS
- Exercise physiologist & rehabilitation technology researcher, Martin Jørgensen

MODELING
- Sketching
- 2D modeling
- 3D modeling
- Physical modeling

4.00

PROTOTYPE

The chosen concept direction is developed further through iterations of prototyping, testing and evaluation; exploring different solution principles and specifying the product requirements needed for the following detailing.

4.01

FUNCTIONAL DEVELOPMENT

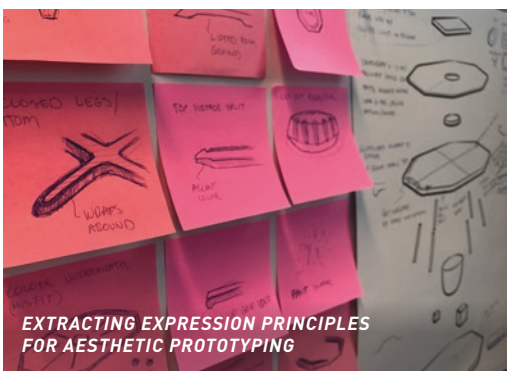
In the following phase, the general product concept will be further developed through prototyping.

Further specification of the product system concept is carried out through iterations of prototyping, testing and following refinement. Up until now, the process has been open and explorative, as the problem has strategically been seen as a wicked problem (p. 48) with the intention of bypassing the limitations of the specific context in which current products operate. Through the ideation phase, exploration has lead to a 'taming' of the problem, meaning that the following development process can be carried out in a more focused manner, as the desired product value and overall working principle has been defined.

To simplify the development process, a basic product structure encompassing the main functional elements is created (ill. 71.01). The development of the different product elements is highly interdependent, meaning that changes often affects the entire system, however, to ease the communication, the different elements will be presented independently in the following spreads. The illustration on the right page (ill. 71.01) shows the basic functional structure along with the general functionality of each element. Each functional element is marked with a page and/or appendix number indicating where the development process is communicated.


CONSTRUCTING & TESTING DESTABILISOR SHAPES

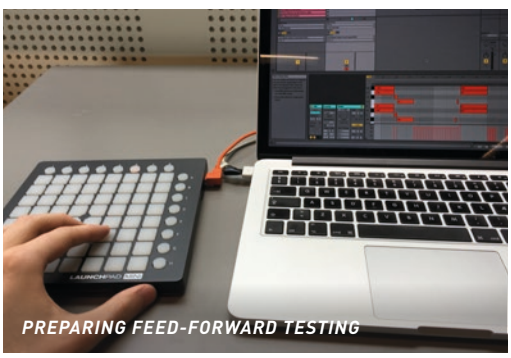

TESTING EFFECT OF STABILISING MECHANISM ON PRESSURE PLATE W. EXERCISE PHYSIOLOGIST [WS 24]


EXTRACTING EXPRESSION PRINCIPLES FOR AESTHETIC PROTOTYPING


TESTING FITNESS FUNCTIONALITIES


TESTING DIFFERENT AMOUNTS OF SUPPORT & RESISTANCE

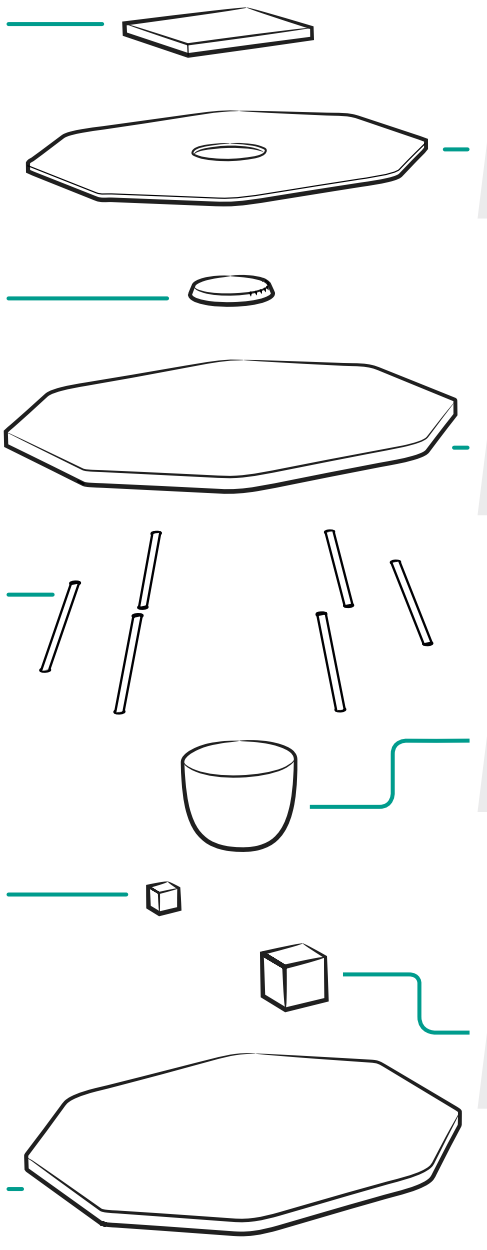

TESTING FITNESS FUNCTIONALITIES


PREPARING FEED-FORWARD TESTING


TESTING FEED-FORWARD

Ill. 70.01: Process pictures

BASIC SYSTEM STRUCTURE, ATHLON TRAINER



INTERFACE
SYSTEM PROVIDING FEED-FORWARD & LIVE FEEDBACK FOR THE USER

Page 74-77, [AP 3]

NON-SLIP SURFACE
SURFACE TYPE PROVIDING A NON-SLIP STAND SURFACE DESPITE ANGLE CHANGE & MOIST EXPOSURE

Page 73, 96

SUPPORT/RESISTANCE ADJUSTER
MECHANISM ENABLING ADJUSTMENT OF SUPPORT/ RESISTANCE LEVEL

[AP 5]

TOP SURFACE
SURFACE ACCOMMODATING FOR BOTH REHABILITATION AND FITNESS EXERCISES

Page 72-73, [AP 2]

SUPPORT/RESISTANCE SYSTEM
MECHANISM ENABLING CREATION OF BOTH SUPPORT AS WELL AS ADDED RESISTANCE

Page 78-83, 92, [AP 4]

DESTABILISOR
MECHANISM ENABLING CREATION OF BALANCE BOARD FUNCTIONALITY

Page 80-81, [AP 4]

SENSOR SYSTEM
SYSTEM PROVIDING OUTPUT FOR DATA QUANTIFICATION, FEED-FORWARD & LIVE FFEDBACK

Page 84-85

POWER & COMPUTING
SYSTEM ENABLING POWER USE, CHARGING, DATA COMPUTING & DATA TRANSFER

BOTTOM SURFACE
SURFACE PROVIDING STABILITY AND SUPPORT

[AP 6]

Ill. 71.01: Athlon, General system structure

4.02

TOP SURFACE

Specifying shape, size & angle

The top surface is the user's main interaction point with the Athlon Trainer. The size and shape of the top surface is influenced by a multitude of factors. For example, it is desired to maintain the rehabilitation quality of the traditional balance board while challenging the current preconceptions found to be partly connected to the basic round shape. Instead of looking either non-responsive or toy-like, the product should communicate the sports performance identity as well as accommodate for a variety of exercises.
To specify the top surface in relation to shape size and tilt angle while meeting the product requirements, phenomenological prototype tests are carried out. Through bodystorming it is investigated how far it is possible to deviate from the basic shape while still keeping the functionality of a balance board and meeting new requirements for added fitness exercises. For the shape and size tests, cardboard and wood cutouts are used in combination with existing balance boards. To test different angles a simple test rig enabling angle variations is mocked up.

More detailed test descriptions can be found in [AP 2] and [WS 12, 13, 14].

TOP SURFACE, SHAPE

RECTANGULAR

OCTAGONAL

TRIANGULAR

FITNESS GRIPS

TOP SURFACE, SIZE

TYPICAL STANCE WIDTHS

FITNESS EXERCISES

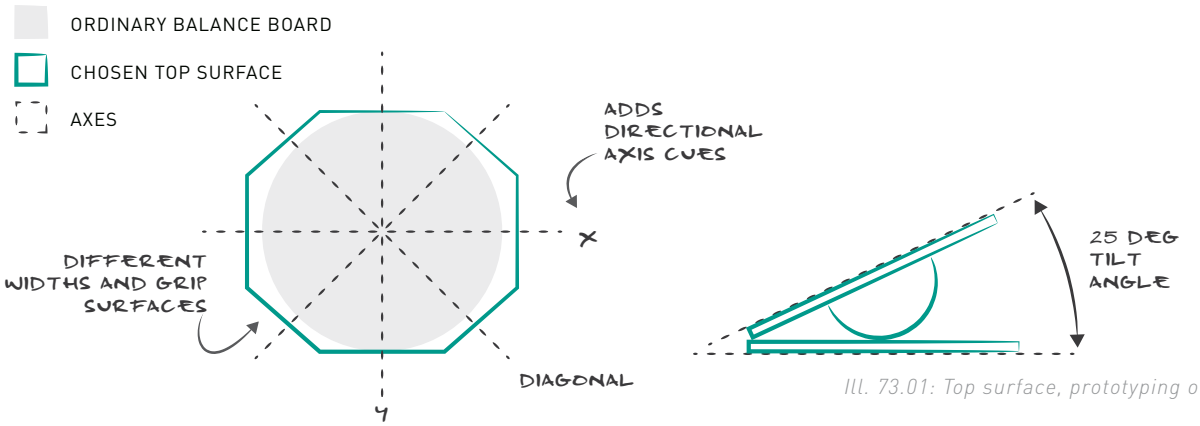
REQUIREMENTS, TOP SURFACE

- Aesthetics reflecting sports identity and performance (p. 86)
- Communicate axial movement directions used when performing the recommended ankle rehabilitation exercises; x, y and diagonal axes (p. 34)
- Provide a similar experience to balance board when performing the typical joint stability exercises including circular motions. (tested phenomenologically)
- Accommodate for both rehab (p. 34) and fitness exercises (tested phenomenologically)
- Does not exceed the maximum flexibility angle of an average person's ankle [WS 25] (tested phenomenologically)
- As small as possible to accommodate home use wishes [WS 11].

TOP SURFACE, TILT ANGLE

ANGLE MOCK-UPS

TESTING ON PREVIOUSLY SPRAINED ANKLE



Ill. 73.01: Top surface, prototyping output

The prototyping and testing shows that a stretched octagon shape meets the desired sporty look without compromising the rehabilitation quality. The octogonal shape additionally provides a directional cue aiding precision feedback. A product size of 40 x 45 cm is found to meet both rehabilitation and fitness exercise requirements. A maximal top surface angle of 25 degrees is found to be challenging even for the athletic test subjects.

TOP SURFACE; SHAPE, SIZE & ANGLE

4.03

PRODUCT INTERFACE

Specifying placement, size & shape

The following section focuses on specifying how, on an overall level, the feed-forward and feedback is communicated when using the product. Through rapid prototyping and bodystorming it is explored which placement, size and shape of the interface creates the best user experience in terms of both clearly seeing and understanding the feed-forward and feedback given [WS 15].
Beforehand it is decided that the overall mechanism should be a visual interface as it offers the opportunity to create more discreet and understandable communication than alternatives such as haptic and audible communication [WS 15].

The variety of exercises intended to be carried out on the product highly complicates the process of defining a good placement, size and shape, as they call for very different use of the product and thereby also the interface. The tests are carried out using simple prorotypes and doing different exercises to test the influence of different distances and angles. In addition to use criteria, parameters influencing cost are also taken into consideration.

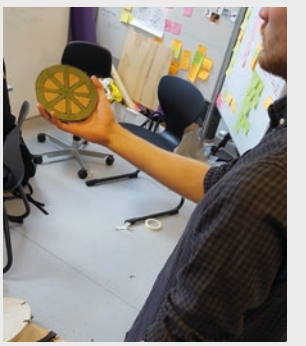
More detailed test descriptions can be found in [AP 3] and [WS 15, 16].

INTERFACE, PLACEMENT

IN CENTRE

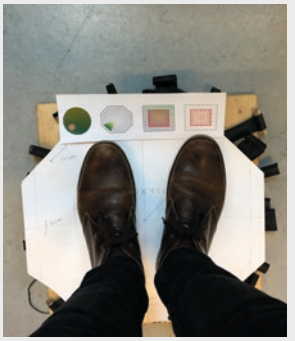
EDGE OF BOARD

AWAY FROM BOARD

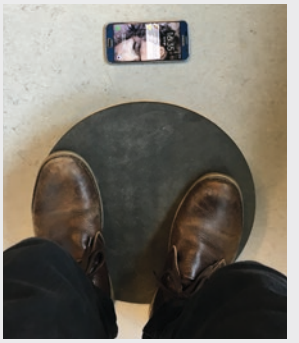


IN HANDS

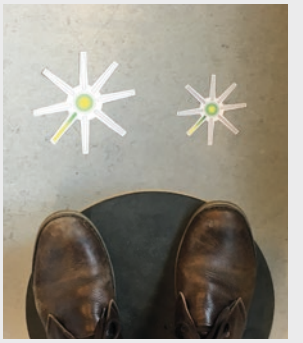
INTERFACE, SIZE



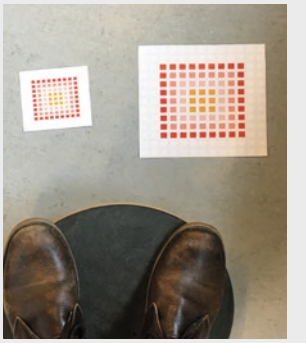
5X5 CM



PHONE, 5”



8X8 - 16X16 CM

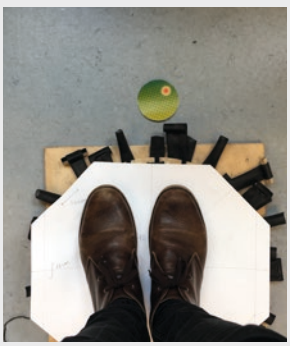


11X10 - 21X18 CM

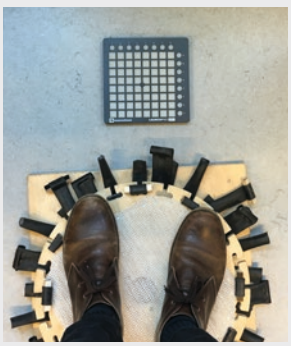
REQUIREMENTS, INTERFACE

- Should be visible and readable for the user while doing the recommended ankle rehabilitation exercises (p. 34) as well relevant fitness exercises (squats, lunges, push-ups, plank etc.)
- Costs should be kept as low as possible without compromising the needed communication quality (phenomenologically tested [AP 3].
- Instructions should be easy to understand (phenomenologically tested, [AP 3])

INTERFACE, SHAPE



CIRCULAR



SQUARE

BOARD SHAPE

INDICATING AXIS

Ill. 75.01: Interface, prototyping output

The prototyping and testing shows that a placement of the interface away from the training product is desired. Depending on the communication complexity and technology, it is found that the interface should at least be 12x12 cm. Additionally, it is found that having a specific interface shape is not that important and that a circular element can help make the connection between the experienced and the seen movement

INTERFACE; PLACEMENT, SIZE & SHAPE

4.03

PRODUCT INTERFACE

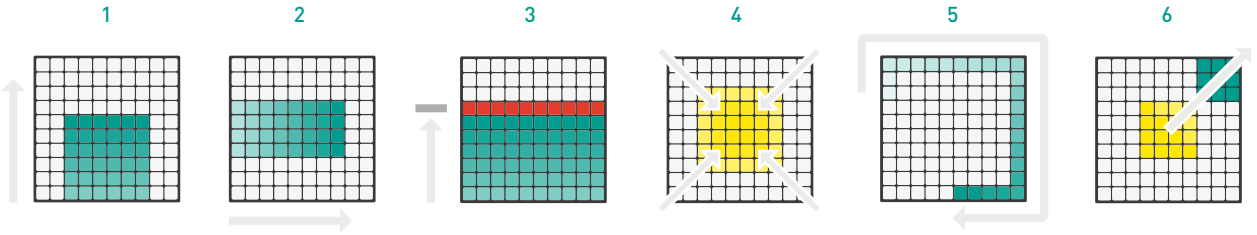
Feed-forward & feedback experience

To figure out how the interface should communicate feed-forward and feedback when the product is in use, a test is set up. Simple visual instructions are programmed using Ableton Live software and displayed with a Novation Launchpad to create a simple prototyping setup. The test is done to get an indication if lights and colours have the potential to instruct the user in how to exercise correctly. The interface is tested with users from different sports and with difference in ankle mobility and general balance skills. The insights from the tests are used to refine the prototype setup and test again to fine-tune the instruction programme.
More detailed test descriptions can be found in [AP 3] and [WS 17]

FEEDFORWARD INSTRUCTIONS

The instructions displayed on the interface are based on the typical balance board exercises as visualised in the illustrations below (ill. 76.01).
The exercises are tested at different difficulty levels and speeds both one by one and mixed together randomly to explore what it takes to motivate and challenge the test persons.

1. Front to back movement
2. Side to side movement
3. Moving to a border
4. Keeping the board stable
5. Around the world movement
6. Moving precisely to a certain area



Ill. 76.01: Feed-forward test; visualisations of exercises

INTERFACE, EXPERIENCE TESTING

TEST, SKATEBOARDER W. PRIOR SPRAINS

SIDE TO SIDE MOVEMENT

KEEP THE BOARD STABLE

MOVE DIAGONALLY

Simple feed-forward is easily understood by test subjects even without any prior instructions. Colours are found to aid communication. Instruction should always be visible during a training programme. Gradual movement instructs the user in movement speed. In general the use experience is described as fun and motivating due to the competitive element of accomplishing the instructed challenges. The final system should incorporate feedback. Two overall game modes are specified; stability mode & precision mode

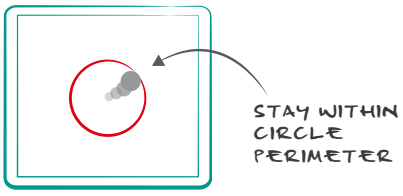
INTERFACE; FEED-FORWARD AND FEEDBACK EXPERIENCE

ACTIVITY MODES

As a result of the tests, the type of feedforward and feedback is determined and two game modes are further developed. Common for both game modes is that software is adapting the exercises according to the user's level and performance. In both modes, the time left of the ongoing exercise as well as time left of the overall workout programme should be communicated visually.

In future iterations of the product, additional modes can be added such as instructions in training speed, time under tension, concentric and eccentric movement guidance etc.

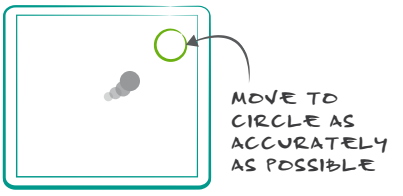
STABILITY MODE



STAY WITHIN CIRCLE PERIMETER AS MUCH AS POSSIBLE. CIRCLE PERIMETER SIZE VARIES TO VARY DIFFICULTY

- **Exercises**
  Rehab: Proprioception and joint stability exercises
  Fitness: Core stability during isometric & dynamic exercises
- **Feed-forward** Lights igniting in the middle of the interface, showing required stability
- **Feedback** Showing performance accuracy by the relative deviance from horisontal position
- **Progression** Starting with a high stability threshold and gradually increasing requirements for stability

PRECISION MODE



MOVE TO CIRCLE PERIMETER AS ACCURATELY AS POSSIBLE. CIRCLE PERIMETER SIZE VARIES TO VARY DIFFICULTY

- **Exercises**
  Rehab: Plantar- and dorsiflexion, pronation and supination, proprioception and joint stability
- **Feedforward** Gradually moving lights, showing where the user needs to move and at what speed.
- **Feedback** Showing live position and movement accuracy relative to the instructions given
- **Progression** Starting with slow and controlled movements, then moving towards quick and random.

INTERFACE DEVICE

Based on user statements on the evaluation of pros and cons regarding use, cost and alike, it is decided to communicate feed-forward and feedback through an application, which is intended to initially be made available for tablets [AP 3]. This is decided as users prioritise simplicity, low cost and a small product size [WS 18].

The screen size and resolution of a tablet is ideal to provide accurate feed-forward and feedback. Another supporting point is that an app is adaptable to change and future product updates compared to having a defined interface on the board itself.

INTEGRATED INTERFACE

Despite moving the main communication away from the product, it is desired to include a smaller visual communication function in order to communicate time and exercise management aspects to the user. While exercising, the user should be able to see time left of current exercise and exercises left of overall training program. When not in use the product should facilitating time management; nudging the user to do his/her exercises. This can be done through discrete visual feedback, additionally making the board more alive, more integrated with the app and more directly visible when nudging and notifying than an app functionality.

Feed-forward and feedback should be communicated through a tablet app. Time management aspects will be integrated within the top surface of the Athlon Trainer.

INTERFACE; SYSTEM TYPE & INTEGRATION

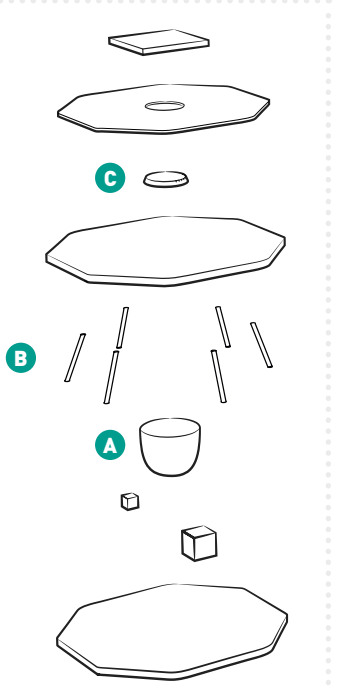
4.04

SUPPORT & RESISTANCE

Functional development

A central part of the Athlon Trainer is the support and resistance system along with the adjuster and destabilising component (ill. 78.01, A, B, C). In order to explore possible solution combinations for the mechanical principle and appertaining interaction elements, a system synthesis inspired by Tjalve's product synthesis model (Tjalve, 1979) is sketched concurrently with the system prototyping and testing. This allows for a systematic approach to the system development, by unfolding possible options for components and working principles as well as associated pros and cons. The most promising principles have been further investigated and developed. These are marked with an icon and a page number indicating where the development process is described.

The overall purpose of the system is to provide the general experience and quality known from traditional balance boards, as well as enabling support when needed and added resistance when this is desired. The felt experience is prototyped using a phenomenological approach comparing to existing products, as there are no direct recipes for the correct functionality and experience.



Ill. 78.01: System component reference

DESTABILISOR
MECHANISM ENABLING
CREATION OF BALANCE BOARD
FUNCTIONALITY
A

DESTABILISATION PRINCIPLES

LIQUID
+ Adjustable
- Uncontrollable rotation point
- Damage issues

AIR PILLOW
+ Adjustable
- Uncontrollable rotation point
- Damage issues

SOLID DOME
+ Known & used product principle
+/- Balance board reference
- Moving rotation point

(p. 80-81)

HOOK JOINT
+ Standard component
+ One point of rotation
- Hard to stay balanced upon

(p. 80-83)

CENTRE SPRING
+ Simple
- Hard to adjust

SUPPORT/RESISTANCE SYSTEM
MECHANISM ENABLING CREATION OF SUPPORT AND ADDED RESISTANCE

B

SUPPORT/RESISTANCE PRINCIPLES

SPRINGS
+ Cheap standard component
+ Simple
- Linear stiffness

AIR
- Requires air compression system
- Difficult to control

MAGNETS
- Heavy
- Difficult to control

ELASTIC BANDS
+ Simple
+ Sports reference
- Vulnerable to deformation or tear

PISTONS
+ Rodeo effect
+ Controllable
+ Precise
- Complex
- Vulnerable to wear, tear & dirt

(p. 82-83, 92-93)

INVESTIGATTED SPRING TYPES

(p. 80)

GAS SPRING
+ Resistant to wear, tear & dirt

LINEAR SPRING
+ Simple
- Linear stiffness

PROGRESSIVE SPRING
+ Simple
+ Adaptable stiffness
+ Gradually more stiffness when compressed

SUPPORT/RESISTANCE ADJUSTER
MECHANISM ENABLING ADJUSTMENT OF SUPPORT/ RESISTANCE LEVEL

C

GENERAL ADJUSTMENT PRINCIPLES

AUTOMATIC
+ Easy for user
+ Accessible
- Requires motor
- No tactile feedback / progression indicator

MANUAL
+ Simple, cheap
+Tactile feedback
+ Sports reference

[AP 5]

ADJUSTMENT PRINCIPLE

ADJUSTMENT PLACEMENT

TURN
+ Simple
+ Sports reference

SLIDE
+ Simple
- Non-sporty

PUSH
- Many buttons required
- No graduation

TOP
+ Easy access
+ Centered

BOTTOM/SIDE
+ Direction
- Harder to access

4.04

SUPPORT & RESISTANCE

Experience prototyping - how does it feel?

It is the objective to create a support and resistance system that enables product use throughout the rehabilitation period. To ensure that the system meets the requirements it is necessary to explore if the working principle can be applied without affecting the general experience and thereby the rehabilitation quality. To create a foundation for the further development it is additionally necessary to specify the desired experience. Lastly, it is needed to explore if it is possible to swap the traditional dome shaped destabilisor for a one-point component, in order to avoid moving points of rotation as this will complicate the integration of the support and resistance system as well as sensor data reliability. The felt experience is tested using a phenomenological approach; comparing the experience to that of existing balance products. A test rig is created, making it possible to vary the amount and type of support as well as changing the destabilisor type. Tests are carried out involving both the team and external users to validate whether the solutions create the desired experience. A curve, describing the needed support (applied resistance) R as a function of the angular tilt, θ, is created with inspiration from the current balance board experience.
More detailed test descriptions can be found in [AP 4] and [WS 10, 25].

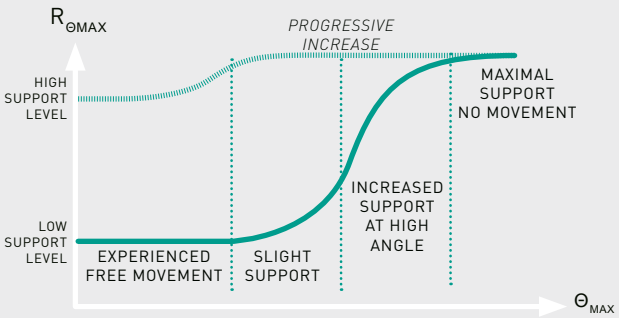
SUPPORT & RESISTANCE VERIFICATION

DIFFICULT
BALANCE BOARD

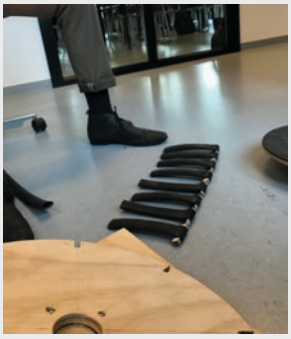
EASY
BALANCE BOARD

SETTING UP & TESTING

SPECIFYING THE EXPERIENCE



DESIRED EXPERIENCE
RESISTANCE AS FUNCTION OF ANGULAR TILT



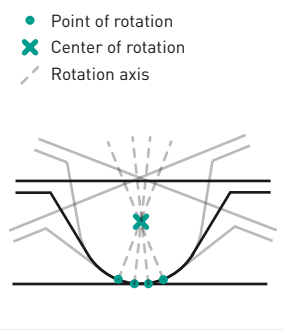
RIG SETUP

TEST, TRIATHLETE

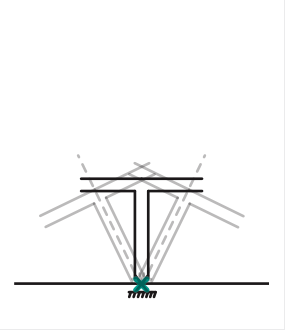
REQUIREMENTS, SUPPORT & RESISTANCE

- Should provide the general experience and quality known from traditional balance boards (phenomenologically tests)
- Should be able to vary from being almost steady, to the experience of the most challenging balance board tested
- Should create even support in all axes
- Movements should be smooth and non-frictional [AP 4]
- Should contain the lowest amount of movable parts [AP 4]
- Should support use of only one adjustment point [AP 4]
- Desired to support construction from standard components [AP 4]

TESTING ONE-POINT DESTABILISOR



DOME DESTABILISOR



ONE-POINT DESTABILISOR

MOCK-UP, DOME DESTABILISOR

MOCK-UP, ONE-POINT DESTABILISOR

The prototyping and testing shows that it is possible to create variable support and resistance while maintaining the wanted experience known from traditional balance boards. By adding or removing elastic bands, in this case acting as the support and resistance system, the experience can vary from very stable and controlled to almost impossible. As described by the curve, it is desired that the system should generally provide a feeling of 'no support' when the board is in balance. Past a certain angle point the support should progressively increase to help the ease out in extreme positions. In cases where more support is needed, the curve is flattened meaning that an almost static board is created. Lastly, the tests indicate that it is possible to obtain the wanted experience even when using a one-point destabilsor. Despite the successful qualitative comparison, the actual effect of the system principle should be tested further to ensure rehabilitation quality

SUPPORT & RESISTANCE, EXPERIENCE

4.04

SUPPORT & RESISTANCE

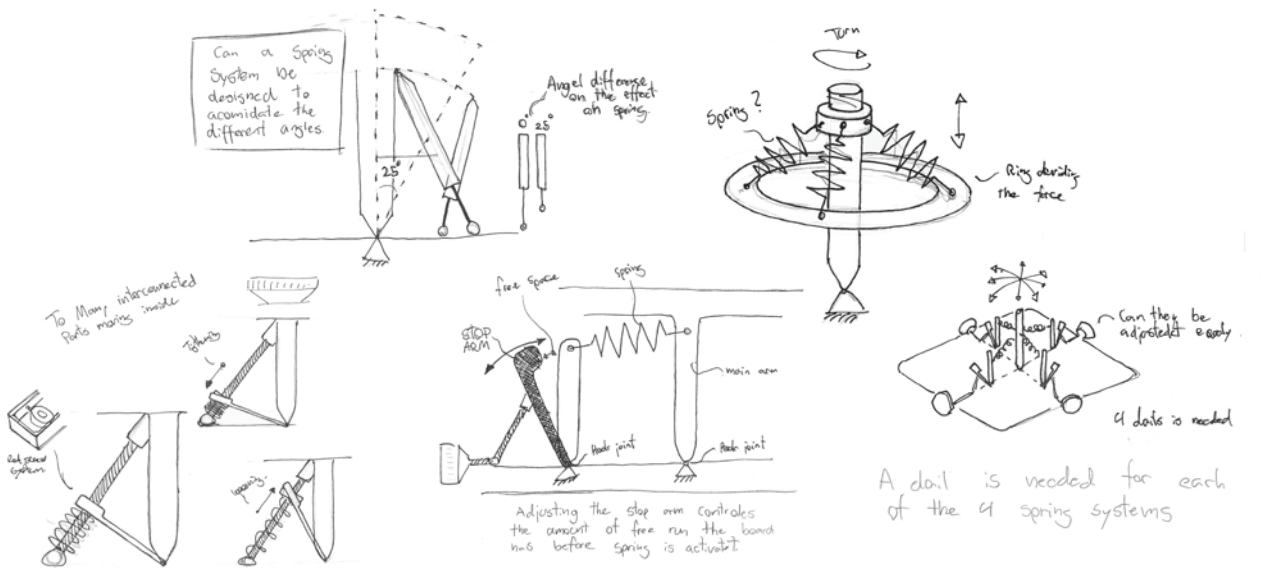
System development

To achieve the desired support and resistance experience, a mechanical system needs to be developed. It is chosen to further develop a spring type system rather than a system using elastic bands, as this has the greatest potential to deliver a system that is resistant to long term use, as well as being easily controllable in order to achieve the desired experience [AP 4]. The development and design is carried out through desk research on similar compression systems, sketching and quick mock-ups. The systems are evaluated in cooperation with the technical supervisor. A central concern when evaluating the different system principles is the complexity, as this increases both cost and risk of system failure.

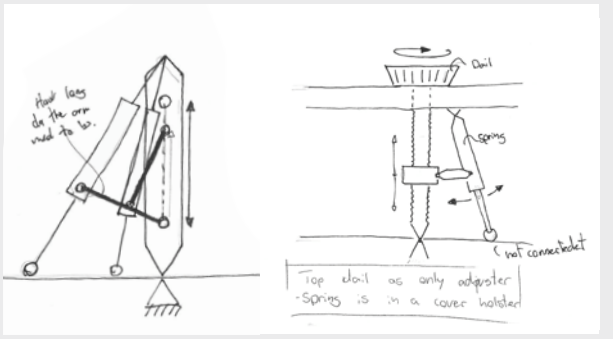
To meet the specified requirements for the system, the development is carried out with special focus put on:

- Creating a single interaction point for the adjustment at the top of the board.
- Simplifying the system to consist of the fewest amount of movable parts and joints
- Ensuring possibility to create the chosen angles and heights
- Ensuring that the spring system is not affected by movement in the opposite direction

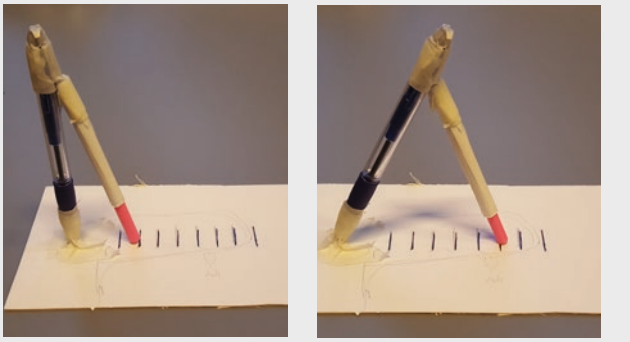
Additional development description can be found in [AP 4].



Ill. 82.01: System development, selection of explorative sketches



ANALOGUE SKETCHES



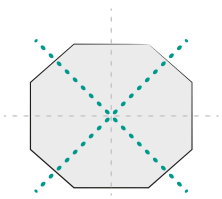
RAPID PROTOTYPE MODELING

The developed system consists of four spring sub-systems and a single top adjuster. Using progressive springs accommodates the desired use experience. The system needs further detailing to incorporate standard components

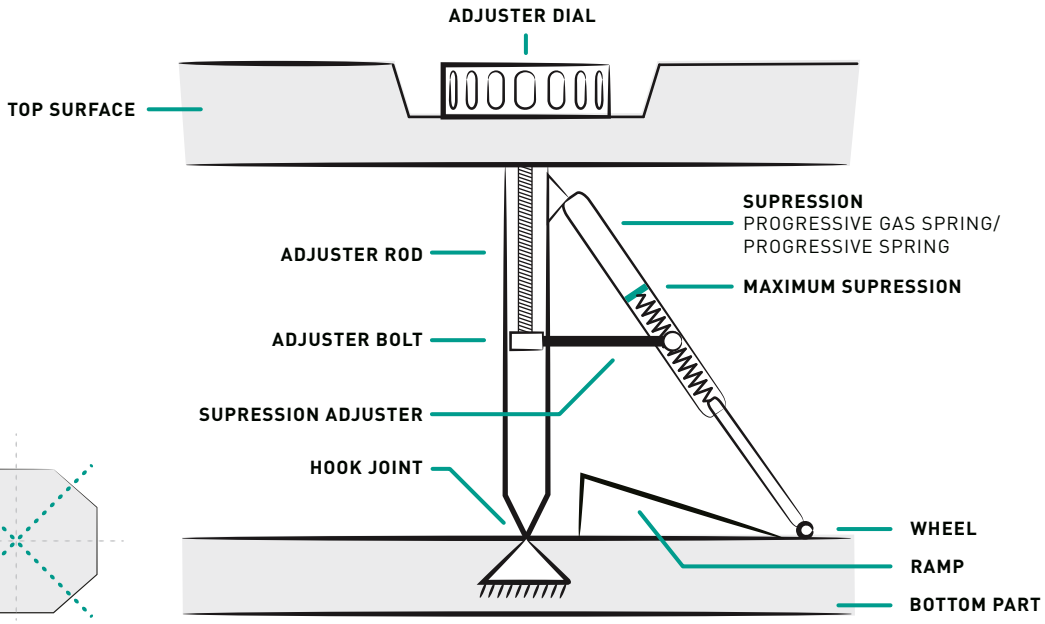
SUPPORT & RESISTANCE, SYSTEM DEVELOPMENT

CHOSEN SOLUTION CONCEPT

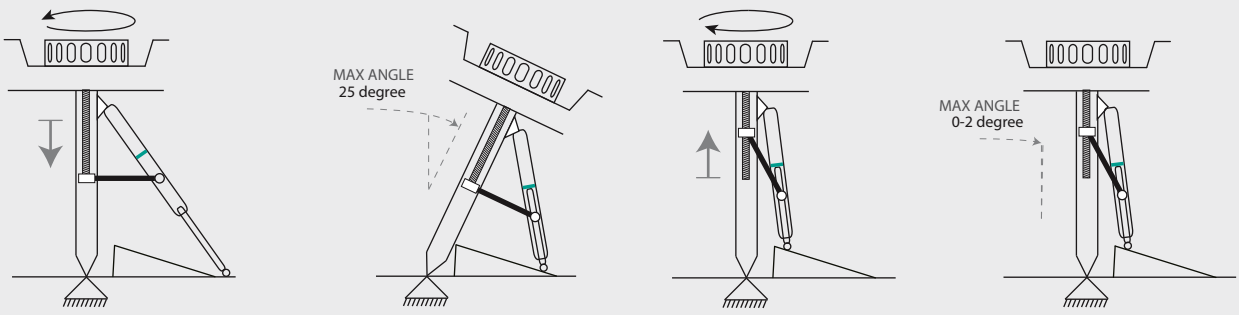
The developed solution consists of four spring sub-systems and a single top adjuster. The sub-systems are paired two and two, movable in the diagonal directions of the product (ill. 83.01). By turning the adjuster dial, the suppression adjuster arms, connected to the spring system, pulls the spring, thereby compressing it. A bottom ramp ensures that a fully compressed spring is achieved when the adjuster dial is fully turned. Not fastening the spring at the bottom ensures that the bottom surface is not pressed during system movement, thereby decreasing the tension within the system.



Ill. 83.01: Paired sub-systems



Ill. 83.02: Adjustment system, one sub-system visible



MINIMAL RESISTANCE - ADJUSTER BOLT IS MOVED DOWNWARDS BY TURNING DIAL

MAXIMAL RESISTANCE - ADJUSTER BOLT IS MOVED UPWARDS BY TURNING DIAL

4.05

SENSOR SYSTEM

In order to quantify the exercise data needed for progress tracking, continuous training adaption as well as feed-forward and live feedback, it is needed to incorporate some sort of sensor system within the product. Through desk research, rapid prototyping and testing it is explored what kind of data is needed and how this can be quantified [WS 23].

DATA REQUIREMENTS

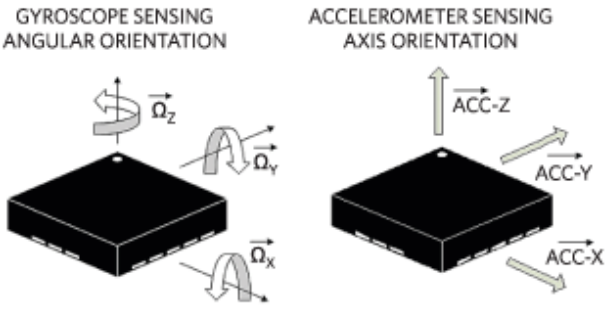
A sensor system can measure almost everything depending on the chosen sensors. It is therefore important to define what the board needs to be able to measure in order to extract the wanted data.
It is desired to be able to measure the board angle to determine ankle mobility as well as measure specific movements to extract data about joint stability as this can be expressed as the ability to keep the board stable (p. 77). Movement data is also needed in order to provide the user with live feedback. Additionally, the movement data should be supplemented with data regarding movement speed, to attain real-time feedback. The requirements can be states as:

1. **Movement** of the board; the sensors must be able to define where the board is and how it is positioned in relation to the ground
2. **Speed** of movement; the sensors must be able to define how fast the board is moving from one position to another

SENSOR TYPES & CHOICE

Given the requirements for the sensor system, two types of sensors stand out in the research as possible choices; the gyroscope and the accelerometer. The gyroscope measures angular movement in relation to time. Spinning and rotation is measured for all 3 axes, giving a complete picture of the rotational movement of a object, however, it cannot measure axial movement (ill. 84.01). The accelerometer measures the change in velocity, or speed divided by time. The sensor is often used to measure movement and vibrations, but cannot measure rotational movement (ill. 84.01).

Due to choice of a one-point fixed destabilisor, the board only has angular and linear movement during use. This means that the needed data can be extracted using a gyroscopic sensor. The sensor can functionally be place anywhere in connection with the moving surface. The placement should instead be determined by construction and e.g. placement of power source.



Ill. 84.01: Gyroscope & accelerometer data output

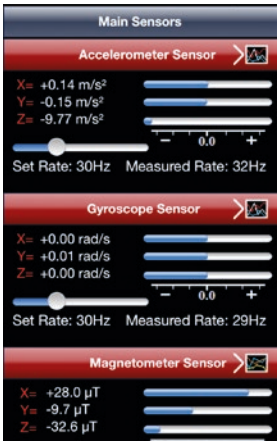
REQUIREMENTS, SENSORS

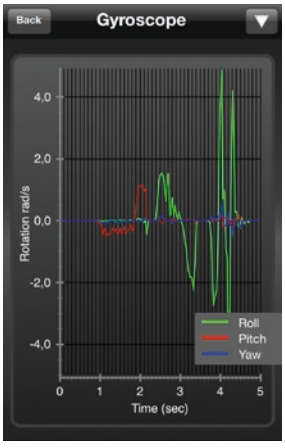
- Must be able to define axial position in accordance to time (providing data output regarding ankle mobility, joint stability as well as live movement feedback)

PROTOTYPING & TESTING

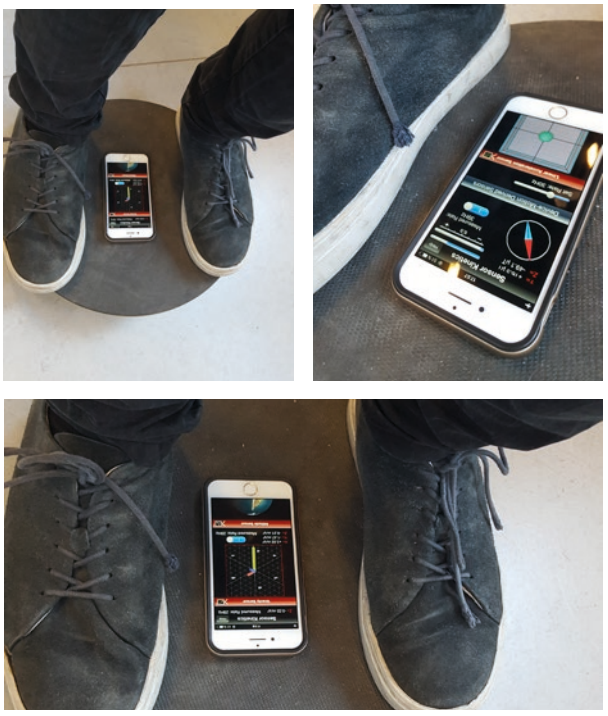
Both gyroscopes and accelerometers are found in most smart phones, which presents an opportunity to easily test the sensors in action. A simple test is conducted using a smart phone, an ordinary balance board and the app 'Sensor Kinetics'. The app shows the data output from various sensors within the phone, including gyroscope and accelerometer. This makes it possible to see the various sensor output in combination with a balance board, thereby visualising the movement created by the user as it is intended with the product-to-be.

It additionally provides different visual representations of the data (ill. 85.01, 85.03), enabling quickly testing of the principle of getting live feedback (ill. 85.02), which is found to add an interesting element to the use, despite the low quality of the app visualisations. Future prototyping should include testing of feed-forward and feedback in the same system.

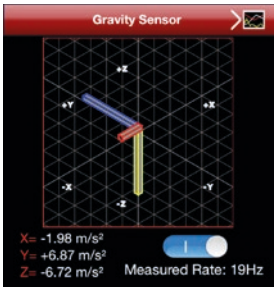


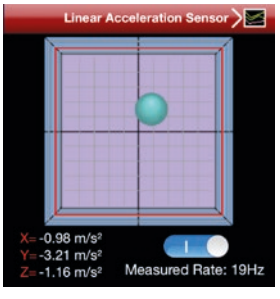


Ill. 85.01: App data output, numbers, scale & graph



Ill. 85.02: Testing live movement feedback





Ill. 85.03: App output, different data visualisations

The needed sensor data can be provided by a gyroscopic sensor
SENSOR SYSTEM

The sensor system can be placed anywhere on the moving top surface
SENSOR SYSTEM

4.06

EXPRESSION

Aesthetic inspiration

It is desired to aesthetically differentiate the product from typical balance boards and other rehabilitation products that are perceived as dull, unserious and, by interviewed users, associated with both elderly homes and high school physical education.
Instead, the goal is to pursue a sporty and performance related expression inspired by the products that athletes own and desire.

Within the spectrum of sporty aesthetics, two directions and the span between them is explored: One that is discrete and minimalistic in its expression and another that stands more out (ill. 86.01).

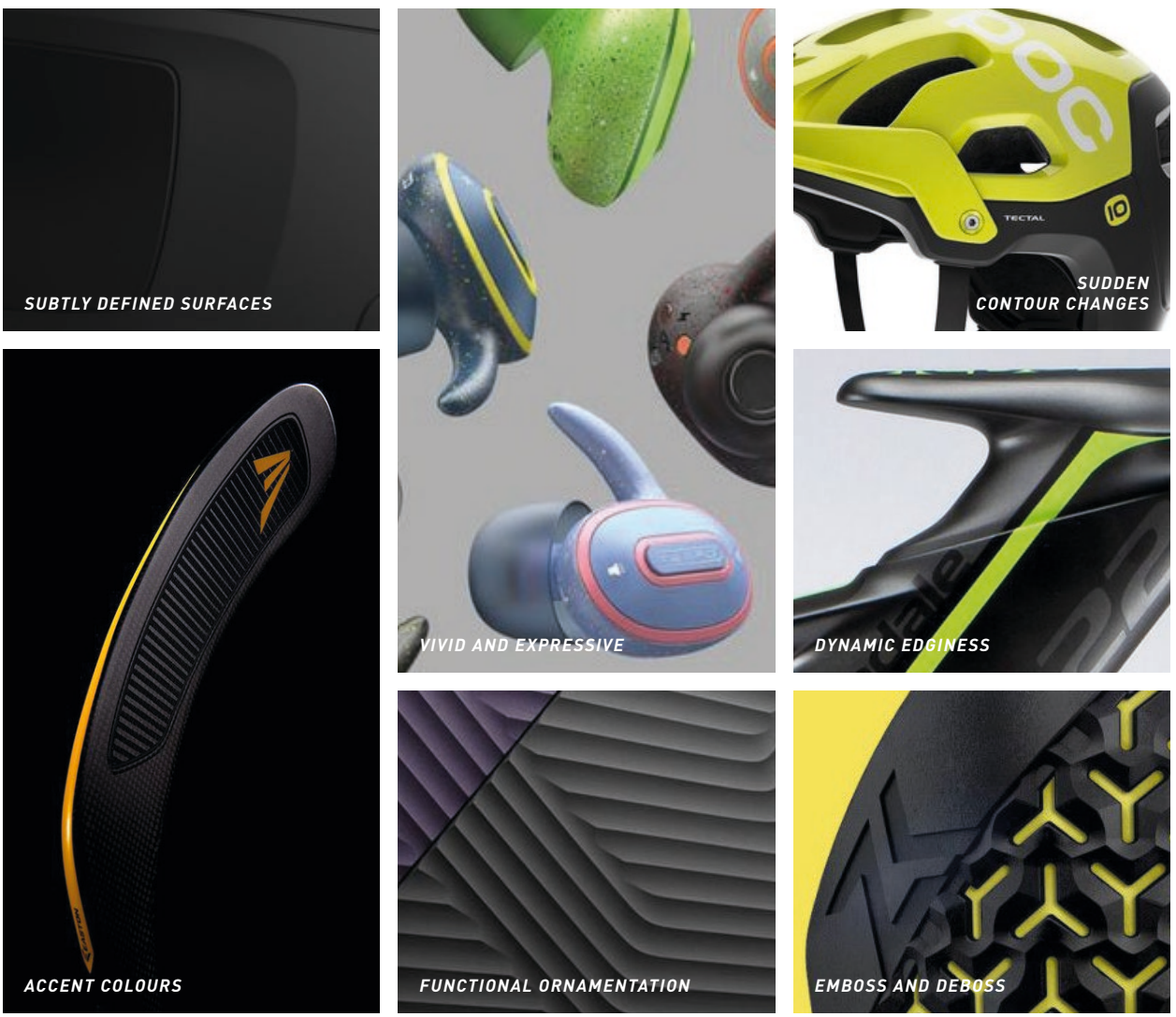
The following styleboards are acting as direct inspiration for the development process and facilitates discussion and alignment within the team.

MINIMALISTIC DIRECTION

The minimalistic direction is relatively simple, professional and discreet in its look. The dynamic sports expression is created through cuts in the shape and differences in texture and materiality combined with subtle colour accents.

EXPRESSIVE DIRECTION

The expressive sports direction catches the eye due to dynamic and edgy lines, sudden change of surface contours and frequent use of vivid colours. The shape of the product expresses elegance and sporty lightness.



Ill. 86.01:Expression, outtake of minimalistic and expressive style mapping, done and shared within the team through Pinterest

REQUIREMENTS, EXPRESSION

- Must reflect sports identity and performance
- Must differ from aesthetic characteristics of a traditional balance board
- Must indicate improved rehabilitation quality through increased complexity (compared to traditional rehabilitation equipment)

Aesthetic principles

In addition to the overall look and feel of the product, the different parts need to express different things to obtain the desired perception and product understanding. Different design detail makes it possible to aid the immediate decoding of the product guiding both the product understanding as well as the use.
The inspiration images makes it easier to concretise how otherwise very abstract terms can be expressed aesthetically, thereby guiding the aesthetic development of the product.

The following principles are examples of how to obtain the desired aesthetic purpose of different elements of the product.

NON-SLIP SURFACE

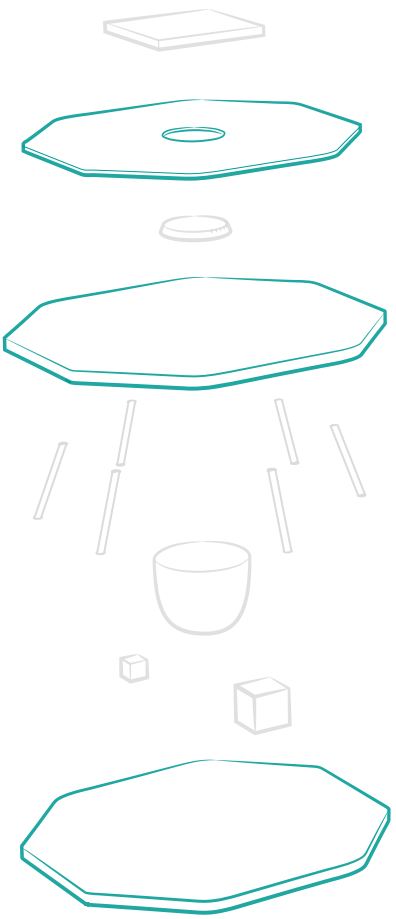
The non slip surface is what makes sure the user has a secure stance while performing exercises. Through functional ornamentation, such as three-dimensional patterns and textures combined with a matte and rubbery look, the desired safety can be functionally creates as well as communicated.
The graphics on the non slip surface can aid in facilitating correct stance positions and communicate movement directions of exercises (p. 74).

TOP SURFACE

The top of the board is in constant movement when the product is being used. It is therefore desired that the shape is dynamic and expresses acceleration, flexibility and has a certain lightness that encourages the user to exercise.
Functional areas, such as grips for fitness exercises, can be indicated by changes in shape and contour and accentuated through graphic ornamentation such as accent colours.

BASE

The base stabilises the product even though it is being exposed to a lot of movement and changes of direction. It has to communicate a certain groundedness that assures the user that the product will not tip during demanding exercises, but without looking heavy and static.
In its shape, the bottom can help in expressing the movement the user needs to perform by e.g. indicating the x and y movement axis. The development of the basic functional stability can be found in the appendix [AP 6].



Ill. 87.01: Expression, main product elements

The product's expression is developed with inspiration from sports equipment. The aesthetic principles should aid in decoding the function of the product's main parts

EXPRESSION

4.07

EXPRESSION

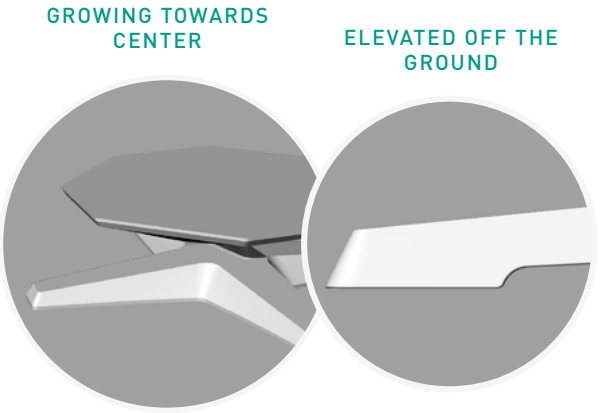
Aesthetics prototyping

The before mentioned desired expression of the product and its different elements are prototyped through an combination of sketching, quick mock-ups and CAD modeling.

The development of the aesthetics is based on exploring the span between the two directions 'minimalistic' and 'expressive', initially through iterations of the two main components: The base and the top surface.

BASE

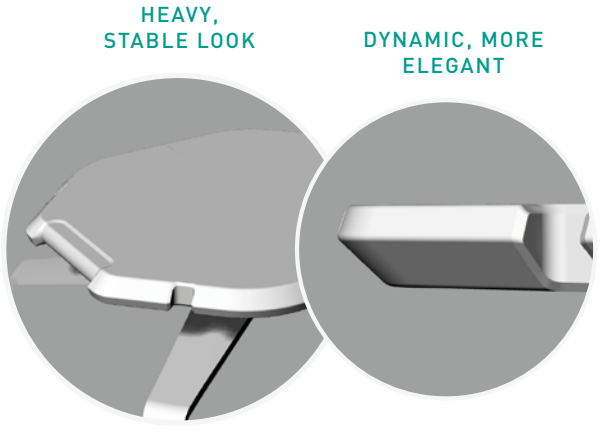
The base provides stability to the product and has to communicate groundedness without looking too heavy. It is found that a shape where the four legs meet the board's diagonals gives the base a stable look [AP 6]. By making each leg start low at its outer point, and gradually grow bigger towards the center of the board, the base attains a more elegant look without compromising on the look of stability. The legs are elevated slightly from the ground by making cuts underside of the profile. Indents in the top of each leg and sweeping surfaces provides dynamic lines and sudden contour changes.



TOP SURFACE

The top surface will be in constant movement when used and therefore needs to look more dynamic than the base while visually communicating its main function.

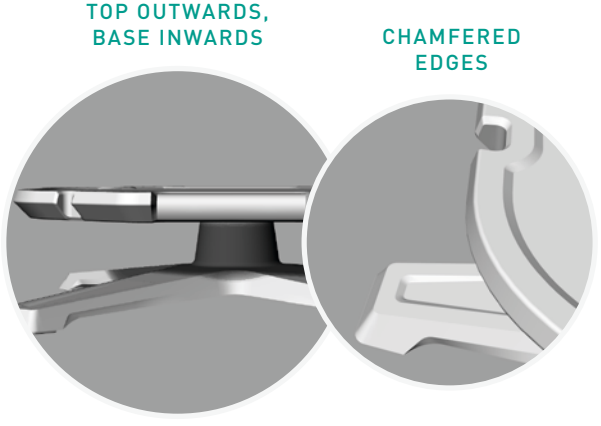
It is found that making the area of the top smaller as it gets closer to the ground, the desired dynamic look is achieved. Different levels of mass vs. structure is tested and it is concluded that a massive top surface provides a more safe and reliable look. In communicating the grip areas and the attachment slots for elastic bands, it is found that a ribbon or chamfer going around the shape aids in highlighting the areas. These areas can stand further out by using accent colours.



UNIFICATION

Even though the he two main parts have different functions, they need to have some degree of resemblance to each other to make the product unified in its expression.

By repeating the same chamfers in both top and base, and making some of the lines of the top follow through in the base, this is possible.
Using the same accent colours and the way they are used in both parts creates additional resemblance.

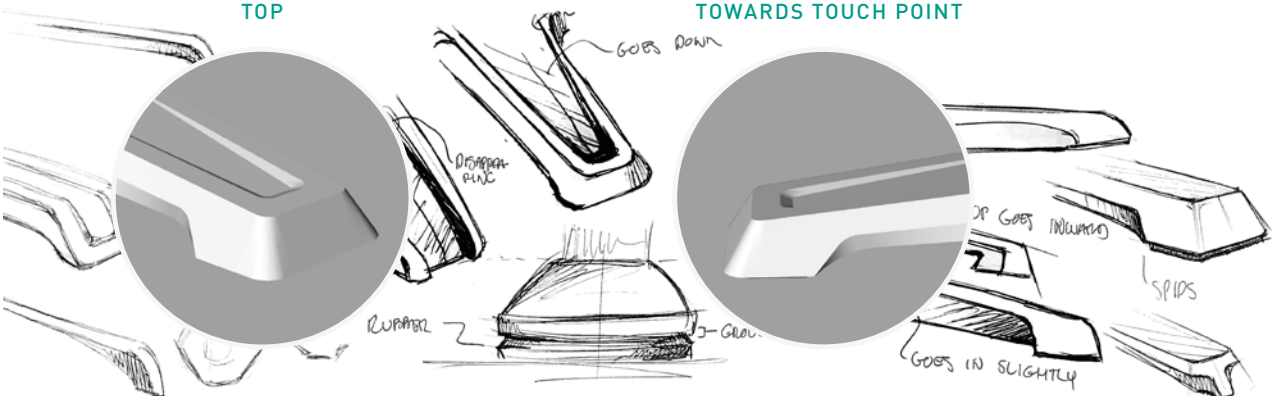


Through aesthetic prototyping using a mix of analogue and CAD sketching supported by physical modelling, it is found that gradually growing legs with cuts and sweeping elements makes the expression of the base stable without looking heavy. The top is made dynamic but reliable. The two parts are unified through repeating form elements and the use of colour.

EXPRESSION

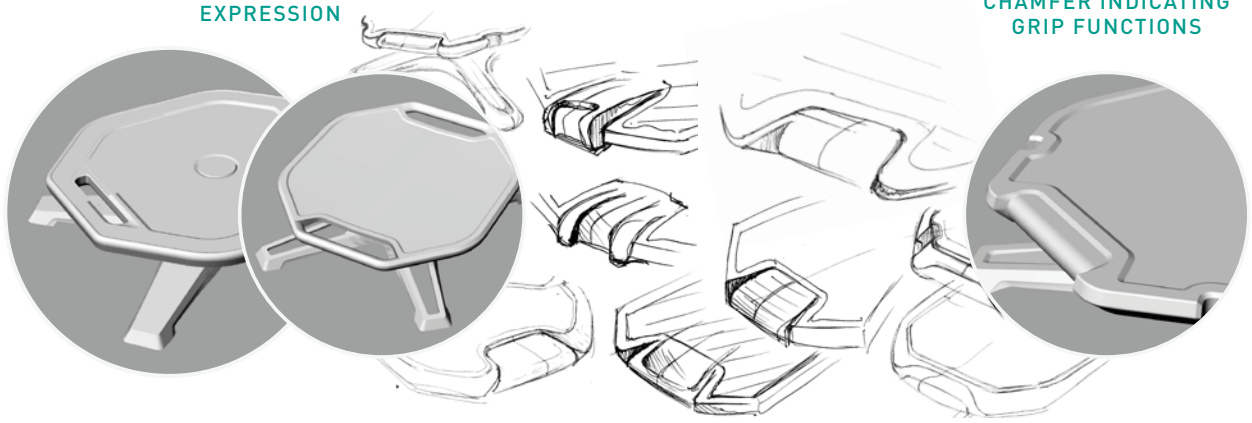
INDENTED TOP

SWEEPING SURFACE TOWARDS TOUCH POINT



LIGHT, STRUCTURAL EXPRESSION

CHAMFER INDICATING GRIP FUNCTIONS

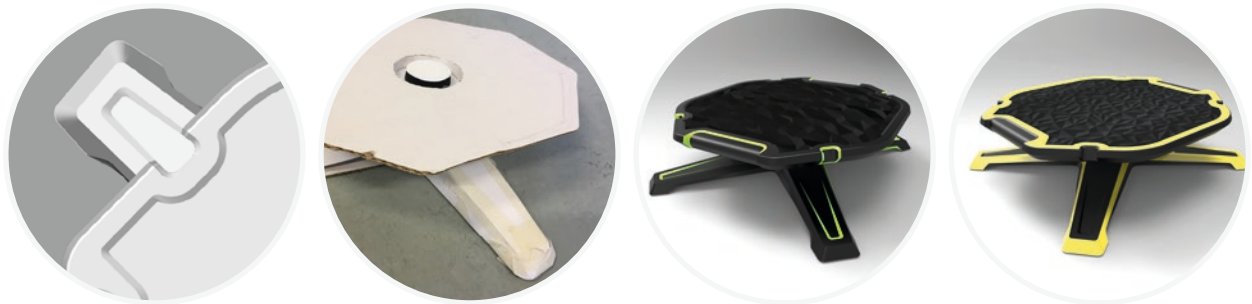


SHAPE RESEMBLANCE

1:1 SCALE MOCKUP

REPEATING ACCENT COLOURS

COLOUR WRAPPING AROUND SHAPE



KEY ACTIVITES

DESK RESEARCH
- Materials & construction
- Standard & customised components

MODELING
- Sketching
- 2D modeling
- 3D modeling
- Physical modeling

- Ergofloor, **Uffe Mølgaard (Rubber prodution quote)**
- **Molding quotes**

■ 5.00

DETAIL

The developed concept is detailed through a combination of sketching, physical modeling and CAD modeling.
Components, dimensions and materials are defined.

5.01

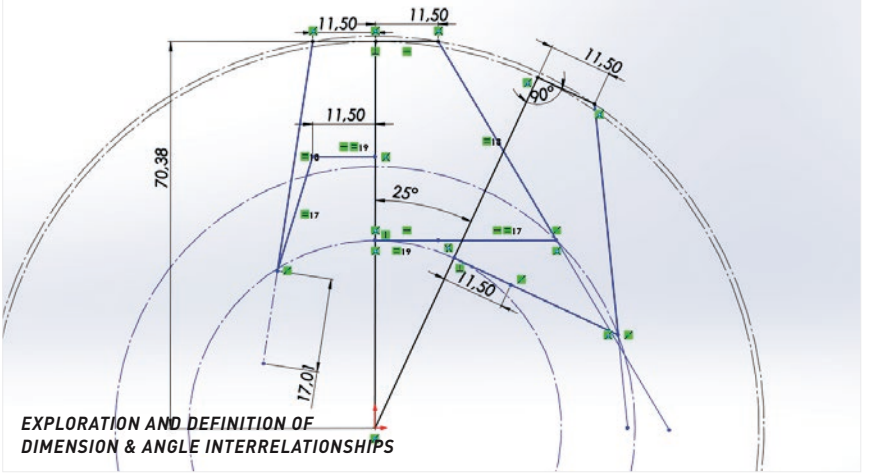
SUPPORT & RESISTANCE

Detailing the spring system

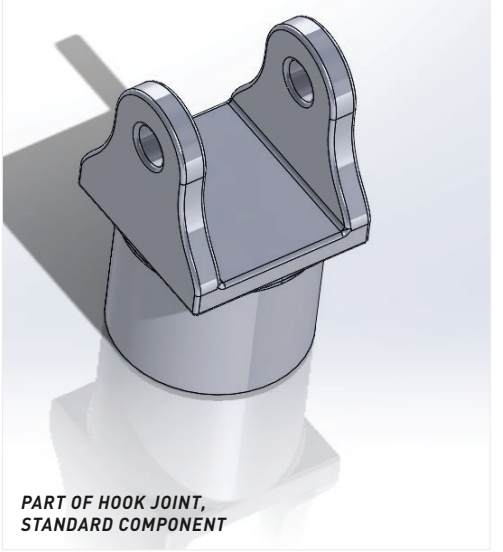
To make the product system ready for initial functional prototyping the mechanical components need to be detailed.
Detailing the support and resistance system concept focuses on defining the needed dimensions for the system making it able to perform as intended, researching to include as many standard components as possible as well as modeling the system in CAD. A 2D sketch using the dimensions of the board and the desired maximum angles aids the modeling and in defining the overall dimensions with which the system would perform as needed (ill. 92.01). These dimensions are used in the following 3D development, where multiple parts are created simultaneously, to ensure they match up and meet the requirements defined in the 2D sketch.

Before the first prototype is produced it is necessary to determine the needed stiffness and dimension of the springs. A rough idea could be calculated based on known forces applied to the system, however, the detailing should be carried out through testing of different springs in order to ensure that the desired experience of the product is created.

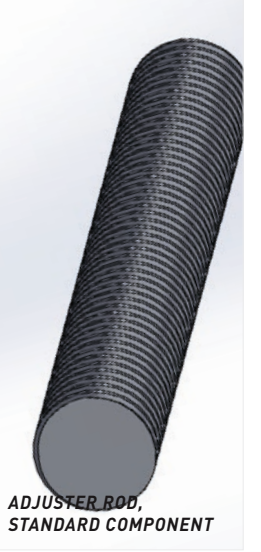
SPRING SUB-SYSTEM



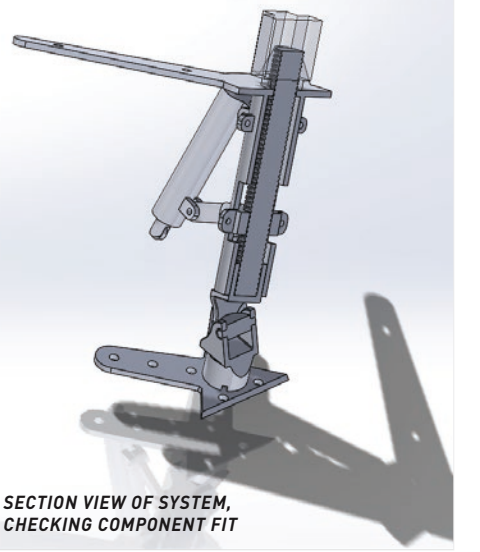
EXPLORATION AND DEFINITION OF DIMENSION & ANGLE INTERRELATIONSHIPS



PART OF HOOK JOINT, STANDARD COMPONENT



ADJUSTER ROD, STANDARD COMPONENT



SECTION VIEW OF SYSTEM, CHECKING COMPONENT FIT

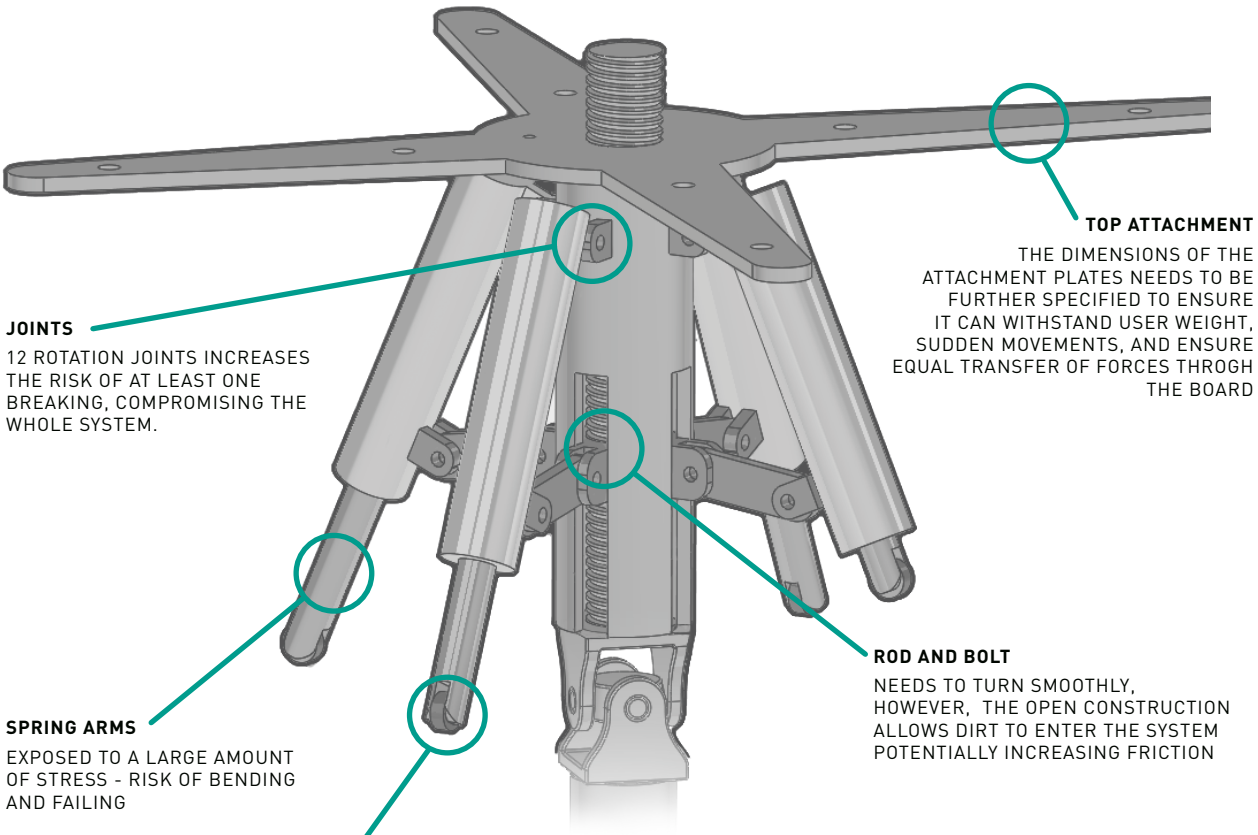
Ill. 92.01: Spring system, CAD development process pictures

5.02

CRITICAL CONSTRUCTION POINTS

Pointing out problem areas

On a principle level, the chosen design of the spring system works and meets the defined requirements for the system (p. 81). However, it has some inherent problems, resulting is weak points within the construction. As strength calculations and other structural or functional analyses are not yet carried out, multiple aspects of the system are potentially in risk for unintended damage due to use. An overview of the designed system highlighting of a range of the critical construction points is created in order to guide the future development of the system. An alternative to refining the current system is to look into the possibilities of creating an even simpler system with less movable parts vulnerable to wear, tear and dirt. This could potentially be done in cooperation with spring suppliers who have expert knowledge in relation to creating spring systems.



Ill. 93.01: Spring system, critical construction points

The designed system principally meets the system requirements. However, the high number of parts, joints and critical points results in a system of relatively high complexity, increasing the risk of failure. As the designed product is intended to be marketed as fairly high end, the high risk cannot be accepted. Therefore, it is preferable to step back and redesign the system as a whole, in order to reduce complexity, while still performing at the same level or better. This could potentially be done in cooperation with possible spring suppliers

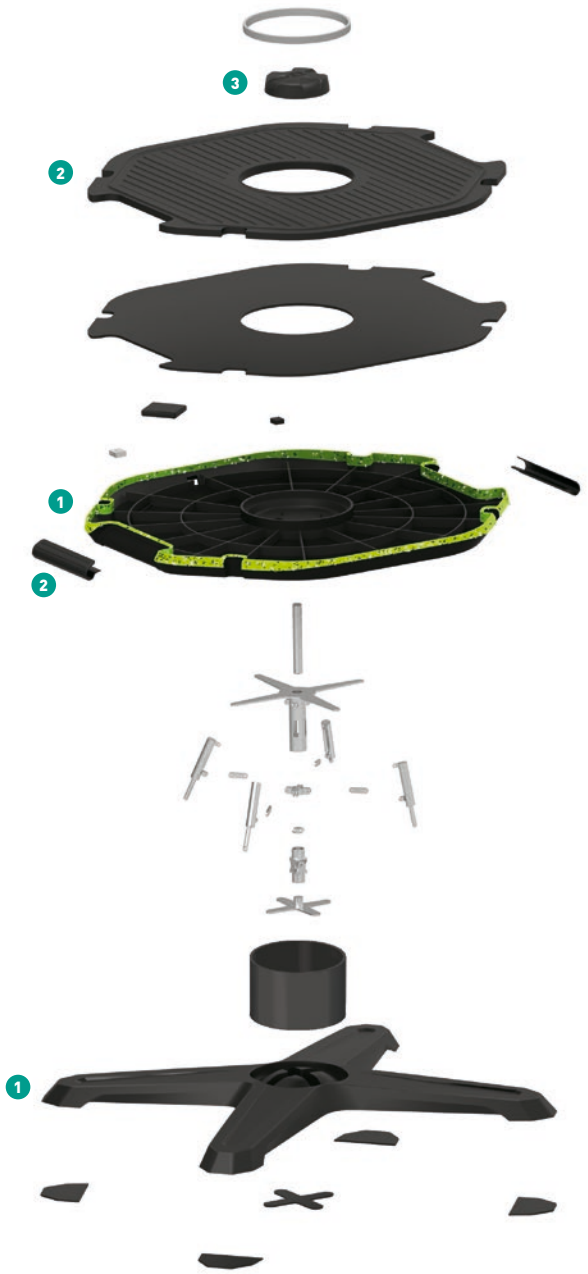
SUPPORT & RESISTANCE SYSTEM

5.03

MATERIALS & PRODUCTION

The Athlon Trainer

This section defines prioritised criteria for the material and production methods of the product's components, along with possible options and the final specification. The selection is based on the general criteria of the product regarding size, function, quality, use and cost, specific criteria for the parts, in accordance with the business strategy, estimating an initial production round of approx. 10.000 units (p. 105).
The standard components and customized components, which do not require setting up a new production, are sourced from suppliers.



Ill. 94.01:. Athlon trainer, exploded view

1 TOP SURFACE AND BASE

Criteria

- High toughness and rigidity
- High surface quality
- Enabling complex parts
- Enabling multi color

Material considerations

ABS, PA, PP, PC/ABS, PUR, HDPE

The material for the top surface and the base is chosen to be polypropylene (PP), which provides a cheap solution that has superior strength and rigidity if receiving glass fibre reinforcements (Lefteri, 2013-1). Polypropylene is used in similar heavy duty sports and fitness products, such as step benches.

The construction of the PP parts will be further reinforced through the wall thickness and rib details that increase bending stiffness.

Manufacturing considerations

Injection molding, rotation molding

It is chosen to manufacture the parts via injection molding, enabling a high surface finish and the possibility to produce the relatively complex parts.
Injection molding has high tooling costs, but a low unit price at high quantities. The parts will be designed to only need a simple split mold without undercuts to lower the tooling investment.

The colored graphics on the parts will be integrated in the molding cycle through the use of film insert molding, which increases cycle time but eliminates the need for finishing processes after molding (Thompson, 2007-1).

2 NON SLIP SURFACE AND GRIP PADS

Criteria

- High toughness
- Friction
- Shock absorbing
- Good surface quality
- Moisture resistance
- Allowing three dimensional pattern
- Easy to clean

Material considerations

Silicone rubber, TPE, PU

It is chosen that the material of the non slip surface and the grip pads will be polyurethane (PU) rubber, which provides the needed toughness and friction (Lefteri, 2013-2).
The size of the PU granules will define the roughness of the surface. After consultation with Uffe Mølgaard from Ergofloor, a manufacturer of rubber mats for the sports industry, it is decided that the non slip surface needs to be 8 mm thick to avoid warping of the part and make it sufficiently shock absorbing when users jump onto the product.

Manufacturing considerations

Compression molding, transfer molding, overmolding with top surface, insert molding with top surface, injection molding

The rubber is compression molded, a method that offers strong parts with high surface quality, geometrical freedom, and has relatively low tooling and unit costs compared to other options (Thompson, 2007-2).
Both the non slip surface and the grip pads are manufactured from the same mold and then cut out. The rubber parts are glued to the board to ensure a tight seal.
A cheaper option would be to buy standard rubber sheets, but that would not allow designing a customized pattern on the parts, which is seen as an important aspect of the product's identity.

3 ADJUSTER DIAL

Criteria

- High toughness
- High surface finish
- Good grip
- Allowing logo deboss/emboss
- Integrated fastening in bottom

Material options

ABS, PA, PP, PC/ABS, PUR

Polypropylene is chosen due to its high toughness and low price point compared to other options.

Manufacturing options

Injection moulding, compression molding, transfer molding

The dial is compression molded, offering high quality and toughness while making it possible to create the needed fastening feature and the logo as part of the mold.

STANDARD COMPONENTS

- Dial fastener
- Threaded rod
- Rod cylinder
- 4x Spring cylinders
- 4x Inner spring cylinders
- 4x Springs
- 4x Wheels
- 2x Fastening parts
- 2x LED strips
- Universal joint
- Gyroscope
- Lithium ion battery
- Bluetooth module
- PCB
- Screws, nuts etc.

CUSTOMISED COMPONENTS

- LED rings. *Polycarbonate sheet*
- Pads under base part. *Rubber sheet*
- Stiffness plate. *Thermoplastic sheet*
- Top fastening plate. *Steel*
- Bottom fastening plate. *Steel*
- Concealer. *Polyester*

The Athlon Trainer's main parts are made of reinforced PP components and PU rubber requireing injection molding and compression molding. Other parts are sourced from suppliers and are either customised or standard components

MATERIALS & PRODUCTION

DETAILING EXPRESSION

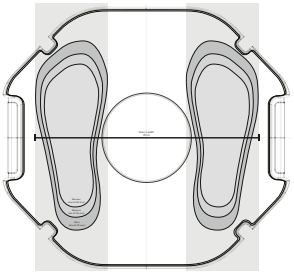
This section describes the further development of the product's expression. In the detailing phase, the main focus is to design the pattern for the non slip surface, the aesthetic of the dial and it's surrounding interface. Lastly, measures are taken to further unify the product's different elements to make a coherent design.

NON SLIP SURFACE

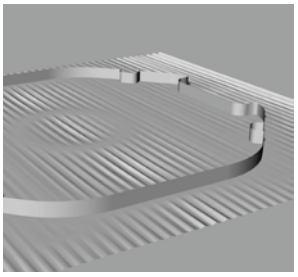
The non slip surface needs to ensure a secure stance for the user when performing exercises. Besides being made of rubber, the surface is molded with debossed and embossed elements that create additional grip.

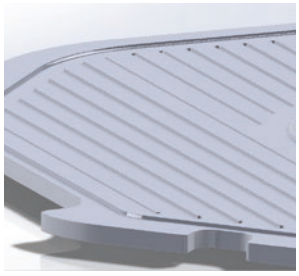
It is found that varying the pattern and its depth in certain areas can aid in communicating how the user should stand while using the product while creating a dynamic expression.

INDICATION OF CORRECT STANCE



PATTERN EXPLORATIONS



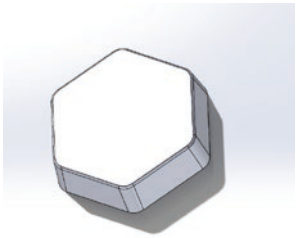


Ill. 96.01: Detailing expression, process pictures

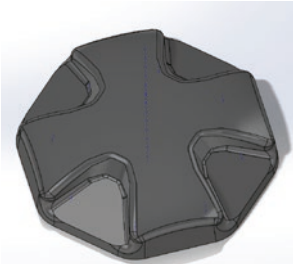
ADJUSTER DIAL AND BOARD INTERFACE

Based on the initial development [AP 5], the adjuster is taken through different iterations to find a shape that has a good grip while simultaneously matching well with the product aesthetics. Different expressions and graphical elements are tested in Keyshot, and it is found that by keeping the dial simple it does not take away focus from the interface communication.
The interface needs to provide information on time aspects of the exercises. The LED rings are put on the inside of the dial indent to not take away standing surface on the board. For extra grip, the adjuster is shaped irregularly and has an in-mold texture on the sides.

SHAPE RESEMBLING BOARD

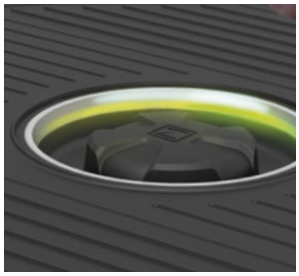


GRIP INDENTS



COLOUR VARIANCE

BOARD INTERFACE



Ill. 96.02: Detailing expression, process pictures

The non slip surface has a simple pattern of debossed and embossed elements, providing grip and indicating correct stance

NON SLIP SURFACE

The shape of the dial is a irregular circle. The board interface surrounds the dial and is split in two areas - one that communicates time left of the ongoing exercise and one that communicates number of exercises left in the program

DIAL AND BOARD INTERFACE

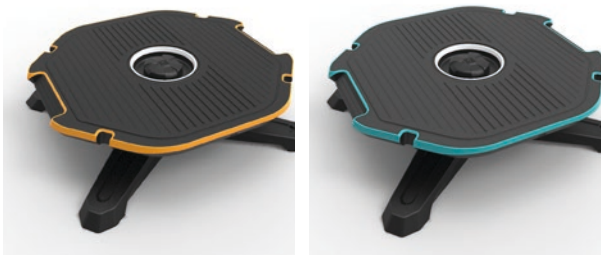
The final aesthetic concept drives inspiration from other sports products and combines a dynamic form with accent colours, colour splash effects, difference in tactility and patterns with emboss and deboss variations

COLOURS, TEXTURES & GRAPHICS

COLOURS, TEXTURES AND GRAPHICS

Lastly, different colours and levels of tactility are explored to find an aesthetic that matches with other sports performance products. Different vivid and expressive accent colours at the edge of the top surface are tested. It is found that applying a colour splash effect, known from other sports products, the expression becomes more refined and professional.

VIVID AND EXPRESSIVE COLOURS



COLOUR ACCENT

SPLASH EFFECT

Ill. 97.01: Detailing expression, process pictures

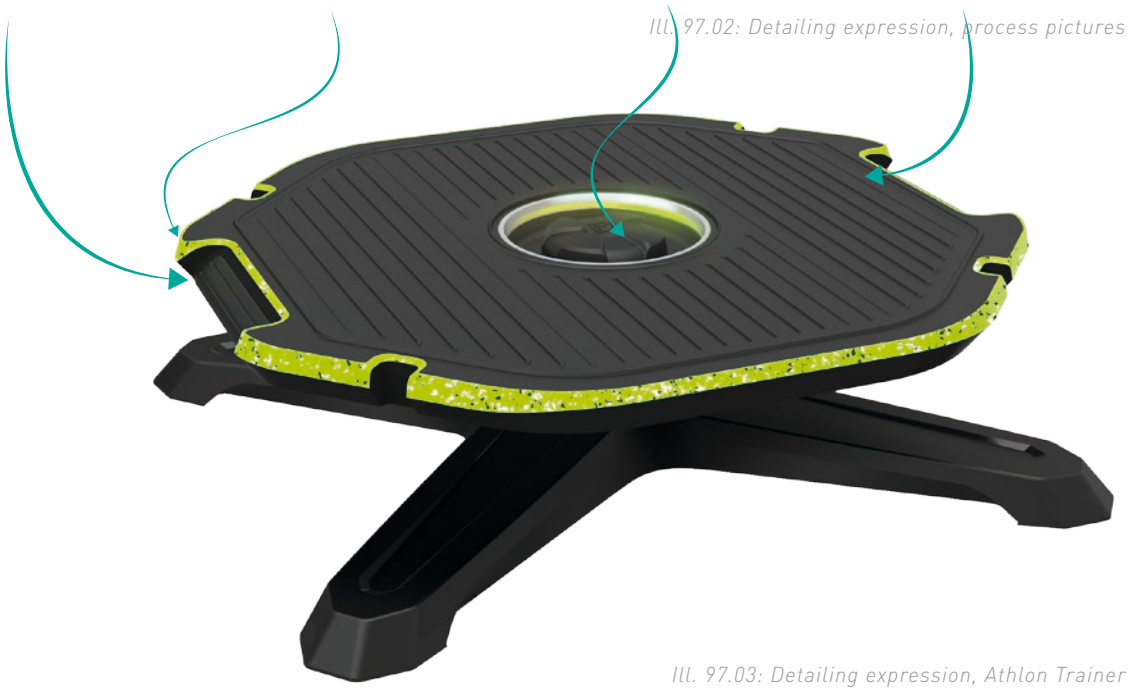
ACCENT COLOUR

SPLASH EFFECT

EMBOSS/DEBOSS VARIATION

SIMPLE PATTERNS

Ill. 97.02: Detailing expression, process pictures



Ill. 97.03: Detailing expression, Athlon Trainer

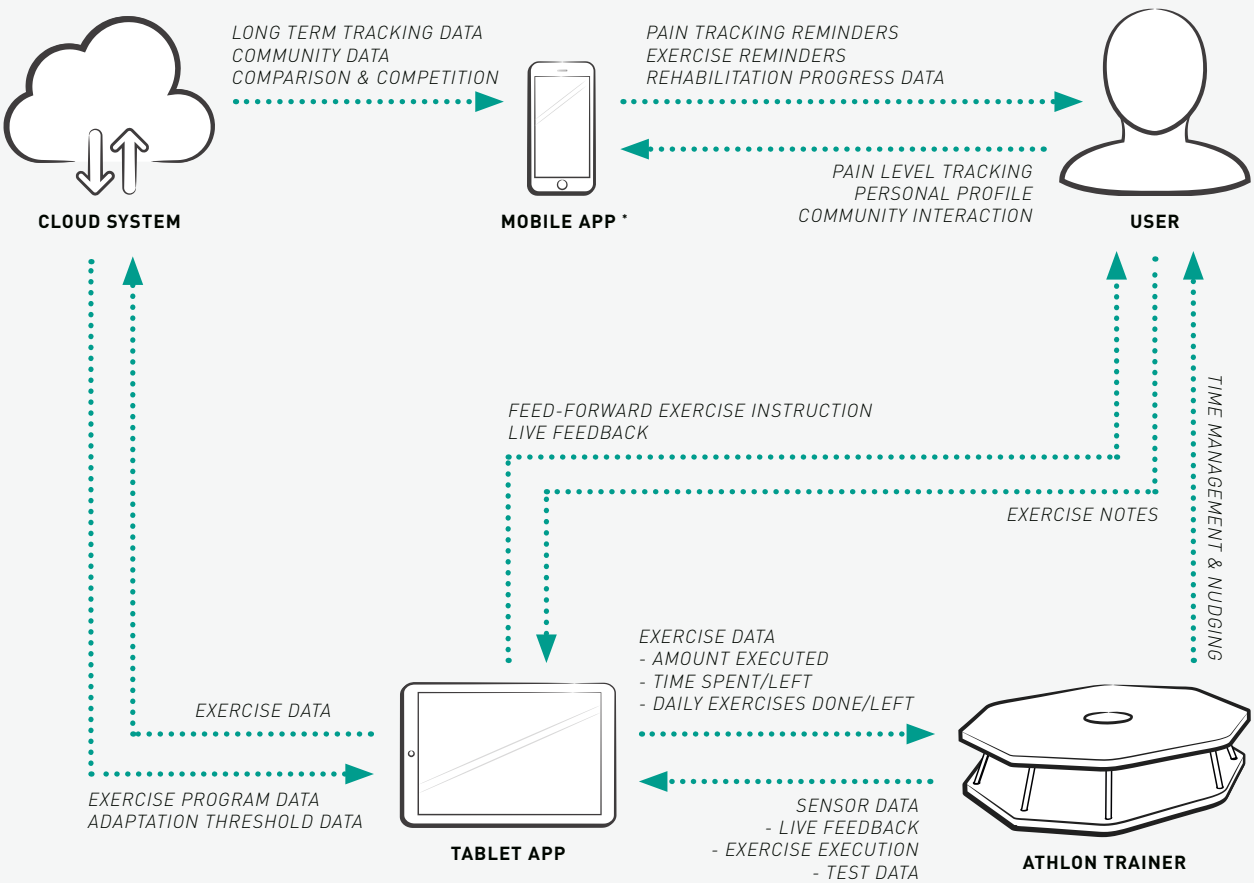
5.05

DATA FLOW

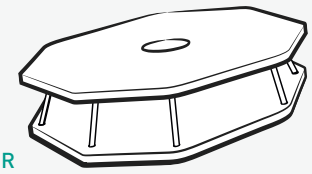
Simplified system map

When in use, a lot of data is created and sent back and forth between the different elements of the system in order to facilitate the progression tracking, exercise communication and more. All the different elements in the product are used to facilitate and communicate different aspects of the data. A general map of the data flow is created in order to establish a overview. In this, the product, user, mobile app, tablet app and cloud system is represented and data flow between them mapped.

DATA FLOW MAPPING



**The communicated data, that in the above illustration is shown as flowing between the user and the mobile app, can also be accessed through the tablet alone.*

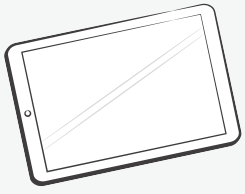


TRAINER

During use, a lot of data is created and sent back and forth between the different elements of the system in order to facilitate the progression tracking, exercise communication and more. The trainer's sensor system provides the data output.

CLOUD SYSTEM

Data is collected from both the performance in relation to the instructional program, as well as the pain tracking. This data is used to adapt the exercise program to optimize the user's experience and outcome of the workout. Collecting data from multiple users creates an opportunity to compare data and further optimise the system. The personal profile with track record, and other performance data is stored in the cloud and available for viewing on the app.

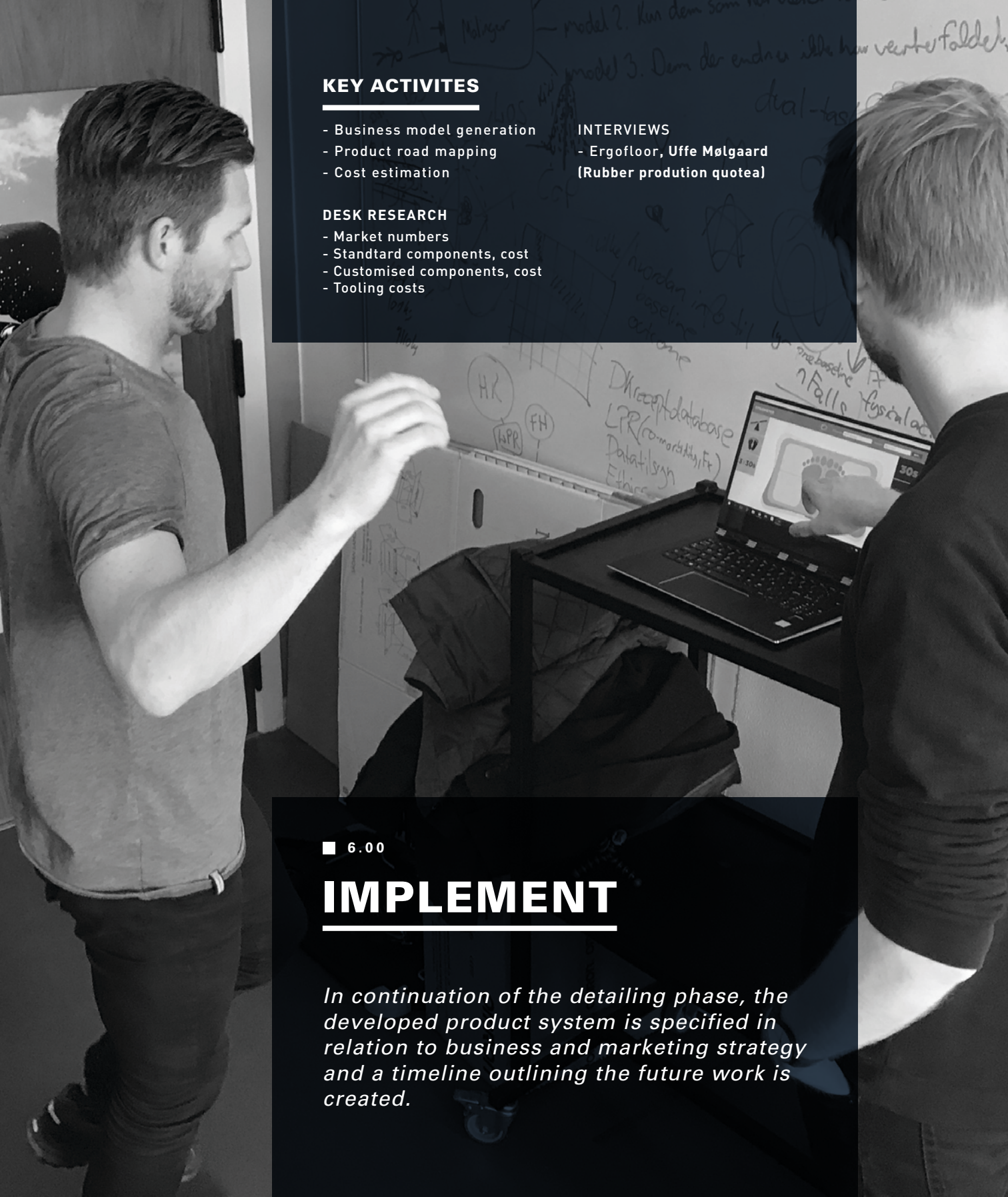


TABLET APP

The workout instructions together with live feedback of the compliance and precision is communicated to the user through the tablet app, in combination with other instructions such as the needed difficulty setting for every exercise. Additional video instruction for each exercise is also available.

MOBILE APP

The mobile app is responsible for notifying the user when it is time to exercise or track pain level, which is done just after and an hour after use. The general personal profile together with the exercise stats, workout overview, progress and long term use data is also available.



KEY ACTIVITES

- Business model generation
- Product road mapping
- Cost estimation

DESK RESEARCH

- Market numbers
- Standtard components, cost
- Customised components, cost
- Tooling costs

INTERVIEWS

- Ergofloor, **Uffe Mølgaard**
(Rubber prodution quotea)

■ 6.00

IMPLEMENT

In continuation of the detailing phase, the developed product system is specified in relation to business and marketing strategy and a timeline outlining the future work is created.

6.01

MARKET POTENTIAL

To assess the potential of the product, the market size is estimated based on current numbers on sports injuries. As there has been a rapid increase in the amount of people doing sports, and followingly an increase in the number of sports injuries (b.dk), it is expected that the target group will increase over time. This is further underlined by the fact that more and more people embrace technology in both their sports and everyday lives, meaning that an increasing amount of people would see the value of utilising technology as part of their rehab.

Additionally, the following numbers only account for sales to individuals, and therefore not the potential sales to physiotherapist, sports clubs and fitness centers.

DENMARK

It is envisioned that the Athlon system will be tested and sold in Denmark before expanding the sales to parts of Europe and potentially the rest of the world.
In Denmark, 2.2 million adults are regularly doing sports (idan.dk-1), of which 28% have had a sports injury within the last year (idan.dk-2).
Based on the numbers stating 20-40% are ankle sprains, it is estimated that around 62.500 Danes will get a sprained ankle of grade 2 or 3 every year, of which approx. 80% will see a healthcare professional [WS 9].

Leaving out the people that do not have the necessary buying power, and also the people that do not see the value of buying Athlon compared to other available rehab products, it is expected that there will be 10.000 potential new customers in Denmark per year of which many would be potential buyers of Athlon. As the market saturates over time and since many ankle sprains are resprains, it is estimated that the market potential in Denmark alone is approximately 50.000 units sold.

WESTERN EUROPE

As the increased time spent on sports is a trend that goes beyond the borders of Denmark, Momentum sees great potential in expanding the product to other countries within a few years. This would initially be Western European countries that are comparable to Denmark in terms of sports habits and individual buying power.
If the ratios are the same as in Denmark, it can be estimated that the market potential of these countries combined is 500.000 units sold per year and 2,5 M units in total, although it is assumed that less than 5% of the broad potential market would buy the product.

Based on these numbers, Momentum expects to sell approximately 60.000 units within the first three years of the company's lifetime, as further clarified on pages 104-105.

DENMARK

62.500 grade 2-3 ankle sprains per year
10.000 potential new customers every year
Accumulated market potential of 50.000 units

MARKET POTENTIAL

WESTERN EUROPE

3.3 M ankle sprains per year
530.000 potential new customers every year
Accumulated market potential of 2.5 M units

MARKET POTENTIAL

Ill. 102.01: Primary and secondary sales regions

6.02

MARKETING STRATEGY

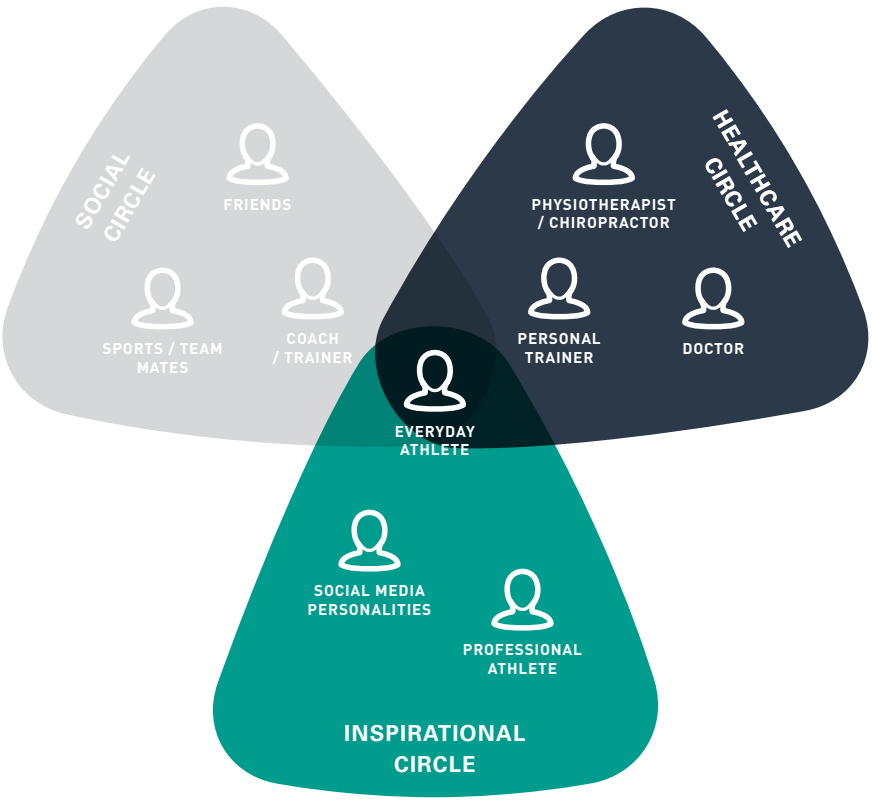
As Momentum is a new brand in the category, it is important to consider the marketing strategy of Athlon in order to create awareness of the product and its value to users. Through user interviews and research into the context of athletes, it is found that the following three areas of influence has a big impact on the athlete's actions and willingness to buy certain products (ill. 103.01).

When an athlete gets injured, *healthcare professionals* are key influencers as their authority and expert knowledge is very important in the athlete's decision-making when going through rehabilitation, as underlined in the survey in which 80% agreed that they rely on the opinion of their physiotherapist, chiropractor or doctor when structuring their rehab programme and buying the products needed [WS 11].

The athlete's *social circle* is highly relevant, as they ask their team mates, friends and sports community for advice and inspiration when buying new products. If someone in the athlete's social circle recommends a product, this is seen as an endorsement of the product, that can potentially make other athlete's buy it.

The inspirational circle consists of the online influencers and idols the athlete is following and is inspired by, e.g. professional sports personalities, bloggers, Instagrammers and YouTuber's. They are idolised, and their approach to the sport and how they treat injuries is often imitated by the athlete. An endorsement from these influencers would have high credibility in the eyes of the user, which is why it is a common strategy to use these influencers in the marketing strategy of sports products.

By marketing the product through all three areas of influence, the reputation of the product can be increased while expanding the outreach.
It is especially important for the success of Athlon that the idea is supported by physical therapists, which is why they have been used as consultants in the development process to ensure that their requirements for a proper rehabilitation are met. These consultations will continue through the further development, increasing the probability that physiotherapists will either retail Athlon at their practice or recommend it for online purchase.



Ill. 103.01: Athlete's influential circles utilised in product marketing

6.03

BUSINESS ECONOMY

The estimated costs concerning the development and launch of Athlon is calculated. The price has to cover the initial investments needed on product development, marketing, tooling and promotional models. The cost is calculated on the basis that the projected sales price is 1599 DKK per Athlon. This sales price is based on the complexity of the product, the amount of money athlete's otherwise spend on sporting equipment, and what value the product adds compared to what the competitors offer.
At a sales point of 1599 DKK, Momentum will earn different profit margins depending on if the product is retailed through physiotherapists (308 DKK per unit) or ordered online (787 DKK per unit).

With the business strategy chosen, the development and establishment of Athlon will, especially on the software side, require a large investment and initially result in a low number of units sold, but when the product is fully established, most expenses will be spent on maintaining the system and acquiring more customers which will result in a big increase in profits, making the company profitable in year 2 (ill. 105.01).

INVESTMENT NEEDED

Before Athlon is fully launched, further development is necessary. The coming year will be spent on optimising the product through tests with users and iterations on both the hardware and software side of the system and then slowly releasing the product to Danish physiotherapy clinics. Internally, it is estimated that Momentum will need three employees for six months to develop the software and two employees working for three months to further develop the hardware and make it fully production ready.

Development costs: 980.000 DKK

As the system relies on constant collection and nalysis of training data from users, it is important that an early version of Athlon is launched within the first year to rapidly improve on the product. The strategy is to give promotional models to physiotherapy clinics with the goal that they will help in creating awareness of the product and its benefit to the athletes they treat and start retailing it at their clinics. There are approx. 1500 of these clinics in the Denmark (Medcom.dk) of which initially 200 will get promotional models with the expenses paid by Momentum.

Promotional models: 82.400 DKK

Additionally, attention will be spent both on creating awareness around Athlon and its launch through marketing efforts.

Marketing: 30.000 DKK

On the production side, there will be tooling costs involved in setting up production for the top surface, base and dial.

Tooling: 380.000 DKK

An investment of 1.470.000 DKK is needed to further develop and launch Athlon

INVESTMENT

PRODUCTION COSTS

All production related activities are outsourced to manufacturers and suppliers, as Momentum does not have the facilities needed. With the materials and production methods chosen, it is estimated that the material cost of the components will be as follows:

Produced components: 82 DKK per unit
Including the top surface, base, non-slip surface, grip pads and dial.

Standard components: 276 DKK per unit
Including the resistance system, sensors, batteries, Bluetooth, LED's etc.

Customized components: 54 DKK per unit
Including fastening plates, stiffness plate etc.

It is estimated that the costs of producing one Athlon Trainer is 412 DKK

PRODUCTION PRICE

ONGOING EXPENSES

The main costs after launching besides production are related to software maintenance, sales and marketing as well as the additional costs that come with assembling and distributing the products.

As the product has many components that need to be manually assembled, especially in the resistance system, it is estimated that a worker can assemble three Athlon Trainers per hour.

Assembly and distribution: 78 DKK per unit

The Athlon software becomes more accurate the more data is collected from users. The collected data needs to be analysed and the software needs to be maintained and upgraded over time.

Software and maintenance: 420.000 DKK a year

When scaling the system and releasing it in new countries, a sales and marketing effort is needed to acquire customers.

Sales and marketing 360.000 DKK a year

Ongoing expenses consist of assembly, distribution, software & maintenance, sales & marketing.
ONGOING EXPENSES

KEY NUMBERS

The sales numbers and contribution margin is calculated for the first three years of the company, which makes it possible to calculate the break even point and return of investment.
In the first year, it is expected that 60% of the products sold will be through physiotherapist clinics. In year 2, this number will be 40% and in year 3, it will be 20% - at that point, 80% of the sales will be online.

BREAKEVEN POINT: 3864 UNITS

RETURN OF INVESTMENT: 20,5%

	YEAR 1	YEAR 2	YEAR 3
UNITS SOLD	1000	20.000	40.000
AVERAGE SALES PRICE	911	1.007	1.103
TURNOVER	911.430	20.147.400	44.132.400
VARIABLE COSTS	1.090.333	10.586.667	20.393.333
CONTRIBUTION MARGIN	-178.903	9.560.733	23.739.067

NUMBERS IN DKK

Ill. 105.01: Key numbers

COMMENTS

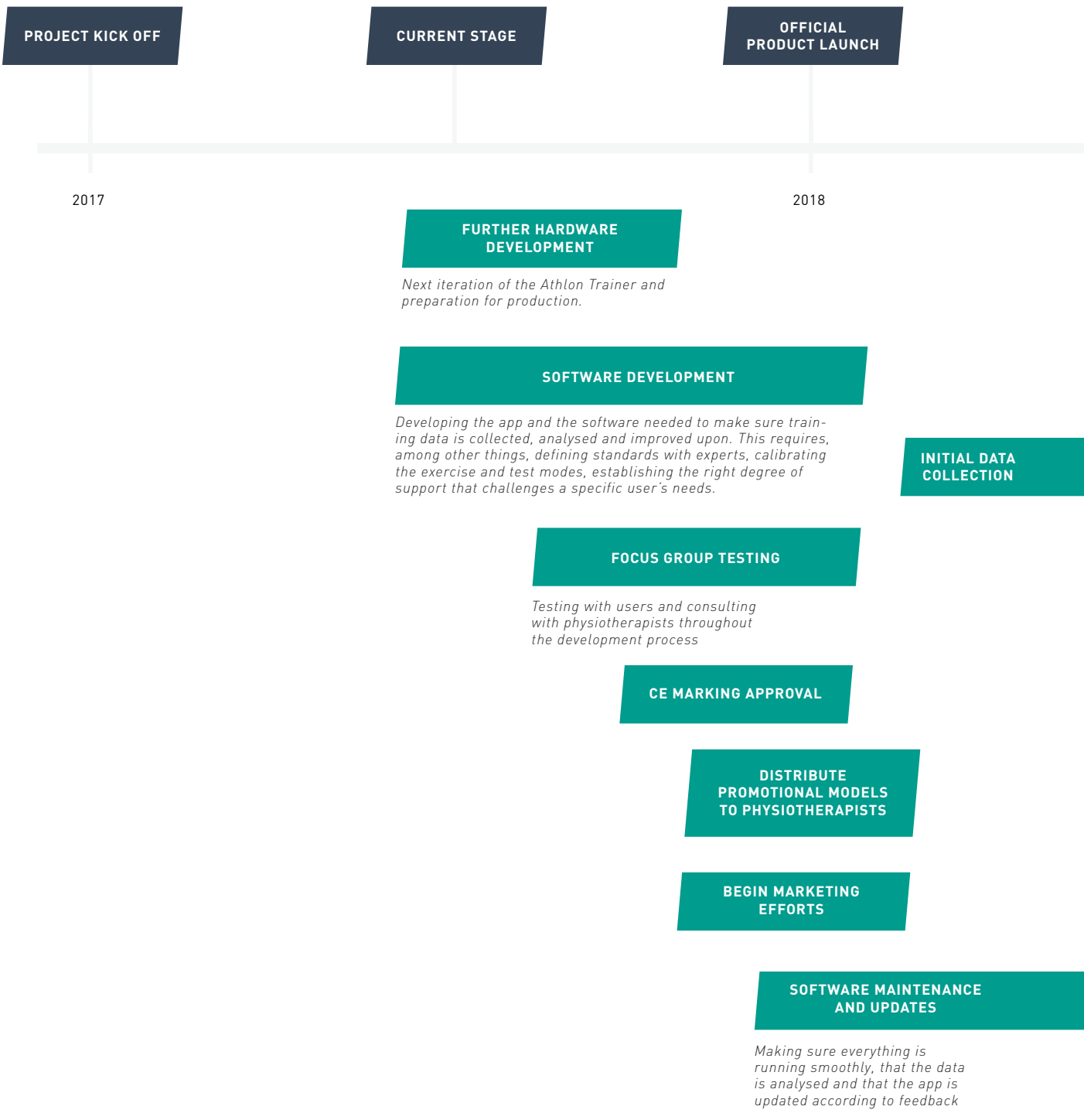
The above estimates are rough and based on the knowledge of the group and what is readily available.
It is likely, that the effort needed to be put into developing and maintaining the complex software and large quantities of data collected through the Athlon system is underestimated. This could result in the need for a larger investment and increased maintenance costs development time, and a postponed launch. Consultation with experts is needed to reach a more realistic estimate on the software. As the company grows and more Athlon's are sold, there will be a need for hiring more developers, marketeers, and people to run the day to day business, which would also increase the ongoing expenses and result in a smaller contribution margin per unit sold.
In the production cost estimate, the standard components account for 67% of the overall cost, mainly due to the high expenses of sourcing the parts for the resistance system. The complexity of the resistance system also causes high assembly costs, and it can be argued that the next iteration should put an effort into simplifying it. In the future, it can be imagined that setting up a production for some or all of the product's components could additionally lower the unit cost.

6.04

BUSINESS STRATEGY

Development & implementation time line

The following time line shows the expected activities and milestones required to launch the product and establish it on the market as well as maintaining the business post launch and preparing the company for new launches and potential exits in the future.



LAUNCH OUTSIDE DK

2019

CLINICAL TESTING

Testing the rehabilitation quality of Athlon to convince both physio-therapists and users and to aid in marketing efforts.

POTENTIAL EXIT

The possibility of a major sports or rehab products brand acquiring the company, e.g. Reebok, SKLZ

NEW MARKETING EFFORT

DEVELOPMENT OF NEW PRODUCT LINE

Branching the business out through a new product category

Rapidly improving the software algorithms through the use of the first Athlon customers

DEVELOPMENT OF ATHLON VARIATIONS

Leveraging the product through new extra sturdy version for fitness centers, sports clubs

VR/AR GLASSES INTEGRATION

Integrating virtual or augmented reality to create a more immersive training experience.

NEW APP GENERATON

Expand the possibilities of the app, e.g. by adding in-app purchases, creating competitions among the Athlon community

MILESTONES

ACTIVITIES

PROJECT CLOSING

CONCLUSION

This master thesis in industrial design engineering is based on the mission of

'enabling everyday athletes to return to their active life and prior physical performance level following an ankle sprain, while decreasing the risk of re-sprains or secondary injuries by making the home rehabilitation fitting for the specific rehabilitation needs of an athlete.'

and the appertaining vision of

'providing the everyday athletes with a sports specific rehabilitation product for ankle sprain rehabilitation, that brings the quality and experience of home exercise programmes closer to that known from supervised treatment of professional athletes.'

When evaluating the proprosed product-service system, Athlon, against the mission and vision it can be concluded that they, on an overall level, have been fulfilled through a sports specific reframing of the typical balance board, adapting ankle sprain rehabilitation to the specific needs of everyday athletes. Through an integrated development process focusing on three overall aspects - function, motivation and expression - the common rehabilitation pitfalls of the target group have been mitigated for, thereby creating the foundation of an increased motivation for going through the phases of rehab through inspiration from triggers known to work in the sports context and from motivational theory. By directing the product identity towards the products that athletes own and desire, utilising the latest trends in technology, and by combining rehab exercises with fitness exercises creating a unique workout experience, it can be argued that some of the target group's preconceptions of balance boards and rehabilitation in general have been circumvented in the product proposal, presumably further increasing the motivation to rehabilitate correctly. Alongside this, it can be concluded that the quality of ankle rehabilitation has been heightened when comparing Athlon's instructive feedforward and feedback as well as overall guidance and customisation to the specific athlete to existing home rehabilitation products, in theory enabling athletes to return to their sport more efficiently while decreasing the risk of re-sprains or secondary injuries.

The quality of this evaluation can be discussed, as it is difficult to verify this based on a product that is not yet fully developed. Especially the product experience and motivational features are hard to asses, and would require further testing with users followed by iterations on both the hardware and software of the system. Likewise, the quality of the rehabilitation would need to be tested through clinical trials and alike.

REINVENTING REHAB VS. BUSINESS POTENTIAL

Initially, the team's goal has been to radically reinvent rehabilitation, but in the end a more incremental path has been followed due to external influence on the business aspects of the product. As the product's potential depends on endorsement from physiotherapists, it has been decided to proceed with a concept that is 'close to home', reusing what is known to work functionally in existing balance boards and focusing the team's innovation focus on the deficiencies in interaction, identity and general preconception. Still, it can be argued that Athlon would not be accepted as a valid alternative to existing products by all physiotherapists, similarly to how 'no dentist would recommend a rethinking of the toothbrush'. From the point of view of the target group, it is possible that they would have been more open to purchasing a solution that further deviates from the typical balance boards, possibly creating a conflict between what the user wants and what the sales channel wants. This conflict would need to be further explored before launching the product.

PRODUCT AND DEVELOPMENT COSTS

With a targeted sales price of 1.599 DKK, it can be argued that some potential buyers of Athlon would not see its worth relative to the cost, and as a result resolve in just buying a balance board for an eighth of the price. The relatively high sales price can be redeemed by the premise that the product-service system adds significant value in both rehabilitation, injury prevention and general fitness, which based on statements, is highly important for the target group, which is why many spend a large amount of money on products that help them reach their goals.

The cost price is a rough estimate based on quotes from experts and what was readily available to the team, and can be affected both positively and negative-

ly, which would again bring the above to question. Even though it can be argued that the production costs of the hardware can be lowered through a simplification of the resistance system, which in the proposed version accounts for almost 70% of the overall production price, the development costs of the system is likely to be underestimated, especially in terms of software development, which could significantly drive up the sales price. The amount of work and manpower needed to develop both the back and front-end of the software as well as setting the system up for ongoing data collection is a rough estimate and is seen as a critical point in the further development of Athlon, highly influencing development time, costs and time to market.
This goes along with a possible over or underestimated projection of the potential number of units sold, in which there might be unforeseen obstacles and expenses, e.g. when scaling the product to other countries.

RESISTANCE SYSTEM

The resistance system is an important part of Athlon, enabling the intended value of guiding the user through the phases of rehab. As presented, the system functions on a principal level, but is at this time practically not an acceptable solution due to the complexity and high number of individual parts that, if damaged, can cause the whole system to fail, as described in the detailing phase. Because Athlon is marketed as a high quality sports performance product, it is a considerable challenge that there might be issues with the quality of the product. Additionally, the system's function relies on an individual adaptation to the user, which with the presented solution of utilising springs creates challenge, e.g. because the spring's function is being affected by the weight of the user. A possible solution is to integrate a weight calibration to adjust the system according to user weight - ensuring the desired personal training experience and coherence of the training data collected.

Before launching the product, a main aspect of the hardware development will be redesigning the resistance system and iteratively testing it while making sure that the intended values and purpose of the resistance is maintained in the development.

INTERFACE

In addition to the resistance system, another main part of the solution is how feedforward and feedback is communicated, as presented through the Athlon App complimented by LED visuals on the Athlon Trainer. One way to lower costs and processing power would be to communicate use information entirely through the app, however the team argues that the Trainer interface adds functional value e.g. when adjusting the dial between exercises as well as interactive and aesthetic value, further differentiating the product from competitors. A reflection regarding the interface is that the digital interaction and the data collected could be linked to the intelligent products the users already own, creating a more holistic training experience. This could be done through integration with e.g. running watches and collaborations with companies such as Garmin.

PRODUCT EXPRESSION

The goal of the aesthetic development of the Athlon Trainer has been to take inspiration from desirable products in the athlete's context. It can be claimed that this is successfully achieved through a dynamic and expressive aesthetic, however this depends on the subjective opinion and preference of users from the diverse target group. Further aesthetical development would focus on further aligning the form, lines and colours of the top surface and the base to achieve a more coherent look. Simultaneously, an effort would be considering both the expression and function of the product when not in use. To some users a more discreet expression or a pack-away option might be more suitable for the home context.

All in all, it can be concluded that if the above challenges are considered in the future development, Athlon has a large potential in enabling athletes to rehabilitate from ankle sprains more efficiently.

REFLECTION

Central process learning points

STAKEHOLDER INVOLVEMENT

A central part of the design thinking approach is involvement of different stakeholders. Throughout the project different stakeholders have been contacted in order to get first hand knowledge on the topic. Especially the field visit and interview with the physical therapist has been beneficial for the project as this opened up for knowledge regarding both the physiological aspects of rehabilitation as well as giving insight into the target audience and their direct and latent needs. Multiple physiotherapist clinics have been contacted in order to get a diverse depiction of the topic. However, it is experienced that time is often an issue for the stakeholders who do not directly see any personal benefits from contributing. Instead, the contacted physiotherapists have been found by ultilising the team's network.
Ideally, more stakeholders and other healthcare professionals would have been involved in the process to aid verification and quantification of different rehabilitation aspect, e.g. which specific elements that are responsible for the quality rehabilitation that a balance board provides. This could have helped quantify parameters that have, at this point, been explored phenomenologically.

In relation to user involvement, it would have been desired to have created a closer contact to central persons found to be within the target group. A lot of the user focused data has been generated based on the survey distributed through Facebook to sports club pages and though the team's athlete network. Both the survey as well as the follow-up email interviews have added valuable insight to the process, however, it is experienced that more in depth personal interviews has been a missing factor within the project both in relation to attaining deeper knowledge about the specific injury experience as well as getting feedback on values, working principles and aesthetics throughout the process.
A lot of user data has been collected rapidly at the university premises where potential users have been found to be readily available for quick explorative interviews and tests of prototypes. This type of user involvement is both good and bad. The loose talks with people about their previous sports injuries and rehabilitation experiences has generated a broad understanding of the situation. However, the same looseness has complicated documentation as most of the interviews have been in-situ without preparations or notes, instead just grabbing every opportunity to gather additional insights. It can additionally be viewed as conflicting that a lot of the potential users found within this context are younger than the generally defined target audience, along with some of them friends or acquaintances.

It could additionally have been beneficial to have taken contact to stakeholders like 'Team Danmark' or different sports clubs in the area, to get first hand insights from the target group and the people working with them. These stakeholders could however be utilised in the process towards getting the product to market.

TAMING A WICKED PROBLEM

As described within the report, the topic has been strategically approached as a wicked problem in order to increase the opportunity to bypass the limitations of the current solution context. Working value-based has in general been beneficial for the project, making it possible to challenge the current solutions on the market, despite ending up with a product that in some ways is close to home. However, the approach has made it possible to break down the qualities and values found in connection with the current rehabilitation products and assemble them again in a new context with the values this context inherently holds - with the aim of rethinking what sports injury rehabilitation of athletes should be.
Through the process, the problem has gradually been tamed through materialisation of different values as sketches and rapid prototypes; facilitating a deeper user group and project focus understanding by exemplifying what could be valuable for the user and why. This has allowed for a more focused process in the development phases, where this is needed in relation to quantifiability of product requirements and the following materialisation.
Although aiding the design process, the wicked problem approach has also created problems within the team. The fact of working with a topic where nothing is inherently right or wrong makes it difficult to define how to progress and often leads to frustrations - especially when the underlying reason for the issues is forgotten, e.g. why concepts are hard to evaluate and compare (p. 60). The approach has also affected the experienced productivity within the team, where the general design process as well as specific tasks have progressed in very different speeds depending on the degree of wickedness.

Retrospectively, many of the experienced issues with the process can be assigned to this approach, something that in future projects can be mitigated by being more explicit about what could be causing the problems and frustrations.

PROTOTYPING, TESTING & MODELING

A central and driving part of the process has been the utilisation of rapid prototypes, making it possible to test different design aspects throughout the process. Especially in relation to the ideation and prototyping phases where the quick mock-ups have been beneficial in order to quickly test different ideas and further iterate on these. In the prototyping phase the models have played a central role in relation to enabling quantification and specification of different product elements as the user's' physical interaction with the product is a central aspect of the design. Having both team members as well as potential users act out different product use scenarios has been driving for the design specification, both aiding verification of design elements, like the feed-forward experience, as well as guiding the further development through test observation insights and user statements.

In the later phases it could have been beneficial to incorporate modeling to the same extent. Due to time pressure, central product elements like the support and resistance system has not been tested and developed through actual spring system modeling as it would have been desired. For further product development it would be beneficial to co-operate with potential suppliers of the springs, as they have expert knowledge in relation to creating spring systems, thereby desirably making it possible to simplify the system.
In relation to product aesthetics, an increased incorporation of 1:1 modeling would have aided the design process - testing different expression through e.g. full scale from models, thereby giving a better indication of the product in real life, compared to how it looks in 3D and renders.

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ILLUSTRATIONS

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WORKSHEETS

Worksheets can be found on the enclosed USB device.

WS 1: Interview physiotherapist 1
WS 2: Interview physiotherapist 2
WS 3: Physiotherapy patients
WS 4: Technology trends
WS 5: Existing market
WS 6: Physiotherapy clinic visit
WS 7: Treatment journey
WS 8: Injury exercises
WS 9: User survey
WS 10: Prototype evaluation
WS 11: Survey follow up questions
WS 12: Dimension variables
WS 13: Dimensions shape and size
WS 14: Angle test
WS 15: Interface placement
WS 16: Interface alternatives
WS 17: Interface experience prototyping
WS 18: Interface review
WS 19: Interface projection
WS 20: Fitness in numbers
WS 21: Balance research
WS 22: Interview gym goers
WS 23: Measurement technology
WS 24: Rehab technology expert visit
WS 25: Angles and heights

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APPENDICES

Appendices a can be found on the enclosed USB device.

AP 1: Project time planning
AP 2: Top surface development
AP 3: Product interface development
AP 4: Support & resistance system development
AP 5: Adjuster dial development
AP 6: Bottom structure development
AP 7: Economy

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RE-IMAGINING PHYSICAL THERAPY
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