Final report Bachelor assignment

“Adjustable handlebars on crosstrainers”

by Jan Willem ten Beitel

by order of Accell Fitness, Almere

Universiteit Twente, Enschede

opleiding Industrieel Ontwerpen

12 juni 2009

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ACCELL FITNESS

Final report Bachelor assignment

Title: “Adjustable handlebars on crosstrainers”

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Preface

This report was written to publish the results of my design project, which I executed by order of Accell Fitness, Almere. With this traineeship, I hope to complete my bachelor phase of the study Industrial Design at the Twente University, Enschede. The assignment comprised the investigation of the possibility of adjustable handlebars on the rear-driven Tunturi crosstrainer line and the following design process.
Via this way, I would like to thank my supervisor at Accell, Mr. Hein Bles. He introduced me to the company and product line, and was always able to help when I needed so.

Summary

with a problem analysis, clarifying the problem areas and setting a project goal.
Next, a series of pre studies started, investigating all the aspects that may be of value for the project and to gain more in-depth knowledge about the matter. For example, competition research, patent research and user tests were part of those pre studies. One of the most important findings during competition research was the implementation of a so called 'multigrip', an extension of the conventional handlebar, offering the user multiple grip options. Only one crosstrainer had been found that had adjustable parts of the handlebar. That particular model is only for sale in the United States and people who had used the device were not enthusiastic about it. From the pre studies, a list of requirements was extracted.
Subsequently, concepts were generated. The first concept consists of a multigrip unit which can be adjusted in height. The second concept is a set of handles, which were mounted on the conventional handlebars. Those handles can be set in every whished position, so that every user can adjust them to their own liking. The third concept enabled the top part of the conventional handlebars to be adjusted into three different positions.
After a thorough evaluation, concept 1 - the multigrip - was chosen without the height adjustment. After refining the design, a prototype was constructed. With that prototype, some user tests were executed. From that could be concluded that most people could find themselves a comfortable position for exercise. A small adjustment was needed to better suit small people. With that, the project was finished and ready to be further developed to integrate it into the product line.

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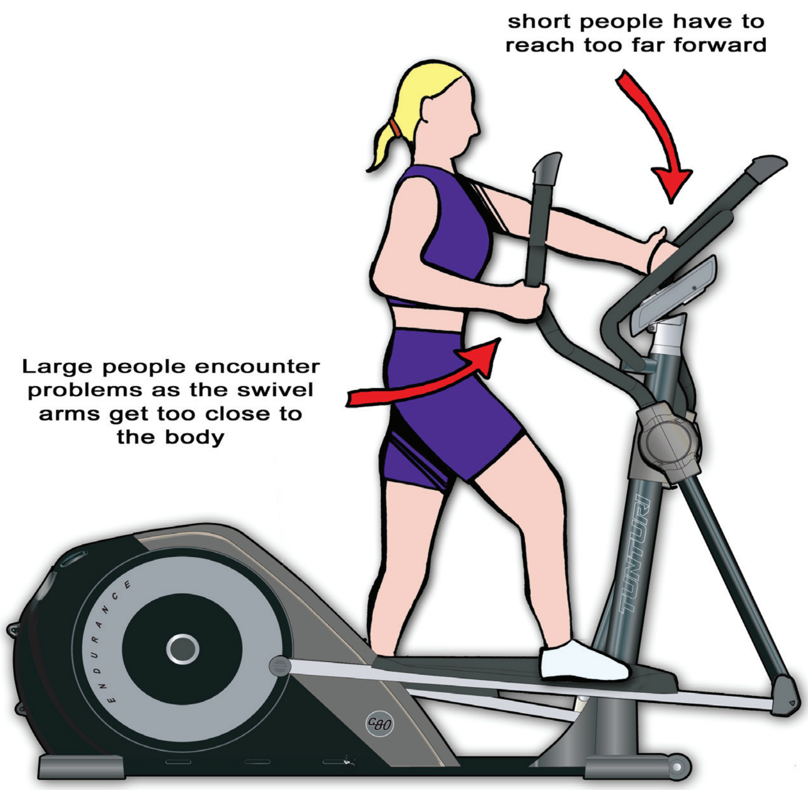

figure 1.1
Example of a problem with current handlebars

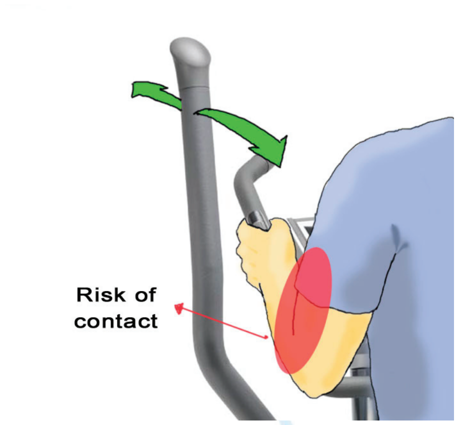

Figure 1.2
Risk of contact when holding the fixed handlebars

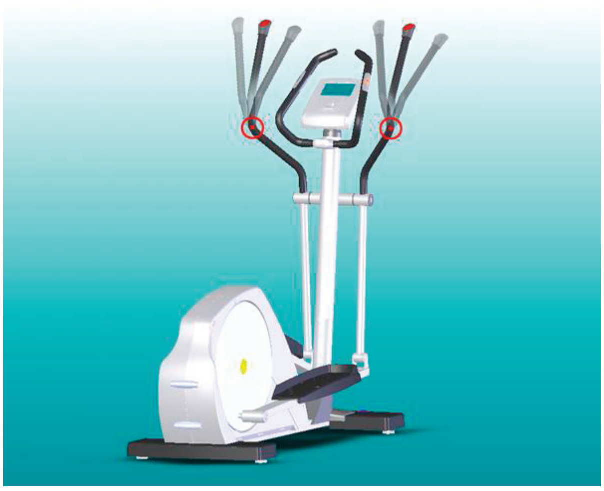

figure 1.3
Possible starting point given by Accell

1. Introduction

This project was completed as my final assignment to complete my Bachelor phase of the study Industrial Design at the University of Twente. I followed this project at Accell Fitness in Almere, a company that designs and develops fitness devices for the home fitness market. Accell is in charge of two brands: Bremshey and Tunturi.
I was asked to examine the possibilities of implementing adjustable handlebars in their Tunturi rear-driven crosstrainers.

1.1 Assignment description/Problem analysis

Accell Fitness is constantly looking for possible improvements for their products. For their current line of the Tunturi crosstrainers, the idea came up to integrate adjustable handlebars to offer the user a more comfortable exercise allowing him/her to set the handlebars at different arm positions. There are also a few problem areas that can possibly be solved by adjustable handlebars. Some of these problems became apparent by customer feedback. In the past, the handlebars were swinging too far for short people. When this was solved by extending the handlebars towards the user, tall people found the handlebars coming too close to the body. Designers at Accell told that it had always been a struggle to design a handlebar that suits tall as well as short people. See figure 1.1.

Another problem became apparent when users held on to the center console; then, the handlebars swung dangerously close alongside the users' arms (figure 1.2). In that case, adjustable handlebars could be set wide to reduce the risk of contact (figure 1.3). The solution shown in the picture was given by Accell and was a possible starting point for the project.

In the remaining of this project, some further research is done to investigate these problems and probably other problems will become apparent.
Also, at this stage some possible problem areas of the design can already be pointed out. This mainly comprises the sturdiness of the hinge or connection point, which should be able to withstand some high torques without any play. Furthermore, the position of the hinge or connection point can form a problem, because of the difficulty to suit tall as well as short people.
Notice that the crosstrainers developed by Accell Fitness are home fitness devices that are sold as a kit and are to be assembled by the user. This should be taken into account during the design process.
Also, some questions were set up to help as a guide line during the rest of the project:

- **What is the problem with current crosstrainers?**
  - How does the position of the handlebars differ from the most ideal position?
  - How is the user's training suffering from the non-ideal position of the handlebars?

- **How can adjustable handlebars improve crosstrainers?**
  - What are possible solutions for integrating adjustable handlebars?
  - Which positions are best for a particular crosstrainer exercise?

- How can contact with the user, while holding the fixed handlebars, be prevented by adjustable handlebars?

1.2 Goal

The goal of this project is to come up with a concept design of adjustable handlebars for the Tunturi rear-driven crosstrainer line, by which it discerns from competitors and is a possible selling point. Besides that, the adjustable handlebars allow a better synchronization of the exercise with user demands. The project is finished with a working prototype.

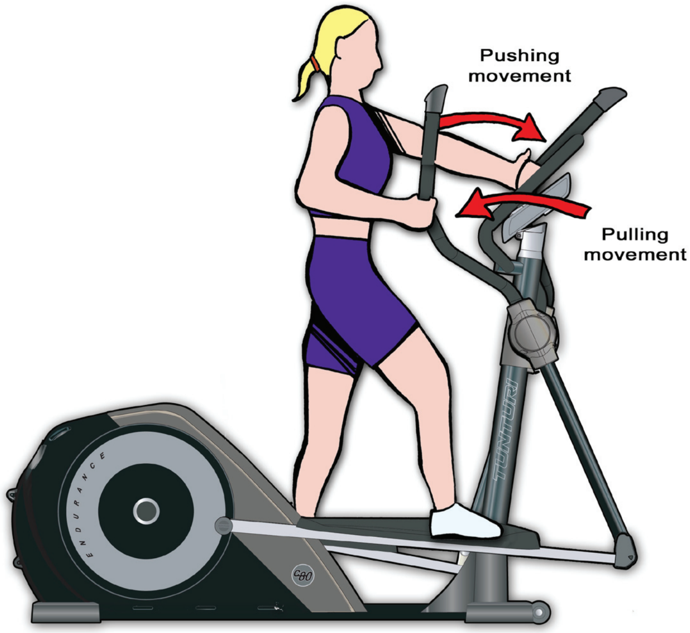

Figure 2.1
Pushing and pulling movement

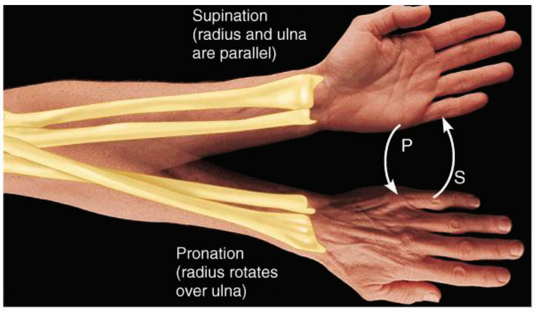

Figure 2.2
Pronation and supination

2. Pre studies

2.1 Ergonomics

Besides the fact that adjustable handlebars allow the user more freedom in setting up the position he/she prefers, it should be an even better addition if it can also be used to train different muscle groups than conventionally. In order to study this, I applied an analysis of movement of the arm region during a typical crosstrainer exercise. My completion of the course 'anatomy and physiology of movement' comes in very useful here. Notice that it is not necessary to use the arms actively during exercise; it is also possible to hold on to the handlebars loosely, relaxing the arm muscles, and even to let go the handlebars completely, using only the legs.
The movement of the arm is accomplished by the muscles around three joints: the wrist, elbow, and shoulder. Ignoring the wrist because of its minor influence on the total force applied, the elbow and shoulder are the joints to focus on. During a typical crosstrainer exercise, the arm movement consists of two steps: a pushing movement and a pulling movement (figure 2.1).

During the pushing movement, extension takes place in the elbow, completely performed by the muscle at the back of the upper arm, the triceps. The forward movement in the shoulder is called ante flexion, mainly caused by the big shoulder muscle, the deltoid muscle, assisted by the biceps and the breast muscle, the pectoralis.
The muscles at the back of the shoulder initiate the pulling motion, by pulling the upper arm back. Flexion in the elbow is mainly caused by the big upper arm muscle, the biceps. Also, the muscles of the fore-arm play a big part in this movement.
So far, the basic movement is discussed.
Next, the consequences of different hand positions have to be examined to determine whether it is useful to apply such a feature on the crosstrainer. In order to do this properly, the difference between pronation and supination has to be explained. Shortly, pronation is when the palm of the hand faces down; supination is when the palm of the hand faces up (figure 2.2).
During pushing, pronation nor supination affects the efforts of the muscles because the fore-arm muscles are not used there. During pulling, however, they are, assisting the biceps in flexing the elbow. These fore-arm muscles are at their strongest in pronation stance, because they are shortened. In contrast, the biceps is at its strongest in supination stance. However, this does not mean that the biceps is best trained when the fore-arm is in supination stance, nor that the fore-arm muscles are best trained in pronation stance. Namely, during endurance training, muscles are best trained at a relatively low intensity, but at a high activity rate. That means that the current handlebar position, which is midway between pronation and supination, is sufficient for endurance training. However, when the user likes to put some power in every now and then, the supination/pronation stances would come in handy. And like stated before, adjustable handlebars allow the user a comfortable exercise to his liking.
Adjustable handlebars can also affect the width of the handlebars in relation to each other. The wider the handlebars, the higher the moment to overcome. This comes down on an increasing effort for the shoulder muscles in particular. Presumably, however, the training becomes more uncomfortable when the width increases too much.

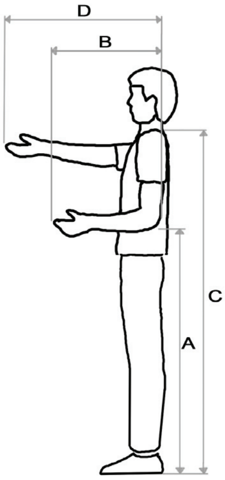

Figure 2.3
Anthropometry

Figure 2.4
Rear driven crosstrainer

Figure 2.5
Front driven crosstrainer

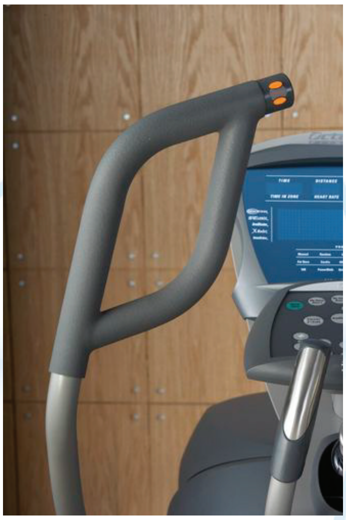

Figure 2.6
Octane Q47

Figure 2.7
Multigrip of the Vision S7200 HRT

Figure 2.8
Vision S7200 HRT

After this analysis, it is also useful to have a look at anthropometry, which determines the margins to work with. Again, only the arm region was studied, looking at values that are important for the dimensions of the crosstrainer, like elbow height, shoulder height, and reaching depths. Besides the average dimension for men and women, also P5 and P95 measurements are included (figure 2.3 and table 2.1).

length	**Average (male & female) in mm**	**P5 in mm**	**P95 in mm**
A	1093	991	1195
B	352	301	403
C	1431	1286	1576
D	726	650	802

Table 2.1

2.2 Competition research

Competition research is done to get a clear view of where Tunturi stands in the home fitness market and to investigate whether the competition has already been working in the field of adjustable handlebars.
The Accell Group is in charge of two brands, Bremshey and Tunturi. Both brands have a variety of fitness devices like home trainers, treadmills, spinners and crosstrainers. Bremshey acts mainly in the low and mid segment, being the cheaper, less quality of the two. In contrast, Tunturi is in the top segment, offering top quality for a higher price than Bremshey. All new developments and innovations are applied on the Tunturi models to keep up with the competition; later on, some of these developments are gradually integrated in the Bremshey models. In the field of crosstrainers in particular, there are front driven and rear driven cross trainers. Front driven crosstrainers have the drive wheel en flywheel in front of the user, while a rear driven has them at the back (figures 2.4 and 2.5). This project will focus on the rear driven crosstrainer, the C80 model in particular, because of it having the most difficulties in getting the handlebars right.

Next, some competition research was done, mainly looking at the handlebars. Crosstrainers of different brands vary a lot on handlebar design; some have large bends and curvature in it, while others are straighter up. Some have a small center console to hold on to, some a bigger one, and some have none. There are also some models, which had solved the problem of different hand positions with a so-called multigrip, a top piece of the handlebar that has multiple grip positions. Examples are the Octane Q47 (figure 2.6) and the Vision S7200 HRT (figures 2.7 and 2.8).

Sales people told that users found the multigrip, which seems to adapt to small users too, very useful and an addition to their exercise. However, the risk of contact exists while not holding on to the grips, but to the fixed handlebars. Furthermore, Octane has slightly converted the standard back and forth movement of the handlebars into a converging movement, similar to a boxing movement, which was often appreciated by users (figure 2.9). From my own experience, this can only be confirmed.

Figure 2.9
Converging movement of the Octane Q47

Figure 2.10
Horizon SXE7.7 with adjustable handlebars

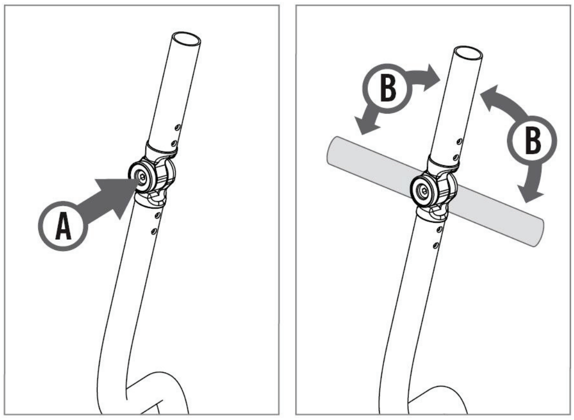

Figure 2.11
Pictures from the user manual of the Horizon SXE7.7

Figure 2.12
Extra handle mounted on the actual handlebars

Figure 2.13
Movable upper part of the handlebars

It was remarkable to find that, except for one model, none of the competition had already applied adjustable handlebars on their crosstrainers. That one exception is a Horizon crosstrainer, model SXE 7.7, which has an adjustable upper part of the handlebar that can be adjusted to five different angles (figures 2.10 and 2.11). It is pre-assembled; thus, no extra assembly steps for the user. Because this crosstrainer is not for sale in Europe, it could not be tested. Therefore, Accells Salesman in America shared his experiences with the device with us. He is not enthusiastic about it, because the grips are positioned at the top of the handlebars, a position few people hold on to normally.
Moreover, small people get pulled too far forward when they position their hands on the adjustable part of the handlebars. In addition, when really some torque is put on the unit, the positioning of the handlebars seems to move a bit.

A bit of text from the user manual:
Your Horizon SXE7.7 elliptical trainer with TARGETtoner™ Handgrips allows you to adjust your handlebar angle to five different positions. This breakthrough innovation delivers two key benefits: First, for beginners, it allows you to find the handgrip angle that's most comfortable to you, and will help you get started on your exercise program. Second, as you advance, you can adjust the handgrip position to tone different areas of your arms and shoulders.
To adjust the handgrip positions, simply push in the adjustment button and turn the handle to the desired position.

An extra remark is that some of the salesmen and –women told that they saw no added value in adjustable handlebars, but instead predicted drawbacks like it being another weak spot and a possible extra assembly step for the user. In the remaining of the project, this should be taken very seriously.

2.3 Patent research

Patent research had been done to find out if there are some patents in the area of adjustable handlebars for crosstrainers. Accell had applied for a patent at some extra handles mounted on the handlebars and also for the hinge point shown in the problem analysis. These handles can be rotated to achieve the best possible position for the user. This Patent can be found in appendix B. There are not really any more patents for adjustable handlebars on crosstrainers. There were a lot more on crosstrainers but not particularly on adjustable handlebars.

2.4 Current mechanisms

In the past, Accell has already been experimenting with adjustable handlebars on crosstrainers. In general there were two different systems: one to adjust the handlebars left to right and one that is an extra device mounted on the handle bars to hold on to (figures 2.12 and 2.13). The latter is a handle that is adjustable in height by sliding along the top piece of the handlebar and can rotate around two axes. This is the system that has been patented (appendix B)

2.5 User tests

In order to determine the ideal position for the hands and arms while exercising on a crosstrainer, two user tests were executed. The exact description of the tests can be found in appendix A. The results are as follows:

- The risk of contact when holding on to the fixed handlebars has to be avoided. According to this test, this can be achieved by only adjusting the handlebars to a wider position.
- Remarkable is the fact that only a few participants used the possibility to adjust the beams inwards or outwards, not even when the possibility to do so was brought moreover to the participants' attention. Most participants seamed to be pleased with the current width of the handlebars.
- According to the test, the preferred height of the handle should vary from somewhere under 115cm. (which was still too high) to 130 cm. Average preferred handle height during this test was 124,75 cm. However, the average height of the participants was higher than average.
- The average handlebar height of 124,75 cm found here is about 8cm higher than the average handlebar height of 116,88 found in user test 1. This can be explained by the fact that during test 1 the participants had nothing to hold on to and naturally adopt a running like position, where the arms are held lower and closer to the body. Apparently, according to user test 2, people like to hold the arms higher up when they have something to hold on to. (Test 1 and 2 can in this manner be compared, while the majority of the participants participated in both test 1 and 2.)
- In the latter design process, vertical rotation of the handle does not have to be taken into account. The option of vertical rotation was very rarely used in this test; most people liked the handle in the neutral, vertical position.
- Like user test 1, most participants preferred the wrist vertical and/or 45˚ pronation. Even so, the options for 45˚ supination and full supination should held open for the further design process, because it was regularly chosen as an alternative.
- The opinions about the free rotating possibility for the wrist were divided; some liked it, some not. Thereby, it is not possible to draw a clear conclusion. However, because it is not disliked by all, it is something to be taken into account.

2.6 Conclusions of pre studies

In this paragraph, all the conclusions of the pre studies are put together, from which a design vision and guidelines can be formed.

One of the first pre studies executed was the analysis of a typical crosstrainer movement. Since the project is aimed at an adjustment of the handlebars, only the arm region was examined. First, the arm muscles that are playing part in a crosstrainer movement were pointed out. After that, the main goal was to examine the difference in muscle usage when the wrist/lower arm is held in different positions. It proved that when the lower arm is held in either supination or pronation, particular muscle groups can apply more force than when the lower arm is held in a conventional position. However, during an endurance training, such as on a crosstrainer, muscles are best trained at a relatively low intensity, but at a high activity rate. That means that the

current handlebar position, which is midway between pronation and supination, is sufficient for endurance training. However, when the user likes to put some power in every now and then, the supination/pronation stances would come in handy.

Competition research was done to get a clear view of where Tunturi stands in the home fitness market, where the competition stands and whether they are already integrating adjustable handlebars in their crosstrainers.
Only one brand, Horizon, has a crosstrainer on the market with adjustable handlebars. Major problems with these adjustable handlebars are the height and strength of it. The adjustable parts are place at the top of the handlebar, making it impossible to use for small people. And when really some torque is put on the unit, the handlebars seem to move a bit.
Furthermore, some brands have introduced a so called multigrip, a top piece of the handlebar that has multiple grip positions. In general, users are very positive about this addition; People of different lengths can use it problem free and it brings variation in the training. Major drawback is the risk of contact when the user holds on to the fixed handlebars.
In addition, one brand has slightly converted the standard back and forth motion of the handlebars into a converging movement, similar to a boxing movement. This adaptation was well received in the market.

Two user tests were executed to obtain information about ideal handlebar position, height and function. The first test was done with the arms freely movable to see what the natural movement of the arms is, when not holding on to the handle bars. In the second test, participants used an earlier made prototype with handles that can be adjusted to almost every position. It was useful to see which adjusting possibilities people use and do not use.
Again, it proved that, the risk of contact when holding on to the fixed handlebars has to be avoided. Remarkable is the fact that only a few participants used the possibility to adjust the beams inwards or outwards, not even when the possibility to do so was brought moreover to the participants' attention. Most participants seamed to be pleased with the current width of the handlebars. Most participants preferred the wrist vertical and/or 45˚ pronation. Even so, the options for 45˚ supination and full supination should be held open for the further design process, because it was regularly chosen as an alternative. The opinions about the free rotating possibility for the wrist were divided; some liked it, some not. Thereby, it is not possible to draw a clear conclusion. However, because it is not disliked by all, it is something take into account.
According to the test, the preferred height of the handle should vary from somewhere under 115cm. (which was still too high) to 130 cm. Average preferred handle height during this test was 124,75 cm. However, the average height of the participants was higher than average.
The average handlebar height of 124,75 cm found in test 2 is about 8cm higher than the average handlebar height of 116,88 found in user test 1. This can be explained by the fact that during test 1 the participants had nothing to hold on to and naturally adopt a running like position, where the arms are held lower and closer to the body. Apparently, according to user test 2, people like to hold the arms higher up when they have something to hold on to. (Test 1 and 2 can in this manner be compared, while the majority of the participants participated in both test 1 and 2.)
In the latter design process, vertical rotation of the handle does not have to be taken into account. The option of vertical rotation was very rarely used in this test; most

people liked the handle in the neutral, vertical position.

After the pre studies, some questions stated in the problem analysis can be answered:

- **What is the problem with current crosstrainers?**
  - How does the position of the handlebars differ from the ideal position?
    - What can be said is that there is no ideal position. Users are individually too different to come up with one handlebar that suits all.
    - People sometimes like to adopt a different angle of the wrist in comparison with the position on current crosstrainers.
  - How is the user's training suffering from the non-ideal position of the handlebars?
    - In the past, the handlebars were swinging too far for short people. When this was solved by extending the handlebars towards the user, long people found the handlebars coming too close to the body.
    - The current position of the hand does not allow the user to apply maximum force. Maximum force can be obtained by a pronation or supination stance. However, this is not probably not often required, since training on a crosstrainer is in general an endurance training.
    - The tests showed that some people liked a free wrist rotation during the back and forth movement.

- **How can adjustable handlebars improve crosstrainers?**
  - What are possible solutions for integrating adjustable handlebars?
    - This will be looked at during concept stage
  - Which positions are best for a particular crosstrainer exercise?
    - Height of the handlebar (the part the user grabs): between 105 and 140 cm.
    - Should allow at least four wrist angles: 45˚ pronation, vertical, 45˚ supination and full supination.
    - Width of the handlebars of around 60 cm. There were no indications that the handlebars should be adjustable in width.
    - Free rotation of the wrist can be an option.
  - How can contact with the user, while holding the fixed handlebars, be prevented by adjustable handlebars?
    - The option tested in user test 2, in which the handlebars could be set wide, worked fine.
    - The best solution is to remove the upper part of the handlebars.

2.7 Design vision

Here, the main points for generating concepts will be listed and a vision of the final product will be described.

Important design points:

- The new product has to fit small as well as tall people; not only in height, but it must be reachable for small people and may not come too close too the

Requirements	Remarks
P5 – P95 people must be able to use the handlebars problem free	
Adjusting the handlebars must be able without the help of tools.	
Adjusting must be performed by max. 1 person.	
The hinge point must be sturdy enough to withstand….	
The hinge point may not need an extra assembly step by the user	Pre assembly
Adjusting the part must be done easily with no extra effort	Current Accell prototype takes too much effort
Height of the handlebar (the part the user grabs) must be between 105 and 140 cm.	Probably height adjustment
The handlebar should allow at least four wrist angles: 45˚ pronation, vertical, 45˚ supination and full supination.	
Width of the handlebars must be around 60 cm.	
There must not be any play in the part	
Production of the product must be done with standard parts en techniques.	no machined parts
The new part must be produced as cheap as possible	
The part the user holds on to must always be covered with foam rubber	
When moving, the new part may not come closer than 25 mm. to stationary parts of the crosstrainer	
The new part will be introduced on Accell's top model crosstrainer and should therefore be of high quality and should match the look of the machine	
The new part may not produce any sound or noise	
The crosstrainer, including the new part, must fit in the current shipping boxes for transport	
Aspirations	
Adding a converging, boxing like movement	
Adjusting the part must be performed with max. one hand.	
The possibility of free rotation of the wrist	
The new part must be produced with no extra production costs.	

Table 2.2
List of requirements and aspirations

body of tall people.
- Some supination and pronation possibilities in the wrist are wished to give the user the ability to apply more force when he or she wants so. For others, it can contribute to a more comfortable training.
- Possible free rotation of the wrist
- A converging, boxing movement could improve crosstrainer exercise.
- The risk of contact when the user holds on to the fixed handlebars should be avoided.

Dimensions:

- Height of the handlebar (the part the user grabs): between 105 and 140 cm.
- The handlebar should allow at least four wrist angles: 45˚ pronation, vertical, 45˚ supination and full supination.
- Width of the handlebars: around 60 cm.

Possibilities for the design

- The new design can be an adjustable part that is fixed to the existing handlebars. Adjusting the part should be performed with no more than one hand
- A multigrip can partly solve de problem of the pronation/supination grip options. A height adjusting can be added to it to fit small as well as tall people.
- It can also be an extra unit that is mounted on/over the handlebars and has multiple adjusting possibilities for the users in order to get the preferred grip. The user can be given the possibility to remove the part and just hold on to the conventional handlebars, if its shape is not adjusted.
- In order too keep the costs low, a low tech option can also be thought of. Risk of that is that it not satisfies the user's wishes.

2.8 List of requirements

See table 2.2 on the left page for the list of requirements and aspirations.

Figures 3.1 and 3.2
Concept 1. A multigrip adjustable in height

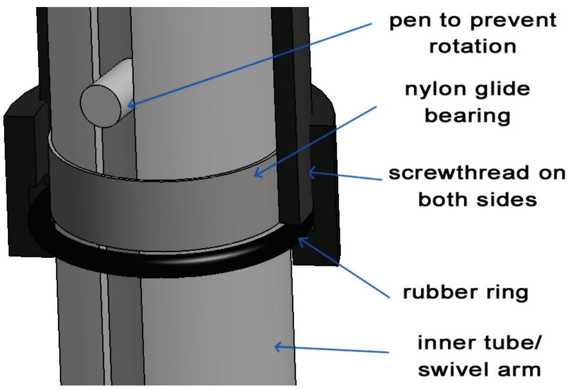

Figure 3.3
Working principle of concept 1

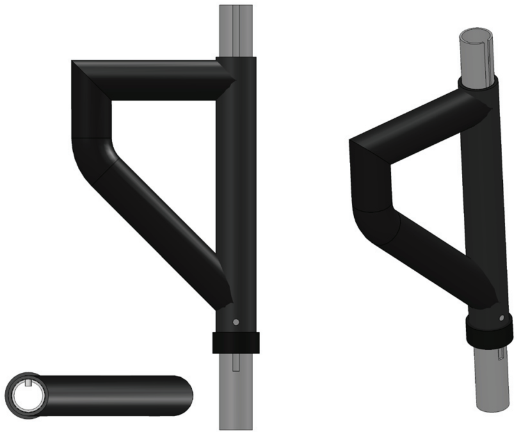

Figure 3.4
Multigrip with the track visible

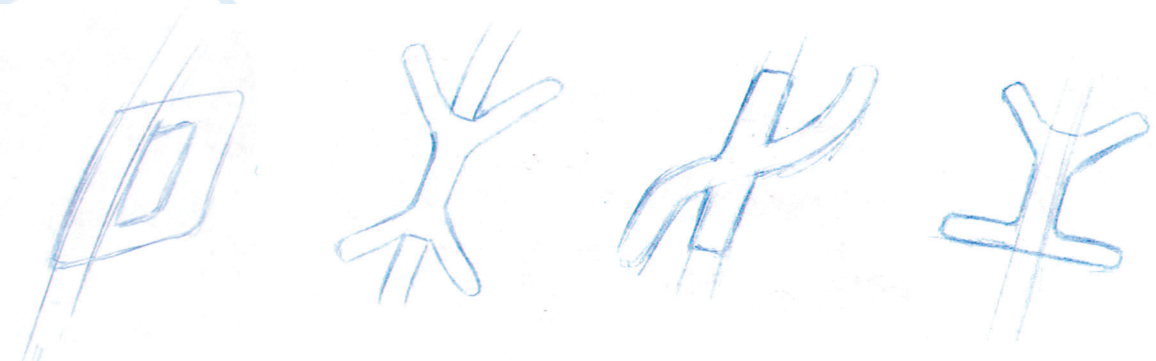

Figure 3.5
Possible designs for concept 1

3. Concepts

3.1 Idea phase

Then, three main directions were pointed out. First, there is the multigrip, which is a unit somewhere on the handlebar with multiple positions to hold on to like previously found at the competition research. Second, some solutions for the problem of the difference between individuals were generated. As previously pointed out, it proves to be very difficult to design a handlebar that suits individuals of all sizes. Ideally, the handlebar is freely moveable in a 3D space, but can still be secured in a certain position. The third concept is a concept which can be adjusted left to right with a simple movement of the hand.

3.2 Concept Phase

3.2.1 Concept 1

This concept consists of a so called multigrip that can be adjusted in height (figure 3.1 and 3.2). A multigrip is a unit attached to the handlebars that has multiple grip options for the user to hold on to. An example of a multigrip can be found on the Q47 model of Octane fitness, see also 2.2 Competition Research.
In user test 2, it was found that there was a lot of difference in the preferred height of the handles. That is why a height adjustment system is integrated in the multigrip.

Working principle

Adjusting the height of the multigrip is realized with a clamping mechanism. The lower end of the multigrip tube contains a screw thread on which a grip with an inner screw thread can rotate and thereby move up and down. As it moves up, it compresses a rubber ring, which thereby pushes against the inner tube (handlebar, swing arm) and clamps itself onto the inner tube. The multigrip contains a pen which slides in a vertical track of the inner tube to prevent rotation around the inner tube. (figures 3.3 and 3.4)

Design multigrip

There are a lot of different shapes possible for the multigrip. Curvature and diagonals can be used to achieve as many grip angles as possible. The most important grip angles are 45˚ pronation and vertical. (figure 3.5)

These designs meet the requirement of 45˚ pronation and vertical; the second also makes 45˚ supination possible and nr. 4 contains all five grip options. For now however, the first design will be used, because it is better producible and stronger as it is a closed shape with no open ends.

Ergonomics

The multigrip offers a number of grip positions that were investigated during the user tests. (figure 3.6)

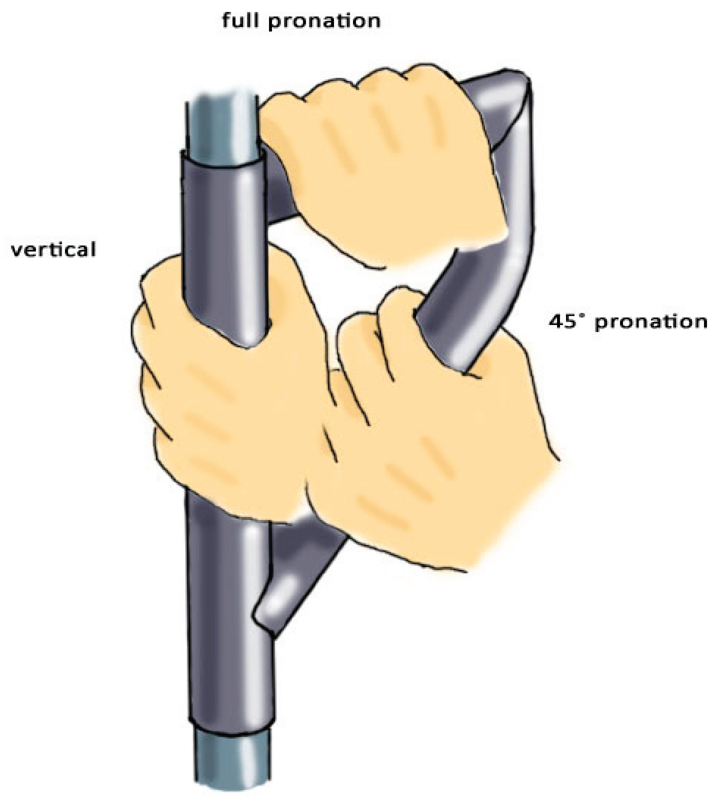

Figure 3.6
Possible hand positions on the multigrip

The multigrip clamps by rotating a grip down. This will not easily come loose during exercise, while this twisting motion does not occur during training.
This clamp mechanism is flatter and better integrated in the shape of the multigrip than a clamp knob would, and can thereby also be grabbed during training.

Materials / production method

The inner tube is a steel tube with an outer diameter of 30 mm and thickness of 1,5 mm.
The multigrip part consists of three steel tube parts welded together. The main tube (which slides over the inner tube) has an outer diameter of 36 mm with a thickness of 2,5 mm. This piece needs extra tooling for the screw thread. The two other pieces have a thickness of 1,5 mm.
The multigrip is dipped in a bath with a rubberlike coating for extra grip. Thread and opening holes up and down should be covered to leave them untouched. A typical coating is 3 mm thick, which increases the total width of the tube with 6mm.
The clamp part will be injection mould of polycarbonate. This requires a mould and perhaps some tooling afterwards to remove irregularities.
The rubber ring will be a purchase part.

Problems

- Risk of play in the mechanism that prevents rotation. The pen must fit very tight in its guide track
- High risk of wear of the rubber ring by twisting from above.
- High risk of wear of the plastic grip part, screwing on metal parts: Grip/clamp part can also be made of steel, but needs lots of tooling if so.
- Current handlebar thickness/width has to be reduced.
- No foam on inner tube / swing arm: paint instead can be a solution but that will be scraped off as the multigrip is sled up and down.
- Weld line of outer tube can cause trouble when sliding over the inner tube. –
- Possible that it requires extra tooling.
- The screw thread end tube ends needs to be covered for the dip bath for the coating.
- The swing arms need some unusual curvature to create space for the multigrips.
- Risk of skin getting pinched in the mechanism.

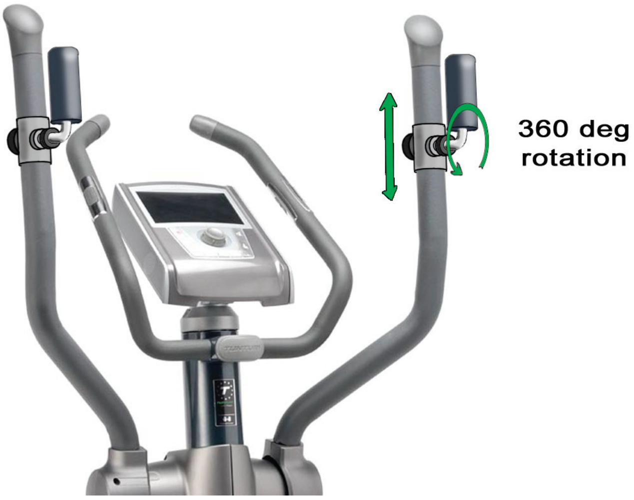

Figure 3.7
Concept 2

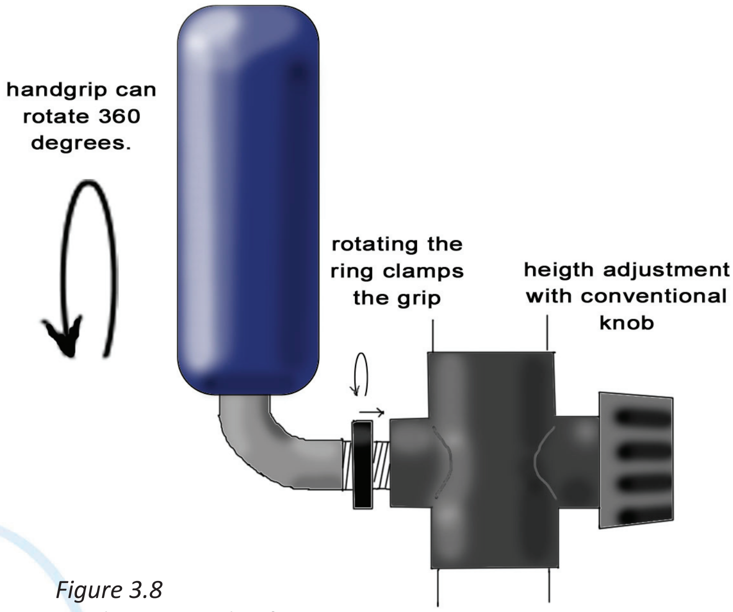

Figure 3.8
Working principle of concept 2

3.2.2 Concept 2

This concept is based on the prototype used in user test 2. The prototype is further explained in Current Mechanisms. This prototype consists of a handle-unit that is adjustable in height along the handlebar. The handle itself can be rotated along its square axle to adjust the preferred wrist angle. In the user tests was found that people like several different wrist angles, especially vertical and 45˚ pronation. The handle of this concept can rotate a full 360˚ and can be fixed at any angle. (Figure 3.7)

Working principle

The handle is connected to the handlebar with a piece of tube that fits around the handlebar. This is height adjustable with a pulling knob at the back, just as Accell already applies on the home trainers for saddle height adjustment. This type of height adjustment requires a set of holes at the back of the handle bar along a vertical path for the pin of the pull knob to lock into.
It is also possible to integrate the height adjustment of concept 1 in this concept, and it might even work better here, because no torque is applied on the handle around the handlebar, such as at concept 1.
To fix the angle of the handle, the user can screw a ring along a screw thread which clips on to the metal piece of the height adjustment unit. This ring can also be left loose, which gives the possibility to rotate the handle freely during training. (figure 3.8)

Design

This is esthetically probably not the best concept, but when this concept is chosen, some further form studies, especially on the handle itself, can be done to improve the looks and match it to the rest of the crosstrainer.

Ergonomics

The handle can be set in any angle, which satisfies every user if it comes to wrist angle. So, also users with different preferences than the average user will be satisfied with this concept. Furthermore, in user test 2, it was not very clear whether people liked a freely rotating handle or not. In this concept the handle can be fixed or rotate freely and should therefore also satisfy every user. The height adjustment allows small as well as tall people to use the handles problem free. As shown in user test 2, the vertical rotation of the handle is of no value and is thereby not integrated.

Materials / production method

The handle itself is a steel tube with a diameter of 36 mm. and a foam rubber tube of 3 mm. thick, sled over it; total width of 42mm.
This tube is welded in a pre-bent bracket of 3mm. thick steel with a width of 20 mm. in the middle and 42 at the weld points. 36 mm. holes are drilled for the tube to fit in.
A 30mm pen with a diameter of 10mm will be machined to give it a screw thread along 20 mm from one side.
This pen is spot welded on the bracket and the clamp ring is screwed on.

when the upper knob is rotated slightly, the whole handlebar can be set in three positions.

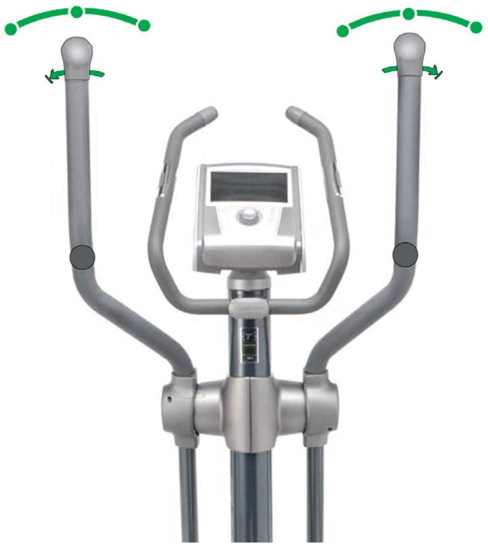

Figure 3.9
Concept 3

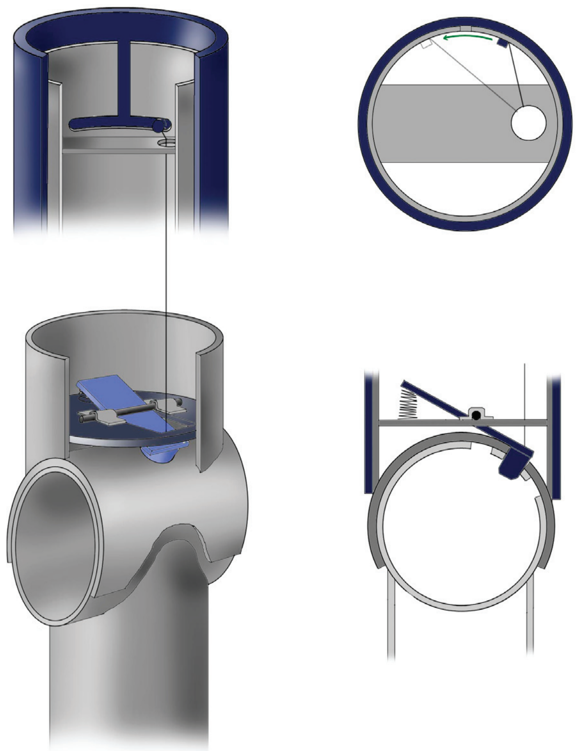

Figure 3.10
Working principle

Next, a metal bush with a diameter of 30mm and thickness of 5 mm is equipped with a bearing and a lock ring.
The pen is inserted in the bearing and also locked with a lock ring.
Now the handle can be welded onto the outer tube for the height adjustment.
On the other side of the tube, a steel bush with an inner screw thread is welded on for the pull knob for height adjustment.
As the holes for the height adjustment are drilled on the handlebar, the entire handle can slide on.

Problems

- High tooling/assembly costs
- Needs to be pre-assembled
- Painting the handle can cause problems, while the foam rubber and the screw threads must remain unpainted
- During exercise, the bearing is loaded in a lateral direction, which it is not designed for.
- Does the clamp mechanism work properly? Can rotation of the handle unscrew the clamp ring? Can the bearing be pulled to pieces by the screw thread?
- The bigger the clamp ring, the more power can be applied.
- Risk of pinching the skin between the clamp ring and steel bush
- The height can not be adjusted while the user is on the crosstrainer.
- Handlebar requires some unusual curvature.

3.2.3 Concept 3

This concept direction was chosen because it was the original idea from Accell. (figure 1.3)
This concept makes it possible to set the handlebars in three different widths as shown above. From user test 2, however, this adjustment possibility is not actually needed and seems redundant. On the other side, the number of participants in user test 2 was not high enough to completely follow its conclusions, they are more like guidelines. In addition, this concept satisfies the wish of the user to set the handlebars wide to be able to use the fixed handlebars problem free (figure 3.9). In that context, this concept can be equipped with a multigrip unit.

Working principle

On the handlebar, the foam rubber is interrupted for approximately 5 cm. On this part, a plastic grip is attached which can be rotated. On the inside, this grip has a little pin that slides in a milled, horizontal path of the handlebar. To this pin, a steel wire is attached that runs down via a hole in a horizontally mounted bracket. This causes the wire to be pulled upwards as the grip rotates.
The wire runs down to the hinge point, which is just above the curve in the handlebar. There, the wire is attached to a bracket with a small rod facing downwards at one end. The bracket is attached with little hinge on a horizontal plate. On the other end of the bracket, a pushing spring is attached, which in turn is attached to the horizontal plate. The spring pushes the rod at the other end down in a hole. This hole is on a piece of

steel tube welded square on the lower part of the handlebar. As the grip is rotated and the wire pulled up, so does the rod, and the upper part of the handlebar can be rotated into three (or otherwise, depending on the number of holes drilled) different positions. (figure 3.10)

Design

In this concept, the locking mechanism has been very nicely integrated in the handlebar. The rotating grip has the same width as the rest of the handlebar and can thereby be easily hold on to during exercise. The hinge point is in design similar to the hinge point lower down, around which the whole handlebar rotates.

Ergonomics

The user can adjust the width of the handlebar from approximately 50 cm. to 70 cm. to his/her own liking. The handlebars can also be set wide to make use of the fixed handlebars better possible.
Furthermore, when the handlebars are adjusted inwards or outwards, a slight pronation and supination is created.
Since there are no extra handles to hold on to, no height has to be adjusted. Instead the curvature has to be right to suit small as well as tall people.

Materials/production

First, the lower part of the upper tube is equipped with the bracket with rod. This is pre-assembled and spot welded into place. It consists of a circular plate with a square hole milled in. In this hole the bracket with rod is placed. This bracket is welded to a little axle, which is held in place by two little clamps mounted on the circular plate. All of its parts are made of steel.
A piece of tube of 42 mm long and the same width is cut in half and a hole for the rod to fit in is drilled. The tube is welded into place. This can later be sled over the lower part, which has a piece of steel tube of 42 mm long and 38mm width and three holes welded square onto it. Two plastic covers cover the tube ends.
The upper part of the handlebar will be machined to give it a milled path along which the pin of the plastic grip slides. Also the bracket with hole, which is punched, is being spot welded into place. Then, the plastic grip, which is injection mould, is attached and the steel wire is attached to it. The upper tube is finished with a plastic part that fits on top.

Problems

- There may not be any play in the rod/hole connection.
- Is the plastic pin strong enough to withstand high forces when someone is putting a lot of force on the grip.
- The locking mechanism may not unlock during exercise; therefore the system must be in the opposite direction of each other, rotating outwards. (inwards is a more natural movement, but will cause the system to unlock).
- Attachment of the spring?
- The spring is not loaded vertical, but along a circular path.
- Sturdiness of the device. It contains mostly tiny, fragile pieces.

Requirements	**Remarks**	**C.1**	**C.2**	**C.3**
P5 – P95 people must be able to use the handlebars problem free		4	4	2
Adjusting the handlebars must be able without the help of tools.		5	4	5
Adjusting must be performed by max. 1 person.		5	4	5
The hinge point must be sturdy enough to withstand....		4	3	2
The hinge point may not need an extra assembly step by the user	Pre assembly	3	3	4
Adjusting the part must be done easily with no extra effort	Current Accell prototype takes too much effort	4	3	4
Height of the handlebar (the part the user grabs) must be between 105 and 140 cm.	Probably height adjustment	5	4	2
The handlebar should allow at least four wrist angles: 45˚ pronation, vertical, 45˚ supination and full supination.		4	5	2
Width of the handlebars must be around 60 cm.		4	5	4
There must not be any play in the part		2	2	2
Production of the product must be done with standard parts en techniques.	no machined parts	3	3	3
The new part must be produced as cheap as possible		4	3	3
The part the user holds on to must always be covered with foam rubber		5	5	4
When moving, the new part may not come closer than 25 mm. to stationary parts of the crosstrainer		5	4	2
The new part will be introduced on Accell's top model crosstrainer and should therefore be of high quality and should match the look of the machine		5	2	3
The new part may not produce any sound or noise		4	4	4
The crosstrainer, including the new part, must fit in the current shipping boxes for transport		5	5	5
Aspirations				
Adding a converging, boxing like movement		4	4	2
Adjusting the part must be performed with max. one hand.		3	2	5
The possibility of free rotation of the wrist		1	5	1
The new part must be produced with no extra production costs.		1	1	1
	Total	**80**	**75**	**65**

Table 3.1
Assessment list of requirements

3.3 Chosen Concept

When all three concepts are worked out to a certain point, it is time to chose one of the concepts to work out to a final product.

3.3.1 Assessment list of requirements

First, in order to get a clear view of how well the three concepts satisfy the requirements and aspirations set up in the list of requirements, the concepts are balanced with the list of requirements. For each requirement, each concept was rated to indicate how well each concept satisfies that particular requirement. The rates vary from 1 to 5 were 1 is the worst and 5 the best possible score. Then, the scores are added up to achieve a total score for each concept after which can be seen which concept satisfies the list of requirements the best. (Table 3.1)

Concept 1 was rated the best with a score of 80 out of a possible 105. It scores particularly well on practical aspects. With this assessment in mind, I personally would go for concept 1, also. When this concept is worked out to eventually a prototype, it is interesting to see whether the height adjustment will actually function in practice. Also, I think that the looks of concept 1 match the crosstrainer the best. That is the main reason why I would not choose concept 2. Concept 3 does not satisfy the wishes of the user concerning ergonomics; and seems the less ideal option.

3.3.2 Final verdict

Next, a videoconference meeting was arranged with Henri Kuivala, the chief project management and Larri Fonsen of the department of Research & Development of Accell Fitness in Finland. After a presentation in which the pre studies and concepts are explained, they gave their opinion and eventually the final idea to work out into a concept. By mutual agreement, Concept 1 was chosen to work out, but without the height adjustment. All the adjusting systems were found a too high risk to implement. That mainly comprises the risk of failure of the system and the extra costs it will contain. Also the quality of the adjusting systems on the long term could not be guaranteed.
However, the multigrip was found a good idea, and with the right design, the problem of the required height differences can probably be solved. The next stage will comprise finding the ideal shape, both on ergonomics and looks, to work out as a prototype for user tests. In the remaining of the report, Concept 1 is called Multigrip.

Figure 4.1
Three views of the conventional handlebars

Figure 4.2
Three views of multigrip 1

Figure 4.3
Three views of multigrip 2

Figure 4.4
Three views of multigrip 3

4. Multigrip

4.1 Finding right shape

When the concept of the multigrip was chosen, it is time to find the ideal design of the multigrip, both on Ergonomics and looks. Some design studies were done, with the results of the pre studies and user tests in mind. The results of the design studies and an explanation are shown below; of every multigrip, the pluses en minuses are pointed out. Note that integrating a multigrip will influence the design of the fixed handlebars. A multigrip would make contact with the conventional fixed handlebars.

First, to get a clear view of the actual differences the multigrip offers, some pictures of the conventional handlebars (figure 4.1).

Multigrip 1 (figure 4.2)

Pluses:
- Almost all desired grip options; only supination is missing.
- Wide grip options for broad people, narrower for slim people.
- For tall users, the broader grip options are further forward (longer arms); for small users the inner grip options are located somewhat closer to the user.
- The lower part of the grip, for real small users, is more vertical (seen from the side in the position closest to the user) to avoid stress on the user's wrist.

Minuses:
- The lower part of the grip, for real small users, maybe somewhat too wide.
- Concerning the vertical parts of the multigrip; the wide vertical parts (presumably mostly used by tall people) are somewhat lower placed than the inner vertical parts, which are presumably mostly used by smaller people.
- The looks of this multigrip do not entirely match and complement the entire design of the crosstrainer.

Multigrip 2 (figure 4.3)

Pluses:
- Number of different grip options; especially the upper outer part offers the user a lot of grip options.
- Wide grip options for broad people, narrower for slim people.
- The design of the multigrip matches the design of the entire crosstrainer.

Minuses:
- The lower part of the grip, for real small users, maybe somewhat too wide.
- The outer parts are placed more towards the user than the inner parts.
- Maybe the curvature in the upper outer part feels awkward to some users.
- Only full pronation for small users.

Multigrip 3 (figure 4.4)

Pluses:
- Grip options: pronation for small and tall people. Enough vertical grip options.
- The lower part of the grip is narrow, so it suits small people better.

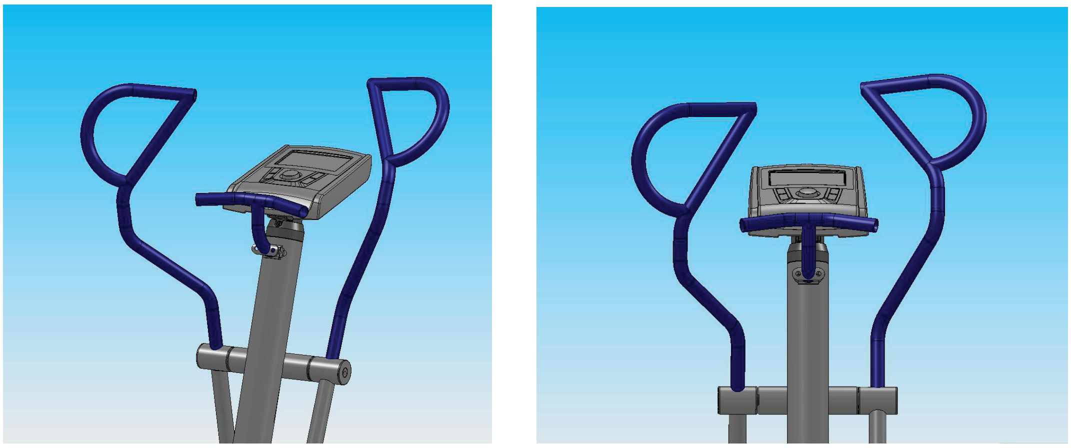

Figure 4.5
Two views of multigrip 4

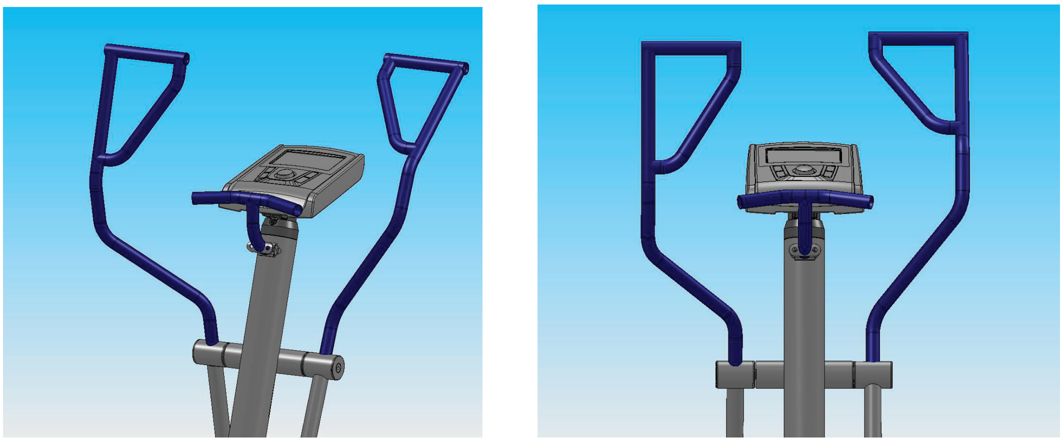

Figure 4.6
Two views of multigrip 5

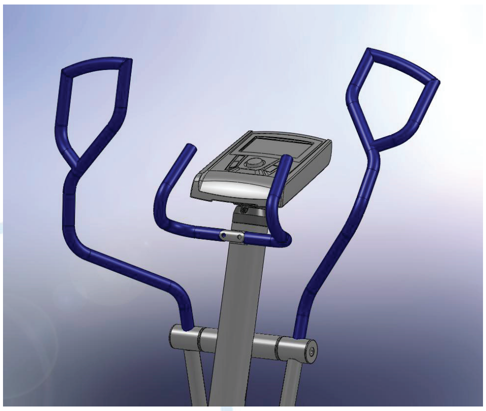

Figure 4.7
Fixed handlebar 1

Figure 4.8
Fixed handlebar 2

Minuses:
- The design of the multigrip not really suits the crosstrainer.
- No supination
- No pronation for 'the average' person
- The wider vertical grip is placed lower than the inner vertical grip.

Multigrip 4 (figure 4.5)

Pluses:
- A lot of grip options; pronation for small, tall, slim and broad people. Also supination is available. Horizontal grip only for tall people.

Minuses:
- Top piece maybe too narrow in relation to the other top piece.
- Radius of the curved part maybe too small, causing possible problems when users hold on to there.
- It is a daring design, which probably does not suit the crosstrainer.
- Sharp angle in the top of the multigrip can feel tight when users hold on there.

Multigrip 5 (figure 4.6)

Pluses:
- Simple, triangular shape with most grip options.

Minuses:
- Angular shape does not really match the design of the crosstrainer.
- For different shapes of persons there is not much choice of grips.
- Horizontal grip only on top; no pronation for tall people.

Fixed handlebars

Two different designs for the new fixed handlebars have been made. In the pictures above, these designs can already be distinguished. For the sake of completeness, some pictures of the two designs (figures 4.7 and 4.8).
Fixed handlebar 1 is designed to give the users two upright handles to hold on to, similar to the conventional handlebars. However, this fixed handlebar is quite a bit shorter and somewhat narrower to avoid contact with the multigrips. Fixed handlebar 2 is more like a small steer and should be a natural feeling shape for users to hold on to.

4.2 Final design

Another meeting has been arranged to decide which of the previously shown five multigrips will be worked out to a prototype. Eventually, multigrip 2 has been chosen, because its shape matches the design of the crosstrainer and offers a nice range of grips. The few drawbacks it has can easily be overcome with some adjustments (figure 4.9):

1. The lower part of the handlebar needs some redesign; it is somewhat too elegantly designed. The big radiuses have to be decreased.

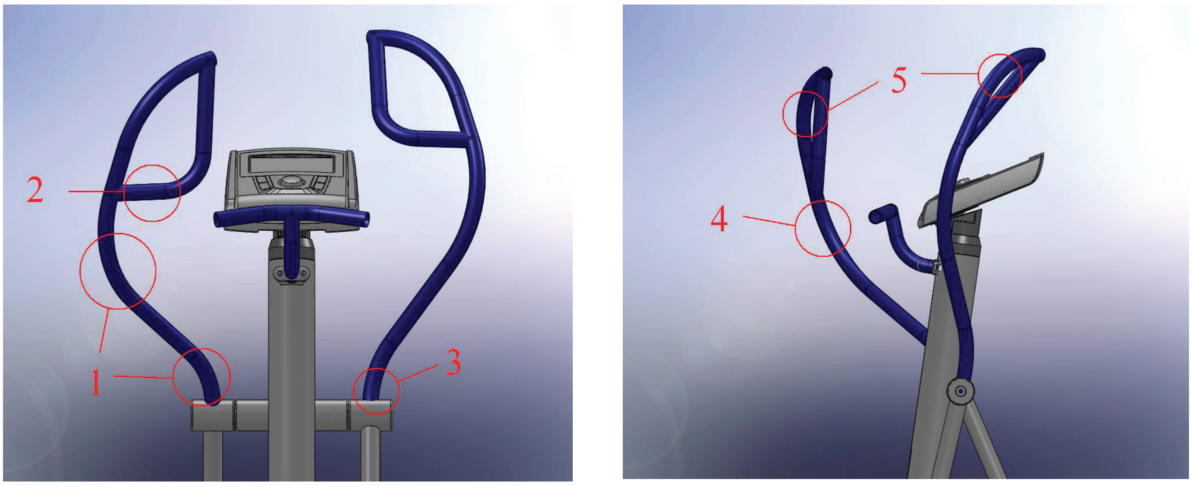

Figure 4.9
Area's that need improvement
The numbered spots are explained in the text

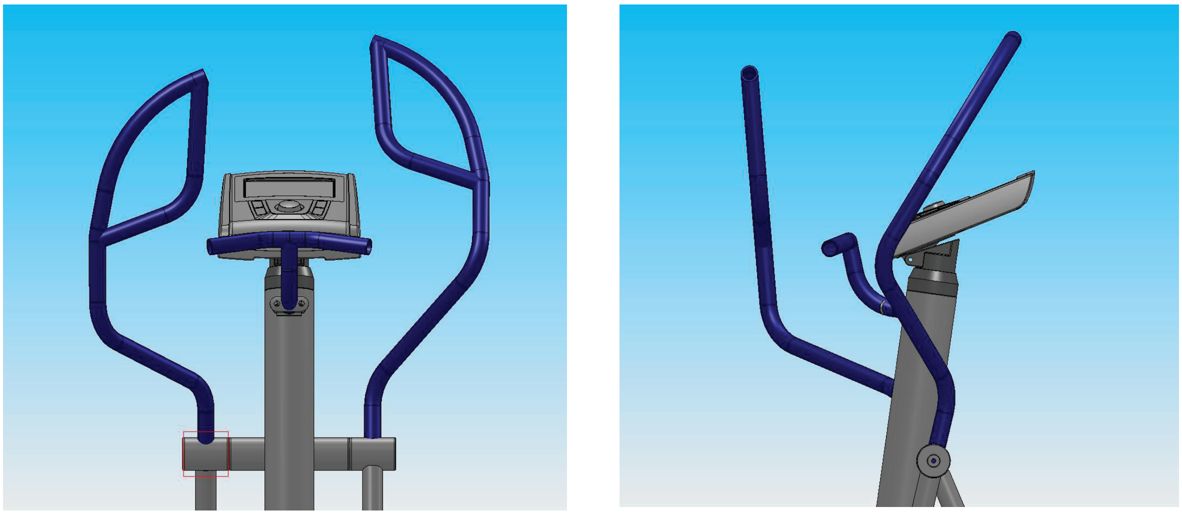

Figure 4.10
Redesign of the multigrip

2. The horizontal part of the multigrip will be given an angle to obtain a more pronation grip.
3. The part where the handlebar is fixed to the hinge point needs to be straight for about 7 centimeters to be able to fit the plastic hinge point covers.
4. The lower part of the grip (the part under the multigrip), for real small users, needs to be more vertical (seen from the side in the position closest to the user) to avoid stress on the user's wrist.
5. The outer parts have to be placed somewhat further away from the user, for taller, broader people.

With these aspects in mind, a redesign has been made (figure 4.10).

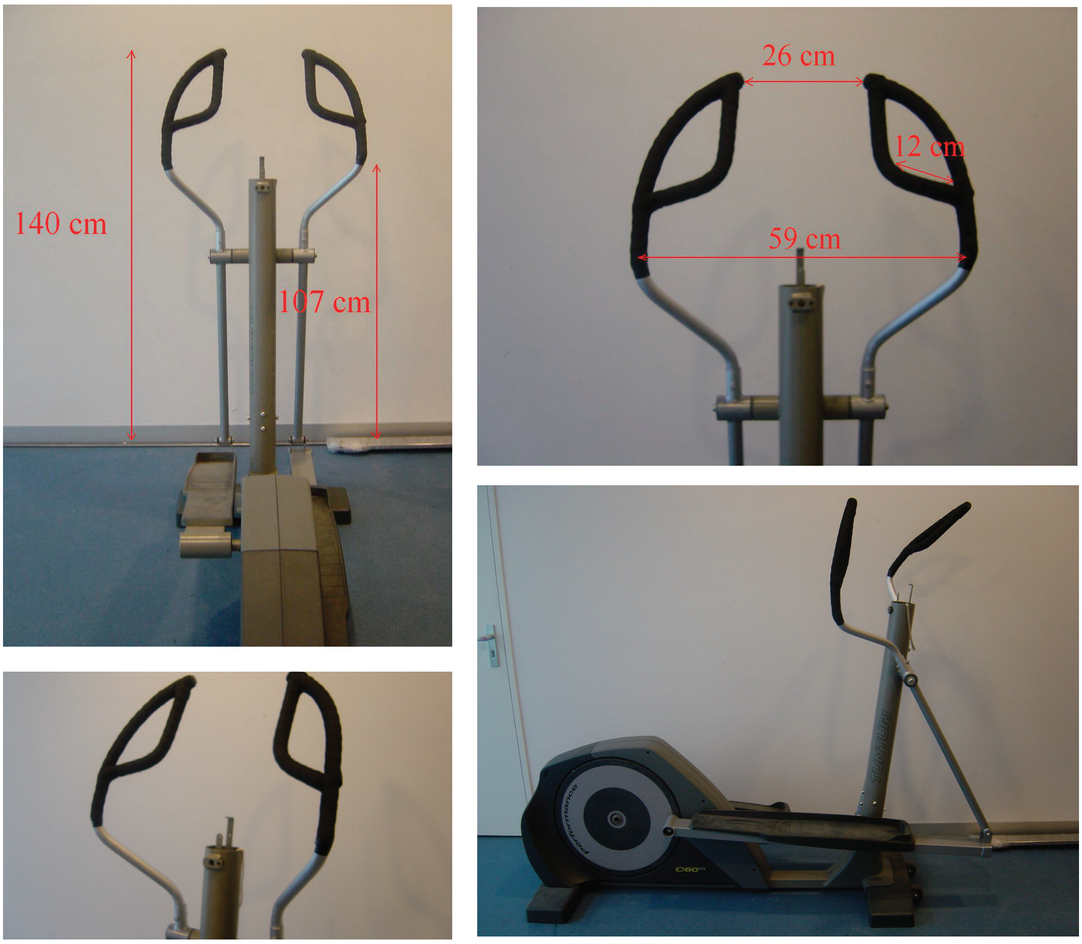

Figure 5.1
Photographs of the prototype

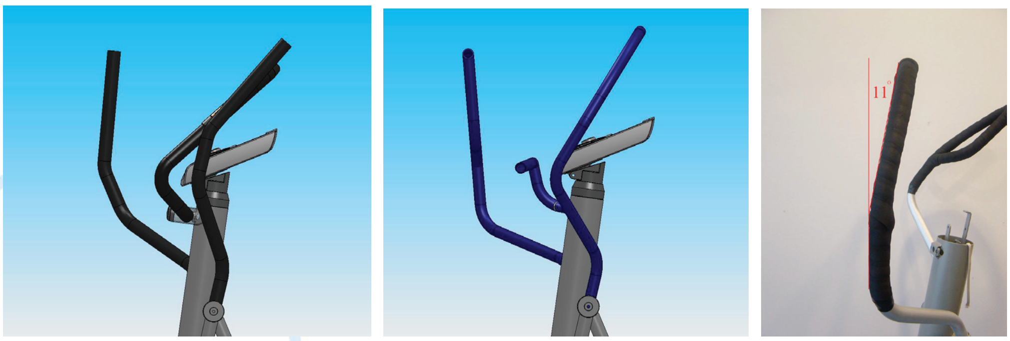

Figure 5.2
The bend that was applied to the prototype

5. Prototype & testing

5.1 Prototype

When the final design of the multigrip was finished, the prototype stage started. The main purpose of this prototype is to execute user tests with it, mainly focusing on ergonomics and comfort, but also the looks of the design will be assessed. Therefore, not only the shape of the handlebars was important, but also the finishing touch was paid attention to. Due to lack of time and due to the attention that was necessary to get the handlebars in the right shape, there was no time left to construct the fixed handlebars also. Unfortunately, the fixed handlebars can thereby not be tested during the user tests.
Each handlebar consists of two tubular parts with a diameter of 27 mm and a thickness of 2,5 mm which were bent in the right shape and welded in place. The handlebars were then mounted on an older C60 model crosstrainer, which does not differ in geometry from a C80 model. As a grip, which in the final product will be a dipped coating, a ribbon used on the steer of race bikes was used (figure 5.1).
During the construction of the prototype, the multigrip part was bent forward by 11˚, an adjustment that was not yet applied in the SolidWorks model. In the series of pictures on the left (figure 5.2), it can be seen that the original handlebars has its upper part leans somewhat more forward than the new multigrip. To avoid the risk of the multigrip getting too close to the body, the multigrip part of the prototype was bent forward.

5.2 Testing

With this prototype, an extensive user test has been executed. According to this user test some design recommendations are stated. User test 3 is the final test of this project. Here, the final prototype of the multigrip concept is tested to find the strengths and weaknesses and to make clear which aspects of the concept need to be improved. Eventually, the test results are used to evaluate whether this design satisfies the clients' whishes enough or whether a redesign is needed.

5.2.1. Test set-up

This final test took place at the Twente University in Enschede. All 21 participants were students or employees at the university. First, after a small introduction about the project, the participants were asked about their experiences with exercising on a crosstrainer. After that, they were asked what they thought about the looks of the handlebars in comparison with the rest of the crosstrainer. Therefore, some pictures of the actual model were shown. Then, each participant tested five different grips of the multigrip to see how each grip satisfies personal preferences. Special interest went out to smaller people, investigating whether the lowest grip causes problems because of its width or vertical angle. Finally, the participant had the opportunity to give some remarks, for example if he/she missed a certain grip on the handlebar. An extensive report of this test can be found in Appendix A.

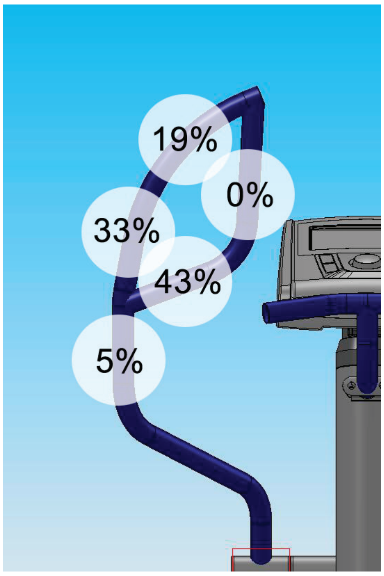

Figure 5.3
Most popular grips by the total group of participants

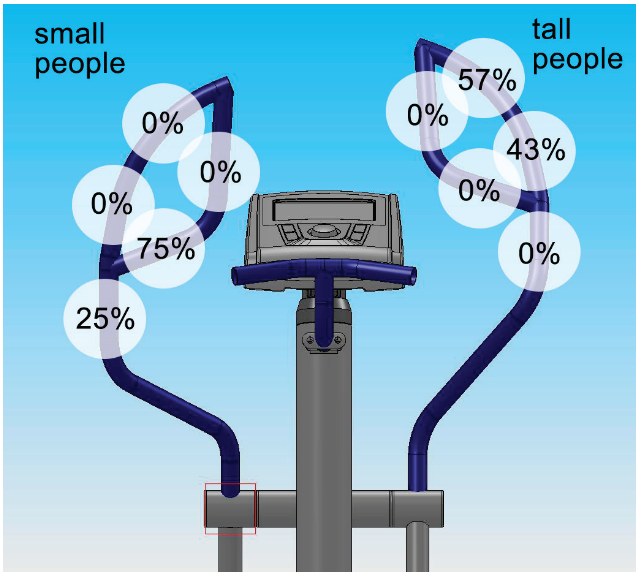

Figure 5.4
Most popular grips by small and tall participants

Figure 5.5
Redesign that has to be made according to user test 3

5.2.2. Test results

In general, participants were positive about the new multigrip design. Every participant was able to find a comfortable position for him-/herself. The looks were also appreciated. The pictures on the left page show which grips were most popular among the participants. Figure 5.3 shows the percentages by which a certain grip was chosen by the total group op participants. Figure 5.4 shows the percentages by which a certain grip was chosen by the small and tall participants.
Although the overall opinion was positive, some small people found the part under the actual multigrip (grip 5 in the user test) still leaning backwards too far, although it had already been changed in comparison to the conventional handlebars. The lower part of the multigrip should be extended more towards the user, so that the part leans backwards more, according to the red line shown left (figure 5.5).
A point of attention when this change is being carried through would be that this particular part does not lean forward to far in the outmost position, which maybe cause problems as overstretching the wrist.

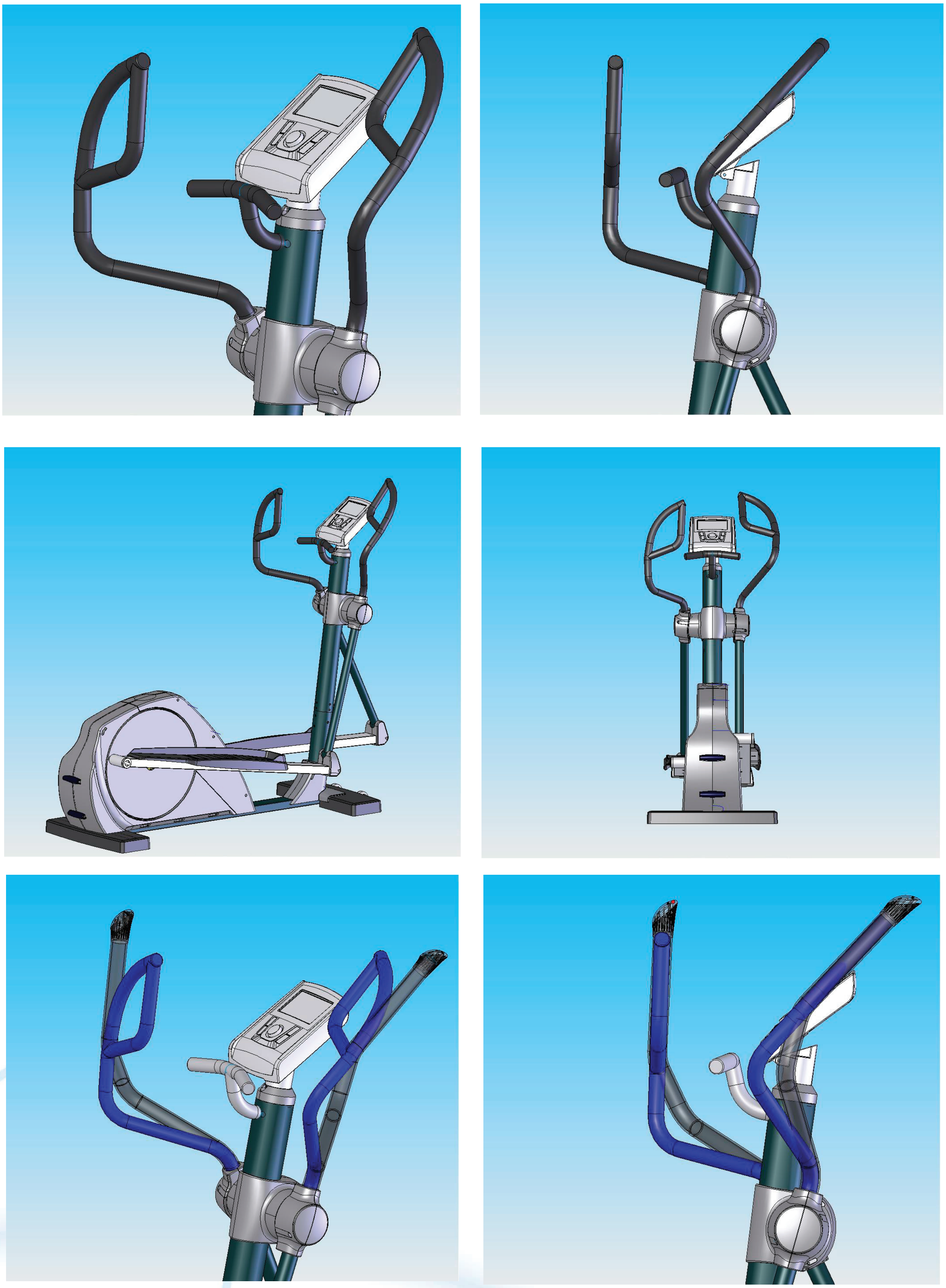

Figure 6.1
Compilation of pictures of the final multigrip integrated in the C80 model. The pictures at the bottom compare the conventional handlebars with the new multigrip.

6. Conclusion

6.1 Result

According to the results from user test 3, this multigrip design has the potential to be integrated in the Tunturi C80 model. All participants were able to find a comfortable position on the multigrip. On the pages on the left (figure 6.1), some pictures are shown of the final model, so with the little adjustment according to user test 3 integrated.
As a conclusion, it can be said that a satisfying result has been realized. The project started off with some thorough research, followed by an extensive design process of concept finding, adjusting, prototyping, and testing. When the final result is compared with the goal set at the beginning of the project, it is clear that the concept of manually adjustable handlebars was put aside. However, that was done with legitimate reasons thanks to thorough research and testing, which made clear that adjustable handlebars were most likely not the best option to solve the problem. The final multigrip offers the users enough grip options and freedom of movement and is easier to produce with a smaller chance of failure.
However, the goal that the final design has to discern itself from competitors is not really accomplished. The idea of a multigrip was already present at a few crosstrainers on the market, although the shape differs slightly among one another.

6.2 Recommendations

Although the result can be called satisfying, there are still some recommendations for the continuation of implementing the multigrip in the product range. First of all, some test should be done with the new design of the fixed handlebars. Although the new design does not reach too far forward and allow the user an upright position, the risk of contact of the multigrip with the user can not be ruled out yet.
During this project, not much attention went to manufacturability so far, because the first priority went out to ergonomics and user comfort. Some research should also be done to that subject, although not many problems are to be expected, as manufacturing the multigrip mainly consists of methods already used in the fabrication of crosstrainers. Also costs and logistics were not paid a lot of attention to, making it points of interest for future development.