Practical Test “Children and Ladders”

R &T project to identify at what height the first rung of a ladder should be placed in order to prevent children under 4 years from climbing this ladder
Part II A - November 2005

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1 Introduction

In 2004, an ANEC Research & Testing study was performed on the climbing skills of children. This study shows how children learn to climb, what their climbing abilities are and what literature is available on this subject. A practical test was required to determine the height of the first rung of a ladder children under 48 months can climb in order to determine at which height the rung must be placed to prevent children from climbing onto it. The results can be used as a guidelines for amending standards.

1.1 Background

Children can and will climb on almost anything that attracts them. Falling from heights is one of the major causes of injuries to children. In many standards for products associated with children, for example playground equipment, the ability to climb is a safety issue that needs to be addressed. In 2004, an ANEC Research & Testing study was performed on the climbing skills of children. This study shows how children learn to climb, what their climbing abilities are and what literature is available on this subject. A practical test is required to determine height, form and dimensions of footholds that are needed for products on which children should be able to climb, such as playground equipment, as well as for products which are meant to prevent children from climbing over. Without this practical information, it is difficult to request appropriate requirements in standards.

The tests in this project addresses the two following subjects:

A – the first rung of ladders used in playground equipment and in other products meant for children
B – the foothold test defined in NPR-CEN/TR 13387 – Child use and care articles
   – Safety guidelines

These subjects are according to the results of the first part of the project and the experience of the ANEC child safety working group members and one of the designers of the foothold test (see report Testing the Foothold test - Appendix D), lacking a good basis of research and testing results.

1.2 Purpose of part A

Determination of the height of the first rung of a ladder that children aged 0-4 years can climb without help.

The research questions are:
- At what height should the first rung of a ladder be placed in order to prevent children under 4 years from climbing the ladder?
- Are the results different for climbing with or without shoes?
- Are the results different for angled (60 degrees) ladders?

Two remarks have to be made
- An important second parameter is the height and form of the first hand support point. Without grip within reach children will probably not be able to climb the first step. In this practical test it will be foreseen that a child is able to grasp a support point at his own grip height.
- Not included in this study are the form and thickness of the rungs because these dimensions can be obtained by using anthropometric child data.

Results of ladder test
- A guideline for designers and testers of playground equipment and other children's products, consisting of the heights of the first rung children in different age groups can climb.
- Recommendations for the overall design of a ladder used in playground equipment.
- Recommendation for the height of the first rung used in safety tests to prevent children of under 4 years from climbing a ladder.

1.3 Purpose of part B

Are the foothold requirements in NPR-CEN/TR 13387 3.11.4 – Footholds, capable of predicting whether a child younger than 4 years can either stand or climb on a foothold which is part of a childcare product or barrier.

Results of testing the foothold test:
- a description of the supports children of different ages (0-4 years) are able to use as a foothold while climbing on or over a rigid structure.
- The smallest ledge, the narrowest gap and the maximum slope that can be used as a foothold by young children.
- recommendations for amending the foothold requirements in NPR-CEN/TR 13387 - – Child use and care articles – Safety guidelines - 3.11.4 footholds

1.4 Scope

The project focuses on the climbing skills of children under 48 months of age who can walk independently.
2 Summary

This is part A of a two part project about footholds. Part B was about the foothold test as described in CEN/TR 13387, 3.11.4 Footholds.

The purpose of this R&T project is: Determination of the height of the first rung of a ladder that children aged 0-4 years can climb without help.

The main assumptions were:

- Children younger than 36 months can climb a ladder with the first rung on 40 cm above ground level considered they can grip a support with their hands.·
- Children's age is not a very good quality for measuring or defining the climbing skills of children. The development stage of motor skills together with character and built can be used instead and will be more reliable as predictor for the child's climbing skills.·
- Slanted ladders are more frightening to climb than vertical ladders are.

The practical tests have been conducted at two different child day care centres in Amsterdam on two different days in each centre. A special test object was prepared containing a platform with a slide which served as a reward for the children’s climbing efforts.

The day care teacher led the participating children one by one to the test object and the children started to climb the ladder. Observations were video recorded and successful attempts scored on paper. Each child had three chances to try to climb the ladder. After all children tried the first rung height, the rungs were repositioned onto the structure so that the first rung was 10 cm higher. As soon as all children failed to climb the ladder the next age group started. The last rung height that all children in the first age group climbed successfully was used as starting height in the second round. In case there was time left, the vertical ladder was replaced by a slanted version and the same test was carried out.

Most children (90%) tended to climb the ladder in the same way: Grab a rung as high as possible, first foot on first rung, next foot on first rung, looking for next rung, foot to second rung, … After climbing the last rung under the top rung they started to look for other places where they could hold on to before climbing onto the platform.
Other observed climbing methods: knees on rung and leg over rung.

The character of a child seems to influence his climbing behaviour and partly the results of the test. Children who are a bit afraid of new situations do in general get less practice in climbing as children who are real ‘go-getters’ which will influence the rate in which they develop their motor skills. However most children are curious enough to overcome their fear and in the end flexibility and strength in the arms will be a more important factor.

As expected a lot of the taller children do climb more easily on a higher rung but other qualities are also important and some of the smaller children can climb the same rung height as the taller ones. Therefore height is not the best predicting quality for climbing abilities of children.

Reasons for failure:

physical
- Not enough strength in arms
- Not flexible enough to pull one leg up to the first rung
- Too small to reach the top rung
- Not knowing the right technique

other
- Afraid to show their inability to other children.
- Wanting to play other games
- Afraid of new situation

The most important conclusions that can be drawn from this testing project are:
- A rung height of 40 cm is not high enough to keep children under 3 years from climbing a ladder.
- 7 of 38 children under 3 years (=18%) were able to climb a first rung on 60 cm.
- All children aged 3-4 years are able to climb a rung height of 40 cm.
- Almost 50% of the children between 3 and 4 years of age were able to climb 70 cm.
- Kind of shoes or bare feet was not important when climbing a ladder.
- Because there was not enough time left to test the slanted ladder as detailed as planned, very little can be said about children climbing this type of ladder. The children of age group 3 and 4 years seemed to climb the slanted ladder as easily as they climbed the vertical one. Younger children seemed to be more afraid of the slanted ladder but further research on this point is required because of the small number of children who participated in this test.
Recommendation for changing the standards formulated in the NEN-EN 1176-
Playground equipment
- Raise the standard for the height of the first rung of a ladder to at least
  600 mm.

Further research is required on the following subjects:
- Are children who are able to climb a 40 cm high rung of a ladder ready to
  play on large playground objects?
- At what age do children see the danger of more challenging large
  playground equipment?
- Research on the number and severity of the injuries occurring when a
  child under 3 years old climbs a large playground object.
- Slanted ladders should be tested as well in order to find out if they are
  more easy to climb than vertical ladders or more difficult.
3 Ladders used

3.1 EN 1176-1 - Playground equipment – Part 1: General Safety requirements and test methods

The current standard for playground equipment makes a difference between children younger than 36 months and older children. Under the age of three supervision of an adult is always required because young children do not yet know the danger incorporated in climbing high objects. They simply follow the inner urge to explore and try new things. Therefore it is recommended to make playground objects that are not meant for this age group inaccessible to them. In the revision of the standard there is no age limit. The basic problem still remains how can we prevent inexperienced young children gaining access to playground equipment that might be dangerous to them. The question then arises: What is inaccessible for young children? And further: At what age are children able to foresee the consequences of climbing and able to evaluate the dangers involved?

The “Handboek Veiligheid van Speelgelegenheden” currently gives the following examples of how this can be achieved:
- The first rung of a ladder shall be 400 mm above ground level (page 123, 2.9 accessibility)
- A platform shall be at least 600 mm above ground level (page 123, 2.9 accessibility).
- Ensure a distance of 400 mm from the playing surface to the lowest foothold.
3.2 Definitions

Ladder: Primary means of access incorporating rungs or steps on which a user can ascend or descend. A ladder is normally inclined at an angle between 60° and 90° to the horizontal. (EN-1176-1, 3.10)

Stairs: Primary means of access incorporating steps on which a user can ascend or descend. Stairs are normally inclined at an angle between 15° and 60° to the horizontal. (EN-1176-1, 3.11)

Grip: Holding of the hand round the entire circumference of a support. (EN-1176-1, 3.14)

Grasp: Holding of the hand round part of the circumference of a support. (EN-1176-1, 3.15)

3.3 Different types of ladders and choices made

Many different types of ladders exist. In the tests the following options were chosen (the chosen options are printed **bold**):

Metal or **wood** – Wooden ladders are broadly used in playground equipment. Metal ladders occur less, most of the time in combination with a slide. It has been assumed that the results of the test will be almost the same for wooden or metal ladders.
Broad or narrow – While climbing on a narrow ladder children can use the sides to hold on to instead of the rungs. Narrow ladders are more frequently used than broad ladders but because the testing will focus on the relation between the first rung and the second rung (used as a handhold) a broad ladder was chosen.

Horizontal or irregular/slanting rungs – Because of their small use the irregular ladders were not tested.

Steps or rungs – Rungs are favoured above steps because most ladders have rungs instead of steps. Rungs give better grip and should therefore not influence the results of the test in a negative way.

Grip or grasp. Grip is used in most ladders in playground equipment. The diameter of grip according to the “Handboek eiligheid van speelgelegenheden, chapter 2.5” is between 16 and 45 mm. For the tests an intermediate diameter of 30 mm is used.

Normal or alternating – The ladder with alternating steps is very different from the normal ladder. It will be interesting to test whether children find it easier or more difficult to climb on this type of ladder. Is it more natural to climb this way or do the children have to think more during climbing? The alternating ladder will not be tested in this research project but it is advisable to include them in future research projects.

Vertically or slanting – Because both the vertical and the slanting version are very common, both types of ladders will be tested.

Height of the platform is 1 m because this distance is enough to make a proper ladder with at least two rungs even when the first rung is placed on 700 mm above the ground. The height of the last rung is always 1 m.

3.4 Conclusions

Children under three years of age do sometimes have the motor skills to climb on playground equipment by themselves. However they may not paying attention to the danger involved. Therefore it is advisable to keep them always under the supervision of an adult and to require a degree of difficulty in accessing equipment that is meant for older children that might be dangerous for young children. This research project will address the question of how to make climbing a ladder difficult for children under four years of age.

4 Practical test plan

4.1 Aims and benefits

The aim of the study is to find out what the height of the first step or rung of a ladder should be in order to prevent children under 36 months from climbing the
ladder. The tests are carried out with children between 36 and 48 months as well in order to get to know if there are children in this age group that are not able to climb a rung height that younger children can climb. This to prevent the requirements from becoming so harsh that children that are old enough to climb an object but who do not have the flexibility or motor skills other children of their age have, are not able to climb it. On the other hand it is interesting to know what is the height of the first rung of the ladder that children can climb at a certain age. It might even be better not to take age but to take another quality of the child as a standard for their climbing skills. This information would be useful to designers of playground equipment for the youngest children and possibly also for other children’s products.

4.2 Assumptions

- Children younger than 36 months can climb a ladder with the first rung 40 cm above ground level if they can grip a support with their hands.
- A child’s age is not a very good quality for measure for defining the climbing skills of children. The development stage of motor skills together with character and build can be used instead and will be more reliable as a predictor for the child’s climbing skills.
- Slanted ladders are more frightening to climb than vertical ladders.

4.3 Methodology

stage 1: Recording the children’s physical features.

stage 2: Identification of the maximum height of the first rung that children of different ages can climb on a vertical ladder with wooden rungs with a diameter of 30 mm.

stage 3: as stage 2 but using an angled (60 degree) ladder.

4.4 Test equipment

Children will try to climb the 1 m high ladder in order to reach the platform. From the platform a slide will bring them back to the playground level. Going down the slide will be the reward for their effort to climb onto the platform. The rungs can be repositioned at 5 cm intervals.
4.5 Age groups and the number of participants

<table>
<thead>
<tr>
<th>age group</th>
<th>number of children</th>
</tr>
</thead>
<tbody>
<tr>
<td>group 1 1 - 2 year</td>
<td>9</td>
</tr>
<tr>
<td>group 2 2 - 2.5 year</td>
<td>8</td>
</tr>
<tr>
<td>group 3 2.5 – 3 year</td>
<td>16</td>
</tr>
<tr>
<td>group 4 3 - 4 year</td>
<td>15</td>
</tr>
</tbody>
</table>

The test was carried out with one age group at a time. Children of the same age need the same kind of explanation of their task and they will encounter the same problems during the test.

4.6 Description of participating child

The children participating in this test all had normal development motor skills. The test did not include children with physical or mental disabilities. The parents were informed about the test by a letter. Most parents gave their child permission to participate in the test and only a few preferred not to see their child on pictures or video recordings.

4.7 Test program

Stage 1
Each age group was measured by 2 persons.

Stage 2
The group with the youngest children started the test. The day care teacher led the children one by one to the ladder and the children started to climb the ladder. One person made video recordings while another person counted the successful and failing attempts. Each child got 3 chances to climb the ladder. The children who were not able to climb the ladder could go and play. As soon as all the children tried the first rung height, the rung was raised 10 cm and so on until none of the children in the group was able to climb the ladder anymore.
Stage 3
The vertical ladder was replaced by an angled ladder and testing repeated.

After these series of tests the next age group was tested. The starting point being one or two steps lower than the end point of the previous age group.

4.8 Information recorded
Anthropometric data were recorded for each child: weight, height, foot length and width, instep height, length until grip. (see Appendix E for explanation of these definitions) These data will be used for the foothold test as well.

Also recorded: age, character of the child (according to the teacher) and kind of shoes.

The trials were video recorded. The variables recorded included:
- attempt/refusal
- completed climb/partial climb
- climbing technique
- reason for failure

4.9 Reporting
The video recordings were considered and the most interesting parts were pasted into special movie fragments addressing the themes: climbing methods, climbing behaviour and character, reasons for failure.

4.10 Critical remarks
It was very likely that the children would learn from other children during the test. It was planned that each child would get 3 chances. In practice most children tried until they lost interest which was often after three times.

The learning effect was very clear indeed. Children watched each other intensely adapted the climbing methods that seemed to work best. Children that were a bit frightened in the beginning lost their fear after having climbed the ladder one time with a little help from one of the observers.

Safety
In order to make the test as safe as possible it was planned that only a few children would be tested at a time. In practice this was not always manageable, but there was always one person near the climbing children. This person did not help the child unless there was a potential dangerous situation or in case the child was very frightened.

It was required that the children could reach the platform with their hands while standing before the test object. Without something to hold on to it would be impossible to climb the ladder. A height of 1 m was thought sufficient (see appendix E height until grip) for most of the children older than 2 years. Younger children had to grasp a lower rung on 70 cm.

5 Test results
See appendix H for the different test situations.
5.1  **Height of the child and rung height**

The figure below shows that there is little correlation between height of the child and rung height. As expected taller children do climb more easily on a higher rung but the deviation is too big to make this quality interesting as a predicting quality for climbing abilities of children. Some children did not complete the test. Of those children the highest rung they climbed is recorded as highest rung without knowing whether they are able to climb even higher rungs.

![Figure 1](image1.png)

*Figure 1 Height of test children versus height of the first rung climbed.*

5.2  **Age and rung height**

As shown in the table in appendix J, test results, the test shows very clearly that a rung height of 40 cm is easily accessible for many children younger than 36 months. In fact, 15% of the children aged 12-24 months, 66% of the children aged 24-30 months, 75% of the children aged 30-36 months and all the children older than 36 months could climb 40 cm.

![Figure 2](image2.png)

*Figure 2 number of children that can climb a ladder with various heights of the first rung*
Figure 3 Children of different ages who can climb a ladder on various heights of the first rung

**Group 1 (12-24 months)**
- 2 out of 13 climb 40 cm
- 4 out of 13 climb 30 cm

**Group 2 (24-30 months)**
- 6 out of 9 climb 40 cm
- 3 out of 9 climb 50 cm
- 1 out of 9 climbs 60 cm

**Group 3 (30-36 months)**
- 11 out of 16 climb 40 cm
- 8 out of 16 climb 50 cm
- 6 out of 16 climb 60 cm

**Group 4 (36-48 months)**
- All 15 climb 40 cm
- 12 of 15 climb 50 cm
- 11 of 15 climb 60 cm
- 7 of 15 climb 70 cm
5.3 Figures for the slanted ladder test

Group 1: 1 out of 3 climbed 30 cm
Group 2: 3 out of 4 climbed 60 cm
Group 3: 2 out of 3 climbed 50 cm
Group 4: 4 out of 7 climbed 70 cm, the other 3 climbed 50 cm

5.4 Observed climbing methods

Most children (90%) tended to climb the ladder in the same way:

Step 1: they grasped a rung which is situated above shoulder height and under the highest point they could reach with their arms stretched out above their head.

Step 2: they placed their right foot on to the first rung. Some children are not flexible enough to get their foot on to the first rung. They use their knees but this method was more painful and therefore only used in case the other method did not work (about 30% of the children).

Step 3: They pulled themselves up until the other foot is next to the first foot.

Step 4: They looked for the next rung and the first three steps were repeated.

Step 5: after climbing the last rung under the top rung they start looking for other points they could hold on to. They tried to grasp the side bars or the floor.
Another option for step 5, which was favoured by the younger children, was to lie down on the platform and crawl further until they have dragged their whole body on to the platform.

Some of the children pulled one knee on to the platform and dragged the other knee next to the first one before they stood up.

The children with better developed motor skills took alternating steps more often than the other children (30%).

When the first rung proved to be too high for the child, another method became more interesting and successful: The child threw his leg over the first rung, pulled himself up, swung the other leg next to the first one until he is in a sitting position. Then he put his foot on to the rung in order to stand up and climb the remaining rungs up to the platform (this method was used by almost all children who could climb the 70cm high rung).
Climbing with foot on rung

Climbing with knees on rung
Climbing with knees on rung

1

2

3

4

5

6
Climbing behaviour and character

The character of a child seems to influence his climbing behaviour and partly the results of the test. Children who are a bit afraid of new situations do in general get less practice in climbing as children who are “real go-getters”. This will influence the rate in which they develop their motor skills. However most children are curious enough to overcome their fear and in the end flexibility and strength in the arms will be a more important factor.

Some children are “real go-getters” and do not stop trying before they have reached their goal: the top of the platform and still more important the slide on the other side while others are giving in after the first attempt. Every child has its own way of dealing with the ladder but certain similarities can be distinguished based on their character:

“go-getter”
Reaction to failure: Becomes angry and starts jumping up and down. Tries other ways, for instance climbing up the slide which seems less difficult.

Shy
1. Reaction on failure: Looks desperately at the person who is closest to him as if to say: Help me, I cannot do this alone! This reaction often occurs after the first attempt. When this person is not showing interest in helping the child he starts to think about other ways to do it alone. Only few children walk away at this moment

2. A bit shy and yet determined. Gives up after the first attempt. However he stays close to the platform and watches other children climbing the ladder. After a little time he starts copying the methods of the other children. He will try to climb the ladder over and over again. Using different methods and hand and foot holds. The will to reach the top of the ladder can be seen on his face.

Lively
Will try every new object in the playground. Does not think about the dangers climbing might involve. Not afraid of falling and a small accident does not diminish his enthusiasm.
Afraid of new situations
Does not want to climb new objects at first. Needs some time to get used to the new situation. Stays close to the object and watches other children climb and having fun. The last child to start climbing.

The tests did not confirm if there is a correlation between the character and the agegroup of the child.

5.6 Reasons for failure

physical
- Not enough strength in arms
- Not flexible enough to pull one leg up to the first rung
- Too small to reach the top rung
- Not knowing the right technique

other
- Afraid to show their inability to other children.
- Wanting to play other games
- Afraid of new situation

6 Evaluation of the test

Test model
- No support points at the top. Children are looking for things to hold on to while climbing onto the platform. When designers want the children to climb a ladder and easily reach the platform they should keep this in mind.

Circumstances
- Because the weather was fine, the test could be performed outside.
- There was too little time left to test the slanted ladder as much as the vertical ladder.
- A large lunch break had to be scheduled between 12 and 3 because most children were asleep at this time.
- It was difficult to keep the children away from the attractive test object. Therefore more than three children were tested at a time. This did not influence the test results.
- There was not enough time to give all children the opportunity to climb all rung heights. Sometimes a child had to go to bed before the test was finished. In some cases this child had not yet reached its limits and we therefore do not know what is the highest rung height he was able to climb. In this case the highest rung height the child climbed successfully has been filled in as the maximum rung height.
7 Conclusions and recommendations

7.1 Conclusions
- A rung height of 40 cm is not high enough to keep children under 3 years from climbing a ladder.
- 7 of 38 children under 3 years (=18%) are able to climb a first rung of 60 cm.
- All test children aged 3-4 years are able to climb a rung height of 40 cm.
- Almost 50% of the children between 3 and 4 years of age is able to climb 70 cm.
- Kind of shoes or bare feet does not make a difference when climbing the ladder.
- Because there was not enough time left to test the slanted ladder as detailed as planned, very little can be said about children climbing this type of ladder. The children of age group 3 and 4 seemed to climb the slanted ladder as easily as they climbed the vertical one. Younger children seemed to be more afraid of the slanted ladder but further research on this point is required because of the small number of children participating in this test.

7.2 Recommendation for changing the requirements
- Raise the standard for the height of the first rung of a ladder to at least 600 mm.

7.3 Further research
- Are children who are able to climb a 40 cm high rung of a ladder (mentally) ready to play on large playground objects?
- At what age do children see the danger of more challenging large playground equipment?
- Research on the number and severity of the injuries occurring when a child under 3 years old climbs a large playground object.
- Slanted ladders should be tested as well in order to find out if they are more easy to climb than vertical ladders or more difficult.
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10. NEN-EN 1176-1

Other sources

11. Website Stichting Consument en Veiligheid. Fences and other separating objects

8.2 Appendix B: Abstracts

1. How do children climb out of cribs?
Biokinetics Research Laboratory, Temple University, Philadelphia

48 children between the ages of 16 and 32 mo. were observed climbing out of a crib. Each child was observed four times climbing out of the crib. All the children were able to walk independently and were less than 35 in. tall. Two different climbing patterns were identified and associated with a location of the climbing event within the crib environment. Most children (90%) climb from a crib by first moving to a corner of the crib and then start climbing from the crib. The remaining 10% of the children used a side-climbing pattern in at least one of the four observations. Crib safety standards have eliminated the most common catch-point, the cornerpost extension from cribs. Since at least 10% of the children climbed over the side of the crib rather than at the corner, any potential catch-points should be eliminated from the complete perimeter of the crib.

2. Age, side height, and spindle shape of the crib in climbing over the side.
Biokinetics Research Laboratory, Temple University, Philadelphia

The crib is the only infant product in which a consumer, such as a parent or caretaker, is encouraged to leave the infant unattended, usually alone in the bedroom, while the infant is sleeping or going to sleep or waking. Given frequent falls from the crib, federal crib regulations have set the minimum distance between the top of the mattress support and top of the crib side rail as 26 in. and this height must include a 6-in. thick mattress. When a mattress is used with the crib, the actual height of the crib side as a barrier is 20 in. These crib regulations also require instructions for the caretaker to discontinue using the crib when the child's height is 35 inches. These federal crib regulations attempt to create an escape-resistant sleeping environment for all children who are less than 35 in. tall. Of 144 children between the ages of 12.5 and 36.5 mo. observed while attempting to climb out of a crib, who also had standing heights of less than 35 in., many were able to climb from cribs with side rail heights of 26 in. When the crib side-rail height was raised beyond the minimum of 26 in., the frequency of children climbing over the crib rails decreased.

3. Climbing performance of children: is the above-ground pool wall a climbing barrier?
Department of Kinesiology, Temple University, Philadelphia

15 children between the ages of 42 and 54 months attempted to climb a 48-in. wall representing the wall of an above-ground swimming pool. Three different climbing tasks were presented to all the children: (1) climbing over the swimming pool wall without any tools which could assist their climb, (2) climbing over the wall with a child-resistant ladder frame placed over the wall, (3) climbing over the wall when a pool filter was placed 12 in. from the wall. Each child's success or failure climbing over the pool wall was recorded. A repeated-measures analysis of variance indicated there were no significant performance differences in performance across the three climbing tasks. None of these climbing tasks
resulted in more successful climbing performances for all the children. The results of these observations indicated the removal of the swimming pool filter or support frame of the ladder did not always stop the children from climbing over the wall. Since the 48 in. wall of the home swimming pool does not consistently function as a barrier, additional fencing is needed to prevent children from entering above-ground home swimming pools. However, no barrier replaces constant supervision of young children.

4. Young children’s ability to climb fences
Rabinovich BA, Lerner ND, Huey RW., Human Factors. 1994 Dec;36(4):733-44. COMSIS Corporation, Silver Spring, Maryland 20910.

Three studies were performed to evaluate the fence-climbing abilities of children who are in the high-risk age group for drowning in residential pools. Study 1 examined the ability of children in the age range of 24 to 54 months to climb commonly used fences (common chain link, small chain link, picket, iron, and stockade) at a 4-ft (1.22-m) height. Study 2 examined children’s abilities to climb fences retrofitted with features that would potentially make them more difficult to climb. Study 3 examined children’s abilities to climb 5-ft (1.52-m) fences. Results of the three studies show that the common chain-link fence is easy to climb even by two-year-old toddlers. Other fence types offered more effective barriers, especially for younger children.
8.3 Appendix C – Types of ladders

- ladder made of wood (90 degrees)
- ladder made of wood (90 degrees)
- slanting ladder 60 degrees with horizontal (wood)
Ladder with irregular steps

rope ladder

ladder made of metal (90 degrees)

ladder with steps on each side of one vertical bar
8.4 Appendix D: Standards for a ladder NEN-EN 1176-1- 4.2.9.1 Ladders and 4.2.9.2 Stairs

- The spacing of the steps or rungs shall be larger than 230 mm or smaller than 89 mm.
- Rungs and steps shall be non-rotating and equally spaced.
- Wooden components shall have positive connections that cannot be undone or shifted.
- Wooden components shall have positive connections that cannot be undone or shifted. Nails or wooden screws shall not be used as the only form of connection.
- To allow for the foot to rest correctly on the rung or step there shall be an unobstructed space at the rear of the ladder of at least 90 mm from the centre of the rung or step measured at 90° to the ladder.
- Rungs and steps shall be horizontal to within +/- 3°.
- Ladders shall have rungs and/or styles that conform to the requirements for grasp (width not exceeding 60 mm) or shall have handrails that conform to the requirements of grip (cross section of not less than 16 mm nor more than 45 mm in any direction).
- For near vertical ladders, it is recommended to apply the grip requirements to rungs and/or styles.
### Appendix E: child data

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</tr>
<tr>
<td>Weight</td>
<td>Steenbekkers, 1993, research with Dutch children</td>
</tr>
<tr>
<td>Leg length</td>
<td>Pheasant, 1988, Great Britain</td>
</tr>
<tr>
<td>Arm length until grip</td>
<td>Pheasant 1988 at Great Britain</td>
</tr>
<tr>
<td>Vertical length until grip</td>
<td>Pheasant, 1988, Great Britain and Steenbekkers, 1993, the Netherlands.</td>
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<tr>
<td>Length difference while jumping</td>
<td>Branta 1984 USA.</td>
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<tr>
<td>Grip circumference</td>
<td>Steenbekkers, 1993, the Netherlands.</td>
</tr>
<tr>
<td>Hand breadth (without thumb)</td>
<td>Steenbekkers, 1993, the Netherlands.</td>
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<tr>
<td>Hand thickness</td>
<td>Steenbekkers, 1993, the Netherlands.</td>
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<tr>
<td>Foot breadth</td>
<td>Steenbekkers, 1993, the Netherlands.</td>
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<tr>
<td>Instep height</td>
<td>Steenbekkers, 1993, the Netherlands.</td>
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<tr>
<td>Arm strength</td>
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<tr>
<td>Gripping force</td>
<td>Steenbekkers, 1993, the Netherlands.</td>
</tr>
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</table>

[33]
### Girls

| age | length (cm) P2 | weight (cm) P3 | leg length (cm) P5 | arm length until grip (cm) P5 | P98 | P50 | P99 | P5 | P90 | P95 | P5 | P90 | P95 |
|-----|---------------|----------------|-------------------|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | 70            | 75             | 80                | 7,1                         | 11,5| 11,5| 11,5| 7,1 | 11,5| 11,5| 7,1 | 11,5| 11,5| 11,5|
| 2   | 81            | 88             | 94                | 11,7                        | 14,1| 17,6| 36,5| 41,5| 46,5| 46,5| 27,0| 31,5| 36,0| 29,0| 34,5| 39,5|
| 3   | 89            | 96             | 104               | 12,9                        | 16,0| 19,6| 40,5| 46,0| 51,5| 51,5| 29,0| 34,5| 39,5| 29,0| 34,5| 39,5|
| 4   | 96            | 104            | 112               | 15,0                        | 18,4| 22,7| 44,5| 50,5| 56,5| 56,5| 31,5| 37,0| 43,0| 31,5| 37,0| 43,0|

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<th>P97</th>
<th>length until grip vertical (cm) UK P5</th>
<th>P50</th>
<th>P95</th>
<th>Step height (cm) P3</th>
<th>P50</th>
<th>P97</th>
<th>Grip circumference (cm) P3</th>
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<th>P97</th>
<th>P3</th>
<th>P50</th>
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</tr>
</tbody>
</table>

| age | hand thickness (cm) P3 | P50 | P97 | foot breadth (cm) P3 | P50 | P97 | Instep height (cm) P3 | P50 | P97 | gripping force (N) P3 | P50 | P97 | P3 | P50 | P97 | P3 | P50 | P97 |
|-----|------------------------|-----|-----|----------------------|-----|-----|-----------------------|-----|-----|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|----------------------|-----|-----|
| 2   | 1,2                    | 1,6 | 1,9 | 5,1                   | 5,9 | 6,6 | 4,7                   | 5,5 | 6,7 |                        |     |     |     |     |     |     |     |     |                      |     |     |
| 3   | 1,2                    | 1,6 | 2,1 | 5,3                   | 6,1 | 6,9 | 4,9                   | 5,8 | 6,9 |                        |     |     |     |     |     |     |     |     |                      |     |     |
| 4   | 1,4                    | 1,7 | 2,0 | 6,1                   | 6,6 | 7,4 | 5,1                   | 6,1 | 7,3 | 14,7                   | 45,8 | 88,2|     |     |     |     |     |     |                      |     |     |

### Boys

| age | length (cm) P2 | weight (cm) P3 | leg length (cm) P5 | arm length until grip (cm) P5 | P98 | P50 | P99 | P5 | P90 | P95 | P5 | P90 | P95 |
|-----|---------------|----------------|-------------------|-----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | 71            | 77             | 92                | 10,7                        | 12,5| 12,5| 12,5| 10,7| 12,5| 12,5| 10,7| 12,5| 12,5| 12,5|
| 2   | 82            | 88             | 113               | 14,5                        | 19,0| 36,0| 42,0| 48,0| 29,5| 34,0| 39,0| 29,5| 34,0| 39,0|
| 3   | 91            | 98             | 138               | 17,0                        | 21,0| 40,0| 46,0| 52,0| 32,0| 36,5| 41,0| 32,0| 36,5| 41,0|
| 4   | 98            | 106            | 155               | 18,6                        | 21,8| 44,5| 50,0| 55,5| 34,0| 38,5| 43,0| 34,0| 38,5| 43,0|

<table>
<thead>
<tr>
<th>age</th>
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<th>P50</th>
<th>P97</th>
<th>length until grip vertical (cm) UK P5</th>
<th>P50</th>
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<th>Step height (cm) P3</th>
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<th>Grip circumference (cm) P3</th>
<th>P50</th>
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<th>P3</th>
<th>P50</th>
<th>P97</th>
<th>P3</th>
<th>P50</th>
<th>P97</th>
<th>hand breadth (cm) P3</th>
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<th>hand thickness (cm) P3</th>
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<th>foot breadth (cm) P3</th>
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</table>
8.6 Appendix F – Letter to the parents
Beste ouder/ verzorger,

Met deze brief willen wij u op de hoogte brengen van een onderzoek dat komende week op het kinderdagverblijf van uw kind gedaan zal worden. Het onderzoek wordt uitgevoerd door ontwerpbureau Jep in samenwerking met de Technische Universiteit Delft en Stichting Consument en Veiligheid, en heeft als doel tuit te vinden wat kinderen jonger dan vier jaar allemaal wel en niet kunnen beklimmen. Het onderzoek wordt gedaan in opdracht van de Europese organisatie ANEC (www.anec.org). Zij behartigen de belangen van de consument bij het opstellen van veiligheidsnormen en zijn de overkoepelende organisatie van Consumenten organisaties in heel Europa. Twee onderwerpen staan bij dit onderzoek centraal:

1. de onderste sport van een ladder (bijvoorbeeld op een speeltoestel).
2. de dingen die kinderen als voetsteun kunnen gebruiken bij het klimmen over bijvoorbeeld hekken.

De resultaten van het onderzoek zullen gebruikt worden om de normcommissie te adviseren bij het maken van nieuwe normen voor speeltoestellen en hekken. Hierdoor zullen toestellen en hekken in de toekomst nog beter kunnen functioneren en dat is natuurlijk ook in het belang van uw kind.

Dat we deze test niet kunnen doen zonder de hulp van kinderen zal duidelijk zijn. Wij hebben met Amanda overlegd over de opzet van het onderzoek en zij wilde graag met kinderdagverblijf De Capriool meewerken aan deze test. De test is opgezet als een soort spel dus de kinderen zullen het zeker niet als naar ervaren. Hoe gaat zo'n test dan in zijn werk en wat wordt er met de resultaten en het verzamelde materiaal gedaan? Waarschijnlijk allemaal vragen die er nu bij u op komen. Hieronder een korte uitleg van de testopzet en alles wat er verder bij komt kijken.

Wanneer?

Wat wordt er opgemeten?
Voetjes, beenlengte, staphoogte, lengte, gewicht. Met deze maten kunnen we achteraf kijken of bepaalde lichaamskenmerken bepalend zijn voor de klimvaardigheid van jonge kinderen.

Wat moet mijn kind doen tijdens de test?
Op woensdag zal aan de kinderen gevraagd worden om via een ladder een platform te beklimmen. Beloning is het glijbaantje dat van het platform afgaat. De eerste sport van de ladder zal na elke succesvolle poging iets verhoogd worden tot het het kind niet meer lukt om op het platform te komen. De leidsters blijven bij de test aanwezig en zullen de kinderen uitleggen wat er van ze verwacht wordt. Doel is om een zo natuurlijk mogelijke situatie na te bootsen waarbij de kinderen dus niet tot het uiterste gedreven worden maar wel enthouisaat gemaakt om het te proberen. Vanzelfsprekend zullen we de veiligheid van de kinderen niet in...
gevaar brengen. Er zijn voldoende helpers aanwezig en het testtoestel is zo gebouwd dat het aan de veiligheidseisen voldoet.

Op donderdag wordt een soortgelijke test gedaan als op woensdag. Nu gaat het er alleen om te kijken wat de kinderen gebruiken als opstappunten bij het klimmen over een hek. Hetzelfde platform wordt nu voorzien van hekken met verschillende voetsteunpunten (denk bijvoorbeeld aan een hek met metaalgaas). De manier van testen blijft hetzelfde.

Waarom video opnamen?

Het is onmogelijk om alles wat er tijdens een dergelijke test te zien is, op papier te zetten. Om te voorkomen dat belangrijke details onopgemerkt blijven zullen we de hele test op video opnemen zodat we die later nog rustig kunnen bekijken. De videobanden zullen vanzelfsprekend alleen gebruikt worden voor dit onderzoek en presentatie in wetenschappelijke publicaties van de resultaten achteraf. Namen van kinderen doen niet terzake en zullen nergens vermeld worden.

Graag willen we u vragen om het bijgevoegde formulier in te vullen en aan te geven of u uw kind toestemming geeft om mee te doen met de test. U kunt het formulier inleveren bij de leidsters van uw groep.

Heeft u nog vragen dan kunt u mij bellen op nummer 06-44880247.

Met vriendelijke groet,

ir. Jenny van Herrewegen

ontwerpbureau Jep, Amsterdam, www.jep-ontwerp.nl
Stichting Consument en Veiligheid, www.veiligheid.nl
Met dit briefje geef ik aan dat ik:
- op de hoogte ben van het onderzoek naar klimvaardigheid van kinderen dat plaats gaat vinden op het kinderdagverblijf op woensdag 17-8 en donderdag 18-8 2005.
- ermee instem dat mijn kind aan dit onderzoek mee doet.
- ermee instem dat videobeelden en foto's van het onderzoek gebruikt kunnen worden voor wetenschappelijke publicaties op voorwaarde dat mijn kind niet bij naam genoemd wordt.

Wanneer uw kind wel mee mag doen met het onderzoek maar u liever niet heeft dat videobeelden en foto's van uw kind gebruikt worden in wetenschappelijke publicaties, kruist u dan dit hokje aan

naam: ................................................. handtekening:.............................................
datum: .....................................................
8.7 Appendix G: test protocol

Purpose of the test
Determination of the height of the first rung of a ladder that children aged 0-4 years can climb without help.

Short description of the test
The test takes place at two different locations (Child Day Cares) at different days. A for this test designed playground object will be placed (see images below).

The children will be divided in small groups (by age as far as possible). They will try to climb the ladder. The first rung will be raised with 10 cm after each successful attempt. This continues until not one of the children is able to climb the ladder. The ladder will be tested in two different positions, vertical and slanted (60 degrees). The height of the first rung is the variable we want to test. The height of the other rungs is less important but they have to make climbing as easy as possible.

Scenario

1 Building the test object
At seven a clock sharp Spereco will start building the test object in the garden of the Day Care Centre. The test object will be ready at 8 a clock.

2 anthropometric data
At the beginning of the day we visit the groups with the measuring instruments to take anthropometric data of most of the participating children. This way we will be able to check if the groups are complete and we can change the schedule if necessary.
The data will be filled in on the data form. Names of the children will be written down as well to make it easier to recognise the children on tape.

3 testing
The first age group (1-2 jaar) will be gathered with help from one of the teachers. The children are allowed to play on their own (as long as they stay within sight) The children of one age group will be ranged by height. The three smallest participants are allowed to start the test. In the older age groups it will be easier to test more than three children at a time because they will understand they have to wait before they start climbing the test object until the child in front of them finished the test.
1. Explanation of the task by the teacher: climb the ladder and slide down on the other side. Each child gets three chances. The children climb one at a time!
2. The teacher accompanies the climbing child. She will catch the child in case of a dangerous situation. She will try to help as little as possible. The child has to explore the ways of climbing the ladder on his own.
3. The video will be turned on. On the sign the child can start climbing. The time this task takes will not be measured.
4. The observer writes down everything that catches the eye, the number of attempts and whether or not the child climbed the ladder successfully.
5. Pictures will be taken from the climbing children.
6. All children have finished climbing the ladder.
7. The first rung will be raised 10 cm (in case the children climbed the ladder very easily we can decide to raise the rung 20 cm.) The test will continue.
8. Until no child in the group can climb the ladder.
9. The next three children can start the test...
10. After all children in the age group finished the test the ladder will be placed in the slanted position and all steps will be repeated.
11. The next age group can start the test.

Caution!
Take care that the second rung is always easy reachable.

Age groups
The children will be divided into age groups. The Day Care works with mixed age groups. The teachers receive a timetable of the test. They will try to keep the children ready at the right moment.

<table>
<thead>
<tr>
<th>Group</th>
<th>Age group</th>
<th>Number of children</th>
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</thead>
<tbody>
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<td>1 - 2 years</td>
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<tr>
<td>Group 2</td>
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<td>8 children</td>
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<tr>
<td>Group 3</td>
<td>2.5 – 3 years</td>
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<td>Group 4</td>
<td>3 - 4 years</td>
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dagschema

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Tasks
Building and moving the test object
The test object will be build on the first testing day. It will stay on the first location for a week. After this week Speroco will move the object to the next test location.
Anthropometric data
Anthropometric data will be recorded for each child: weight, height, foot length and width, step height, height until grip. Other qualities that will be recorded: age, character of the child (according to the teacher) and kind of shoes.

Explanation of the test to the children
It will probably be the best if the teacher explains to the children what is expected from them. The teacher is someone they know and trust. They can encourage children who are a bit afraid to start climbing.

Observations
During the test one person will be busy filling in the observation form. He will count the number of attempts and if the child succeeded climbing the ladder yes or no.

Repositioning the rungs
During the test the rungs have to be repositioned many times. The test object is designed to make this task relatively easy.

Video/digital camera
One person is responsible for the video camera. The camera will be placed on a fixed spot in order to get images from the same point of view. The camera man takes care of the following tasks: the video camera has to be turned on when the children are climbing the ladder, the batteries have to be loaded, the tape has to be replaced when full, the camera has to get a good overview of the methods the children use to climb the ladder.

Safety
One person is responsible for the safety of participating children. This person had to be near the climbing child and is preferably a teacher.

Watching the other children
Someone has to keep an eye on the children that are not climbing the ladder.

What in case of:
- A child is not paying attention to the test object and does not show interest in participating in the test. – Do not pay too much attention. Leave the child alone and start testing the other children. Probably the child will come back when he sees how much fun the other children are having climbing the ladder and using the slide. If not, do not push the child.
- A child during the test stops, stays on to the platform, does not want to come down. – A task for the teacher to persuade the child to join in. Leave the child alone for a short while and try again a little later is another possibility. Older children like to play games and are willing to do the best they can to reach the goal. It might work out well to lay down a toy on top of the platform to attract their attention.
- More children are climbing the ladder at the same time. – encourage them to form a small row.
- Children are climbing the test object on the wrong side. – Interesting to observe but not the purpose of the test.
- Group 1 will probably be the most difficult one. It might be better to test the children one by one.
- When children are sleeping we have to wait until they are awake again. The time schedule will be used as a flexible guideline.
8.8 Appendix H: Test situations and observations

Capriool

participants: 7 (from different age groups)
successful: 7

Observations
Upper rung is positioned above platform level. Most children find it difficult to climb over this last rung onto the platform. By climbing this way they cannot lie flat on their belly's or use their knees which are the two most used methods for climbing a platform for young children.

participants: 7
successful: 3

Observations
Difficult for smaller children. The taller ones climb this ladder easily.
participants: 15
successful: 10

Observations
Being able to put their foot onto the first rung does not mean they are able to climb the ladder as they have to be able to pull themselves up as well. Most younger children find this last step very hard.

participants: 6
successful: 5

Observations
- Children use their knee on the first rung because it is more easy to bring their knee up than their foot. Climbing this way requires less flexibility. Children are really putting a lot of effort in their attempts to climb onto the platform. It causes a lot of strength in their arms to pull themselves up. Young children are not able to do this.
- Not so many children can climb a ladder with the first rung at a height of 70 cm. As shown in the picture this posture is very uncomfortable for the child. Climbing a rung height of 70 cm will become easier with a handhold positioned at grip height.
- Most children find it difficult to place their foot onto the rung which is very high in comparison with their body length.
- First reaction is: no, I can not do this. I give up. If other children are successful they often want to try it again.

Participants: 15
Successful: 10

Observations:
- Most children under 3 years old can not climb this ladder.
  One 2 year old child can do it.

Participants: 5
Successful: 3

Observations:
Two sisters are helping and stimulating each other to climb the ladder. The older one is encouraging and challenging the younger one.
participants: 4
successful: 1

Observations
These participants were all very young. Most of them were a bit afraid and did not know how to climb this ladder.

participants: 8
successful: 5

Observations
Easy for most children.
Speeltoren

participants: 5
successful: 5

take 1

participants: 5
successful: 3

take 2

participants: 8

take 3
participants: 13
successful: 10

participants: 4
successful: 3

participants: 5
successful: 5

participants: 4
successful: 3
participants: 8
successful: 6

Observations
Very young children who could hardly walk. Did not know how to climb a ladder yet.

participants: 3
successful: 1

Observations
One of the children becomes very sad when she notices she is not able to climb the ladder now.
participants: 5  
successful: 3  

participants: 4  
successful: 4  

Observations  
Once the children are able to put their leg over the first rung and they are able to pull themselves up, this slanted ladder is a piece of cake.
participants: 5
successful: 5
## appendix I: Anthropometric data

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Group 1: 1 out of 3 climbed 30 cm
Group 2: 3 out of 4 climbed 60 cm
Group 3: 2 out of 3 climbed 50 cm
Group 4: 4 out of 7 climbed 70 cm, the other 3 climbed 50 cm

*Deleted: (namen weghalen en vervangen door nummers). Ik vind die namen wel erg leuk, maar ik denk samen met de leeftijd en het kdv dat het wel erg veel weggeeft van eht kind*)
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Appendix K: Expression of thanks

All participating children for putting so much effort in their attempts to climb the platform.

Frans Everaerts
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Henk Lok

Martine van Herrewegen
Masja Notenboom
Barbera Keukens
Gijsbert Koren
Doortje van de Wouw